



Infrastructure

The necessity of building, maintaining, operating, renovating and retiring infrastructure will loom large in the next 20 years. Both developed and developing countries require massive investments in quality infrastructure for current and future generations, but meeting these needs requires a shift in mindset and leadership. The Global Infrastructure Outlook report, a G20 initiative, forecasts that global infrastructure investment needs will reach \$94 trillion by 2040.¹ However, worldwide investment in infrastructure is expected to be \$79 trillion by 2040, resulting in a \$15 trillion infrastructure investment gap.² Of this global infrastructure investment gap, about \$8 trillion is concentrated in the road and electricity sectors, which are critical to developing and sustaining economic growth.

The negative impacts of an ongoing investment gap are clear. For instance, in its 2013 and 2017 Infrastructure Report Card, the American Society of Civil Engineers (ASCE) gave U.S. infrastructure a grade of D+, citing challenges in financing, leadership and planning.³ In their latest reports, they claim that the biggest obstacle to improving the U.S.'s score is a lack of consistent and well-allocated investment, specifically from dedicated public sector funding sources.

As the government is a primary actor in most infrastructure projects, it is not surprising that many national and international entities such as the ASCE implore governments to earmark more funding towards this sector. A recent World Bank study estimated that approximately 83 percent of infrastructure projects in developing countries were sponsored by government entities and state-owned enterprises (SOEs).⁴ Given that governments are both key drivers of demand and financiers for infrastructure projects, public officials have an imperative to consider this investment gap in infrastructure policy and decision-making.

As societies' infrastructure needs evolve, the investment gap persists, and as countries face mounting financial, societal and environmental concerns, there is a need for cohesive leadership. The objective of the infrastructure sourcebook is to provide its readers – including

policymakers, leaders in the government and private sector and practitioners in development institutions and organizations of learning – with a synthetic overview of the sector, a stocktaking of current challenges and proposals for managing the challenges of the next 20 years.

The sourcebook documents the extent to which infrastructure is and will continue to be one of the core state functions in both developed and developing countries.

Defining the Infrastructure Sector

ISE argues that the provision of infrastructure services is one of the core ten functions of the state. To allow for comparisons across eras and countries, we differentiate between the following key components:

- **Network infrastructure** (transportation, communications)
- **Utilities** (energy, water)
- **Public infrastructure** (healthcare, education, parks)
- **Commercial infrastructure** (agriculture, manufacturing, banking)
- **Housing** (public, private)

The sourcebook also differentiates between the **stock** and **flow** of infrastructure, taking into account the accumulated gains of the past and the nature of investments that have or have not taken place. This distinction between stock (i.e., existing infrastructure) and flow (i.e., infrastructure being created) enables us to use a dynamic rather than a static definition of infrastructure. Analysts who operate with a static definition freeze the policy discussions on critical infrastructure at a particular moment in time. A dynamic definition, by contrast, allows us to see how technological, societal and political change brings about a significant redefinition of what constitutes critical infrastructure at any moment in time or across decades.

The importance of identifying both stock and flow of infrastructure manifests in how countries determine their budgets and priorities and brings additional focus onto the needs of operations and maintenance

1. Global Infrastructure Outlook Report, Global Infrastructure Hub and Oxford Economics, 2017, 3, <https://outlook.gihub.org/>.

2. Ibid., 25.

3. 2017 Infrastructure Report Card, American Society of Civil Engineers, 2017, [infrastructurereportcard.org/wp-content/uploads/2017/04/2017-IRC-Executive-Summary-FINAL-FINAL.pdf](https://www.asce.org/wp-content/uploads/2017/04/2017-IRC-Executive-Summary-FINAL-FINAL.pdf).

4. "Who finances infrastructure, really? Disentangling public and private contributions," The World Bank, 2020, <https://blogs.worldbank.org/ppps/who-finances-infrastructure-really-disentangling-public-and-private-contributions>.

as well as the renovation or retiring of older infrastructure. For instance, Japan recently used a dynamic definition of infrastructure by accounting for both stock and flow when it conducted a comprehensive investigation into its infrastructure. The country's leadership concluded that Japan would not be able to renew, operate and maintain its existing stock, and urgently needs to develop policies and criteria for both retiring a significant amount of infrastructure and updating the flow of infrastructure to account for the assets being retired.

Historical Evolution: The Centrality of Infrastructure

Even as far back as the earliest irrigation systems in agricultural societies, infrastructure has played a dramatic role in societal development. The period from 1825 (when the first railway was completed in Britain) to 1914 (the construction of the Panama Canal) marks the creation of the infrastructural underpinning of the first wave of globalization. During this period, investments in infrastructure became a global phenomenon, made possible by the advent of industrialization and the embrace of an open trading system by the U.K. and then the first wave of globalization.

More recently, the response to both the global financial crisis of 2008 and the 2020 COVID-19 pandemic has taken the form of stimulus relief packages, and investment in infrastructure was a core driver of both recovery and future competitiveness in the 2008 response. It is yet to be determined whether infrastructure investment is going to be part of the 2020 coronavirus pandemic recovery spending by governments.

Additionally, the types of infrastructure investments will change after the pandemic, as people's work and living patterns have shifted. In the course of implementing their stimulus packages in 2008, most developed and developing countries discovered that they were not sufficiently ready to quickly invest in infrastructure. However, some countries (e.g. Canada, China, Malaysia and Singapore) were able to move both comprehensively and with speed to use the 2008 stimulus packages to deliver thousands of projects aligned to serve the goal of recovery and renewal of growth. The sourcebook highlights the governance systems leveraged by these countries to be able to effectively and quickly manage the influx of funds to deliver these projects. By investing in infrastructure, these administrations were able to advance long-term economic and social goals through a single process.

Governance: Creating the Foundation

National and subnational government entities, private industry and international financial institutions (IFIs) all play a role in the governance of infrastructure projects. Each of these entities may take on one or more of the following roles: standard setter; regulator; enforcer; owner; project manager; financier; supplier; and/or builder. The allocation of

these roles to different actors can vary significantly depending on the situation and the distributed responsibilities (though not always evenly) throughout the project life cycle.

Despite the allocation of roles, coordination among these entities is key. First, coordination across government bodies is essential, particularly in national planning. A whole-of-government approach encourages various perspectives and empowers subnational governments to take ownership of projects. Second, infrastructure also requires active coordination with the private sector. Successfully understanding and managing infrastructure projects starts first with understanding the supply chain. While the government has a role in regulating the private industry in terms of setting standards for construction and maintenance, it does not paint the full picture of supply chain governance. The sourcebook defines governance beyond the broad sense of "government," and includes the state's interactions with private firms and the formal and informal rules that exist between them.

In 2015, the International Monetary Fund (IMF) introduced a framework to promote the development of strong infrastructure governance. The Public Investment Management Assessment (PIMA) is the IMF's key tool for assessing infrastructure governance, which has been utilized in more than 60 countries to date. PIMAs summarize the strengths and weaknesses of countries' public investment processes and set out a prioritized and sequenced reform action plan. The IMF uses this tool to make recommendations and determine its lending in a country. The sourcebook provides an overview of this tool, along with other key resources in developing infrastructure governance structures.

Planning & Design: Where to Begin

Before diving into project implementation, the sourcebook outlines preliminary steps that are key to national infrastructure planning and prioritization. Public officials should first consider a national (or regional) infrastructure plan, outlining the country's (or region's) priorities and vision for the coming years. Such plans are a useful tool and a recent global trend, with more countries developing plans every year. Because infrastructure projects are capital intensive, this allows countries to forecast and allocate budgets over longer periods of time while considering population shifts, urbanization and other complex social and environmental priorities.

Once a national infrastructure plan has been developed, infrastructure projects can be evaluated and selected based on established national priorities. The sourcebook details the following key steps in the evaluation process:

Project Appraisal: Once the infrastructure plan is approved, line ministries can submit project proposals to an independent investment

authority (IIA) for evaluation. The IIA will prepare a preliminary feasibility study to determine whether to proceed with a detailed feasibility study, which is costly and time-consuming. Of the 15 key institutional factors/phases assessed by the IMF's PIMA framework, project appraisal is one of the phases performed by government entities that needs the most improvement.

Feasibility Studies: To attract foreign and domestic investors to invest in infrastructure projects, the IIA should prepare a list of bankable feasibility studies to have a pipeline of projects ready for investment. Feasibility studies are expensive and time-consuming, therefore the IIA must be selective on which projects to evaluate.

Project Selection & Financing: This phase plays a key gatekeeping function in infrastructure governance by ensuring only economically viable projects reach the implementation stage. During project selection, there must be clear criteria for project prioritization, selection and funding. Project selection is typically based on a bankable feasibility study prepared by a credible firm (as described above) and independent reviews by a team in the line ministry (e.g., preliminary land acquisition assessments, preliminary environmental and social impact assessments, etc.). As projects are being selected, financing is likely the biggest hurdle. **The inability of most countries to close the financing gap continuously plagues the industry, making it difficult to produce the necessary infrastructure for development.** Some sources of infrastructure financing include earmarks in government budgets, public-private partnerships (PPPs) and international finance institutions.

Throughout this process of planning and design, the sourcebook describes how a proper rule of law framework can be set up to promote transparency and accountability in investment decision-making.

Delivery: From Procurement to Demolition

While the process alone of selecting government infrastructure projects is complex, implementing these projects also involves several crucial and complex steps. The process begins with **procurement and tender**, where the general practice to work with the lowest bidder often fails to account for *lifecycle cost* and ignores non-financial factors such as the expertise and experience of contractors. Procurement has a direct impact on the next stage, **implementation**, where misalignment between the government's vision and designers and builders can lead to cost and time overruns. **Commissioning**, which occurs throughout project design, construction and often the first year of use, acts as a control mechanism to ensure the project meets legal and quality assurance standards, as well as design specifications. Much like the overall infrastructure landscape, infrastructure **operations and maintenance** suffer from capacity and funding constraints.

Creative solutions like performance-based financing can overcome these obstacles and ensure better infrastructure upkeep and value-capture strategies that reinvest revenue into communities. Finally, governments often struggle to fully consider the budgetary and policy implications of infrastructure **renovation, retirement or demolition**, where required costs can exceed those of typical operations and maintenance.

Benchmarking: How Do We Measure Progress?

Benchmarking practices are common in the business world and are no less prevalent in infrastructure development. It is a method of improving performance by measuring one's level of performance against either personal year-after-year performance or that of others'. The simple comparison, however, is not enough. For the most effective benchmarking, groups (in this case a government) should use these measurements to make improvements in targeted areas. There are three major types of benchmarking: (1) internal benchmarking, which is carried out inside an organization, where the best practices of one facet should be taken on by another if that facet is higher achieving; (2) competitive benchmarking, which monitors and compares processes with other organizations, and determines the best practice based on the comparison; and (3) functional benchmarking, which compares an organization's processes against those who are considered to be the "best in class" in the industry.

Operational Challenges: Industry Pain Points

While significant empirical work has been carried out on the components of the infrastructure sector, we lack a framework that would allow for the investigation of linkages and the re-thinking of better alignment between or among these components. The sourcebook highlights the following key pain points where the process most commonly breaks down:

The Planning Gap: Many countries lack a pipeline of bankable feasibility studies, which is detrimental to the implementation of future projects. A large number of bankable feasibility studies should be prepared and available to attract private sector investment. This step becomes a major gatekeeping function in infrastructure governance as it ensures that only economically viable projects reach the implementation stage.

Financing: Infrastructure is a capital-heavy investment, requiring upfront costs that may be difficult for low-income countries to cover. As previously mentioned, there is an expected \$15 trillion infrastructure investment gap for the next 20 years. The sourcebook discusses mechanisms and best practices to address this gap and enable private sector investment.

Operations & Maintenance: Aging infrastructure has highlighted the critical importance of inspection and maintenance to preserve the integrity of these facilities. Poor O&M – including cost overruns, lack of timely delivery and the need to redo significant portions of the work – is a common feature in the building of infrastructure. O&M risks can be reduced with proper project design, contractual safeguards, supervision engineering oversight and validation, citizen participation and infrastructure asset management tools.

The Productivity Problem: The construction industry, a large component of the infrastructure supply chain, is known as one of the world's least productive industries. At the same time, this industry also represents a large percent of the global economy. In developing countries, the construction industry typically accounts for 6-12 percent of the GDP. However, few organizations have paid systematic attention to the role of the construction industry as a driver of growth. The only organization that has gathered systematic data over time on construction is the United Nations, whose records for most of the world go back to 1970, and for the former Soviet Union, to 1990. The sourcebook describes how, in recent years, both public and private institutions have joined the U.N. in their efforts to analyze this industry, consequently highlighting its immense productivity problem. Productivity growth has averaged only one percent per year over the past two decades, compared with an average of 2.8 percent per year for the total world economy.⁵ Per analysis from the McKinsey Global Institute, the productivity gap can be reduced by taking actions in the following areas: regulation; collaboration and contracting; design and engineering; procurement and supply-chain management; onsite execution; technology; and capacity building.⁶

Supply Chain Management: The public sector directly intersects with the private sector in the infrastructure supply chain in numerous ways. Most of the time the public sector acts as the *client*, always as the *regulator* and sometimes as a *key player in the supply chain*. Understanding this relationship is contingent upon understanding the supply chain and the government's role within it. For example, cement – the most widely used substance on the planet after water⁷ – is composed of raw materials such as limestone and clay, which require a governmental mining license to extract. Therefore, for the government to successfully attract the private sector to build a cement factory, it

must also package the offer with licensing rights for the raw materials to make the cement. This highlights a key role that the government plays in the infrastructure supply chain. Without the proper mining license and incentives, companies will not manufacture cement, and without an uninterrupted supply of cement, the construction sector cannot function efficiently. In another example, the government can subsidize or promote a sector for strategic purposes, such as the U.S. government's recent executive order to establish critical minerals supply chains for domestic industry and national defense.⁸

Siloed Clusters Across Infrastructure Delivery: Clusters are a concentration of related industries in a particular locale, ranging from the subnational to global in scale. The sourcebook identifies key clusters that are the 'building blocks' of infrastructure delivery. The efficiencies of individual clusters are hindered by a lack of alignment between them. Examples of these clusters may include the policy cluster (bodies responsible for rules and regulations); the construction cluster (private construction firms); the commissioning cluster (government departments responsible for contracting); the O&M cluster (i.e. bodies responsible for O&M depending on the contract); and the transportation and logistics cluster (bodies responsible for the transportation of materials). As the infrastructure sector empirically has one of the largest back-and-forth connections to other industries, analysis of these clusters provides for a focus on the creation of efficiencies both in overall costs and the delivery of services. Each of these building blocks of the construction industry opens the possibility of benchmarking across levels of government and industry.

Cross-Cutting Themes

This sourcebook frames the issues of the infrastructure industry in terms of the following cross-cutting themes:

Citizen Participation: Public policy and infrastructure can either be a driver of a virtuous circle of the inclusion of citizens and the creation of opportunities for their upward social and economic mobility, or a factor in reinforcing a vicious circle of exclusion and poverty. Engaging citizens in the process helps ensure a smooth transition and delivers a product that is not just beneficial to the developer but to the whole community. The sourcebook highlights not only the importance of citizen participation in the process but also the need for a diverse

5. Reinventing Construction Through a Productivity Revolution, McKinsey & Company, 2017, <https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/reinventing-construction-through-a-productivity-revolution>.

6. Reinventing Construction: A Route to Higher Productivity, McKinsey Global Institute, February 2017, 7, <https://www.mckinsey.com/business-functions/operations/our-insights/reinventing-construction-through-a-productivity-revolution>.

7. Jonathan Watts, "Concrete: the most destructive material on Earth," The Guardian, February 2019, <https://www.theguardian.com/cities/2019/feb/25/concrete-the-most-destructive-material-on-earth>.

8. President Trump's Executive Order (EO) 13953 on "Addressing the Threat to the Domestic Supply Chain from Reliance on Critical Minerals from Foreign Adversaries and Supporting the Domestic Mining and Processing Industries," September 2020, <https://www.whitehouse.gov/presidential-actions/executive-order-addressing-threat-domestic-supply-chain-reliance-critical-minerals-foreign-adversaries/>.

range of voices. In particular, women are often excluded from the sector; from project planning to construction and demolition, jobs relating to infrastructure projects are notably male-dominated.

Risk Management: Infrastructure projects often become burdensome due to poor risk management, resulting in cost and time overruns. Infrastructure projects, especially those based on public-private partnerships, can overburden the treasury with unexpected debt without the right risk management mechanisms in place.

Digitalization and Cybersecurity: The infrastructure sector comprises not only physical but also informational networks. The incorporation of information management systems into smart grids makes us dependent on ever-changing technology and growing webs of connectivity. Although these tools are incredibly important for improving efficiency and service delivery, including predictive maintenance and remote design, this dependency also creates the distinct problem of cybersecurity and the risks that emanate from disruptions to these network-managed infrastructural systems. The infrastructure underpinning cybersecurity and the threats that will emanate from cyberspace will continue to have a significant bearing on how citizens, the private sector and governments use, build, manage and regulate infrastructure.

Corruption: Infrastructure continues to be the basis of the consolidation of security and projections of power. Corruption in the construction industry, as one example, is perceived to be among the highest in the world, exceeding perceived corruption even in the defense industry. By implementing best practices in infrastructure governance, corruption in the infrastructure sector can be reduced.

Social and Environmental Impacts: The potential social and environmental price exacted by infrastructure makes attention to design imperative for sustainable progress. Additionally, IFIs require environmental and social impact assessments before providing financing to an infrastructure project. There must be a balance for these social and environmental concerns; on the one hand, standards are necessary to protect citizens in the short- and long-term, but on the other hand, regulations cannot be so stringent that a project cannot be completed.

Climate Change Resilience: Global infrastructure (both stock and flow) must be able to meet the changing landscape of climate change. The frequency of natural disasters (e.g., hurricanes, floods, droughts, etc.) have increased in recent times. For example, rising sea levels will change infrastructure as we understand it today, especially ports and land-based transportation infrastructure near the coast. Governments must consider both the resiliency of their existing infrastructure assets in these regions, as well as future investment plans.

Conclusions

Our analytic framework on infrastructure has been explicitly developed to provide for both a stock-taking of assets and constraints at the subnational, national, regional or global level. By focusing on integration across the building blocks of the construction industry and highlighting key points, we allow for the development of policies, programs and projects that would result in systematic efficiency and sustainability gains. Applied across countries or subnational regions, this framework will allow for benchmarking within each of the individual building blocks as well as across the value chain.

The sourcebook provides specific recommendations in the following ways:

1. It will offer governmental policymakers and private sector partners an empirical framework for identifying their assets and constraints.
2. Each of the building blocks of the construction industry opens the possibility of benchmarking across levels of government and industry.
3. Through the discussion of examples of best practices in effectiveness, efficiency and timely delivery, policymakers and practitioners will be provided with options for tackling the needs of the next 20 years.
4. An examination of current practices leading to adverse environmental and social consequences, as well as documentation of breakthrough solutions in sustainability, clarifies how to tackle the challenges of sustainability – such as avoiding the trap of aiming at short-term savings for medium- and long-term penalties.
5. An examination of organizational cultures as constraints in sustainable design will facilitate an exploration of use and delivery and articulate better ways of learning, designing and building.

We hope that the existing communities of practice will find sufficient value in this sourcebook to embark on serious discussions of innovation within and across their communities. Attention to the overarching frame can also catalyze a global discussion to seek ways to bring about cooperation and to lower the current cost projections while building a new stock of infrastructure that will serve as a sustainable basis for the needs of coming generations.