Engineering for Sustainable Development

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Preface

Through their role in supporting many of society's critical functions, infrastructure systems have the ability to influence future development, both in positive and negative ways. With global infrastructure investment needs estimated to be $97 trillion by 2040,[1] the engineering community has a massive opportunity to ensure that this development is sustainable. This short report identifies a number of key linkages between engineering and sustainable development, highlighting areas where engineers can work towards building a sustainable and prosperous future for all.

The global commitment to sustainable development

Broadly defined, sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.[2] Over the past four decades, the concept of sustainable development has become an increasingly central theme of nation states and their citizens. Amongst others, the Sustainable Development Goals (SDGs) — as part of the 2030 Agenda for Sustainable Development;[3] the New Urban Agenda;[4] the Paris Agreement;[5] and the Sendai Framework for Disaster Risk Reduction,[6] demonstrate high-level international commitments in this area, on the part of governments, international organizations, business and civil society. Table 1 provides a description of these commitments and their relevance for engineering.

***Table 1**: Key sustainable development-related international agreements and their relevance for engineering.*

Agreement	Description of the agreement	Relevance for engineering
The 2030 Agenda for Sustainable Development	A commitment to eradicate poverty and achieve sustainable development by 2030. Based on a shared global vision, described by the 17 Sustainable Development Goals (SDGs)	Infrastructure systems have the ability to influence all 17 SDGs, including the majority of their targets.[7]
The New Urban Agenda	A commitment to an urban development framework that lays out how cities should be planned and managed to best promote sustainable urbanization	Infrastructure systems are of vital importance for cities and play a key role in defining their future development.
The Paris Agreement	A commitment to reduce greenhouse gas emissions for the purpose of keeping global average temperatures to well below 2°C above pre-industrial levels and pursue efforts to limit to 1.5°C	Infrastructure systems, including energy and transportation systems, are major contributors to greenhouse gas emissions.
The Sendai Framework for Disaster Risk Reduction	A commitment to prevent new and substantially reduce existing disaster risks, as defined by seven global targets and four specific action priorities	Infrastructure systems form a central theme within the Sendai Framework, including explicitly in one global target.

These agreements have been collectively established to address many of the greatest challenges of the 21st century. To name a selection, these challenges include: persistent poverty, climate change, demographic change, rapid urbanization, resource depletion and increasing threat of natural disasters. By their very nature, these challenges are highly interconnected and influence one another. This is represented within and between the agreements themselves, with similar and synergistic goals, established to enable a collective vision for a future which balances social, environmental and economic development and prosperity. These challenges affect all people, everywhere – as demonstrated by the inherently global nature of the agreements. Whilst the Millennium Development Goals dealt primarily with the needs of developing countries, the SDGs imply responsibilities and needs for action in all countries.

With ranging contexts worldwide, implementation of these agreements will however be undertaken primarily through actions at national and sub-national scales.

Infrastructure and development

By providing and supporting essential services, networked infrastructure systems, such as energy, transportation, water, waste management and digital communications form the backbone of modern society. As well as providing for people in their homes, the services from these infrastructure systems support other non-networked infrastructure systems that are critical for the functioning of society. Non-networked systems are comprised mainly of a single asset type, a building or a facility, which supports the delivery of a service. These include hospitals, schools, industrial facilities, community centres and government buildings. However, no infrastructure system exists in isolation. Interdependencies between the assets, institutions and knowledge that make up an infrastructure system mean that infrastructure must be considered as a system of interacting systems: a 'system-of-systems'.[8]

Recent analysis has shown that infrastructure systems have the ability to profoundly influence sustainable development.[7] Figure 1 provides a summary of these influences across all targets of the SDGs for both networked and non-networked infrastructure. On the left side of the figure, networked infrastructure is shown to influence 72 % of 169 targets across all SDGs. This includes all targets for SDG 3: Good health and wellbeing, SDG 6: Clean water and sanitation, SDG 7: Affordable and clean energy, SDG 9: Industry, innovation and infrastructure, and SDG 11: Sustainable cities and communities. This broad array of influences emerges due to the vital role networked infrastructure plays in delivering essential services to communities, working as the life-support to many of societies functions. On the right of the figure, non-networked infrastructure is shown to influence 81% of all SDG targets. Like its networked counterpart, this includes all targets of SDG 3: Good health and wellbeing and SDG 9: Industry, innovation and infrastructure. In addition, non-networked infrastructure influences all targets of SDG 4: Quality education and SDG 16: Peace and justice. The magnitude of influence exemplifies the importance of this type of infrastructure for the achievement of specific SDGs.

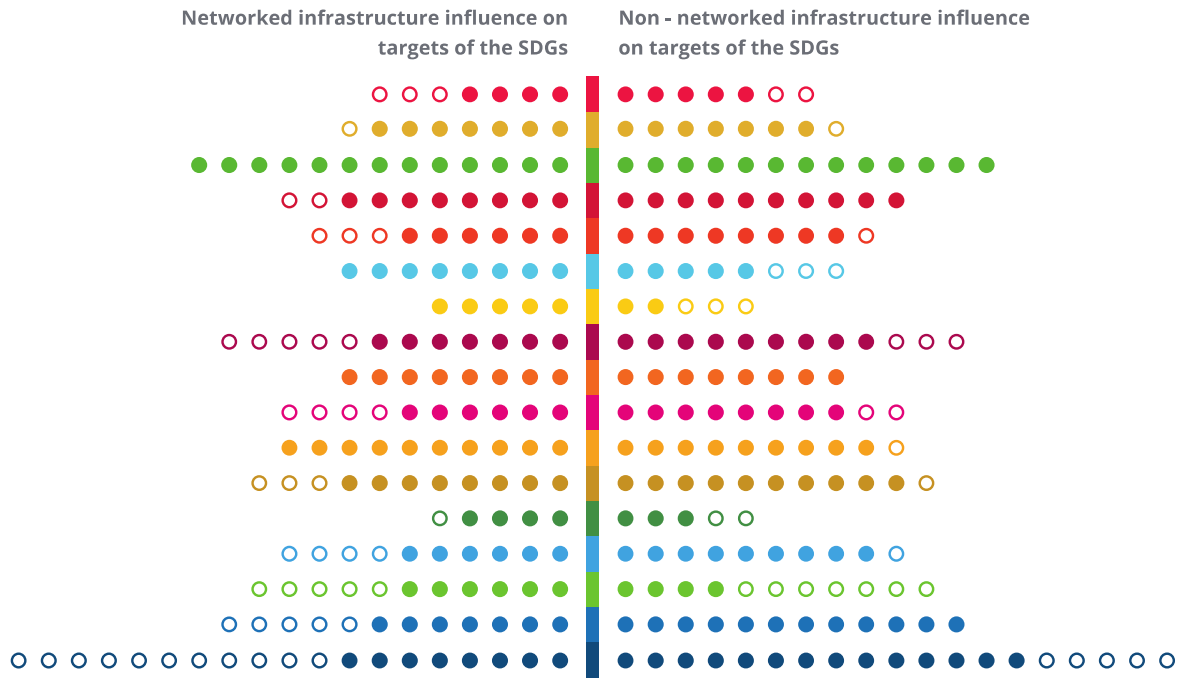

Figure 1: *Summary of the influence of networked and non-networked infrastructure across all SDGs. Circles represent the individual targets of each SDG. Circles are coloured when they can be influenced by at least one type of infrastructure. ©UNOPS/ITRC/University of Oxford.*

Infrastructure influences the SDGs in many different ways, including for example: energy and water systems which support essential services including the ability to produce nutritious food and support healthy, productive and enriched lives; waste management systems, through the effective collection and treatment of solid waste, helping manage our environmental footprint and combat diseases that can debilitate communities; and transportation and digital communications systems which are essential for enabling access to resources, markets, education, work, culture and participation in governmental decision making.

Infrastructure systems can also be harmful to society and the environment, both in their construction and as a result of their use. With current levels of global urbanization (54%) expected to increase to 66% by 2050,[9] one area in which these negative impacts are increasingly being felt is in cities. Examples of where negative impacts can be observed include in housing, traffic, pollution, flooding, employment, inequalities and health. The New Urban Agenda has been developed to address these and other challenges and has infrastructure at its core. In doing so, increased communication and partnerships between the multiple organizations, agencies and communities that occupy cities will be required. This includes within infrastructure systems, requiring consideration of the complex interdependencies between sectors and recognising that the performance of an infrastructure system is determined by the assets, institutions and knowledge of which they are composed.[10]

One of the largest challenges of our time relates to our changing climate and associated negative impacts. In line with global trends, over half of the UK's greenhouse gas emissions originate from infrastructure systems (transportation 26%, energy supply 25% and waste management 4%),[11] making them major drivers of climate change. Meeting the commitments set out in the Paris Agreement will therefore require significant infrastructure-related action over the coming decades,[12] including through implementing portfolios of progressive policies and investments. These will incorporate demand management strategies and new technologies such as low-cost renewables and efficient energy storage.[13]

One consequence of our changing climate is the increased severity and likelihood of extreme natural hazards.[14] Whilst the nature of natural hazards is changing, so is the nature of the built environment, leading to new risks to society and the economy. The increasingly networked and interconnected properties of our infrastructure systems are creating new vulnerabilities by allowing failures to cascade across vast distances and have broader impacts.[15] The Sendai Framework establishes priorities to better understand and manage risks and to build systemic resilience. Amongst other actions, this will require utilising new data and tools, from satellites and crowd-sourcing, to establish disaster preparedness and effective rapid hazard warning and response systems.[16]

Infrastructure systems form a key determinant to future development. With an estimated $97 trillion of investment in infrastructure that is required globally by 2040,[1] there exists a massive opportunity to achieve meaningful progress. However, there is also a risk that poorly planned or implemented infrastructure systems will result in negative development outcomes. The long life-spans and high-costs of infrastructure mean that the wrong infrastructure policy and investment choices can lock-in unsustainable practices for decades in to the future.[17] With so much at stake, timely action is required to ensure that the right infrastructure choices are made, averting mistakes of the past and harnessing the opportunity presented of infrastructure for sustainable development.

Engineers for sustainable development

Through their role in planning, designing, building, operating, governing, maintaining and decommissioning infrastructure, engineers are at the front line of delivering the sustainable development agenda. Figure 2 provides a framework for realising this agenda, including the vital role that engineers will play. The framework consists of: (i) internationally agreed development goals; (ii) integrated planning of infrastructure which is driven by a shared development vision – to meet the development goals; (iii) coordinated implementation of the infrastructure plans – across the lifespans of infrastructure; and (iv) the engineering capacity, knowledge and skills that will be necessary across all aspects of the framework, to ensure its success.

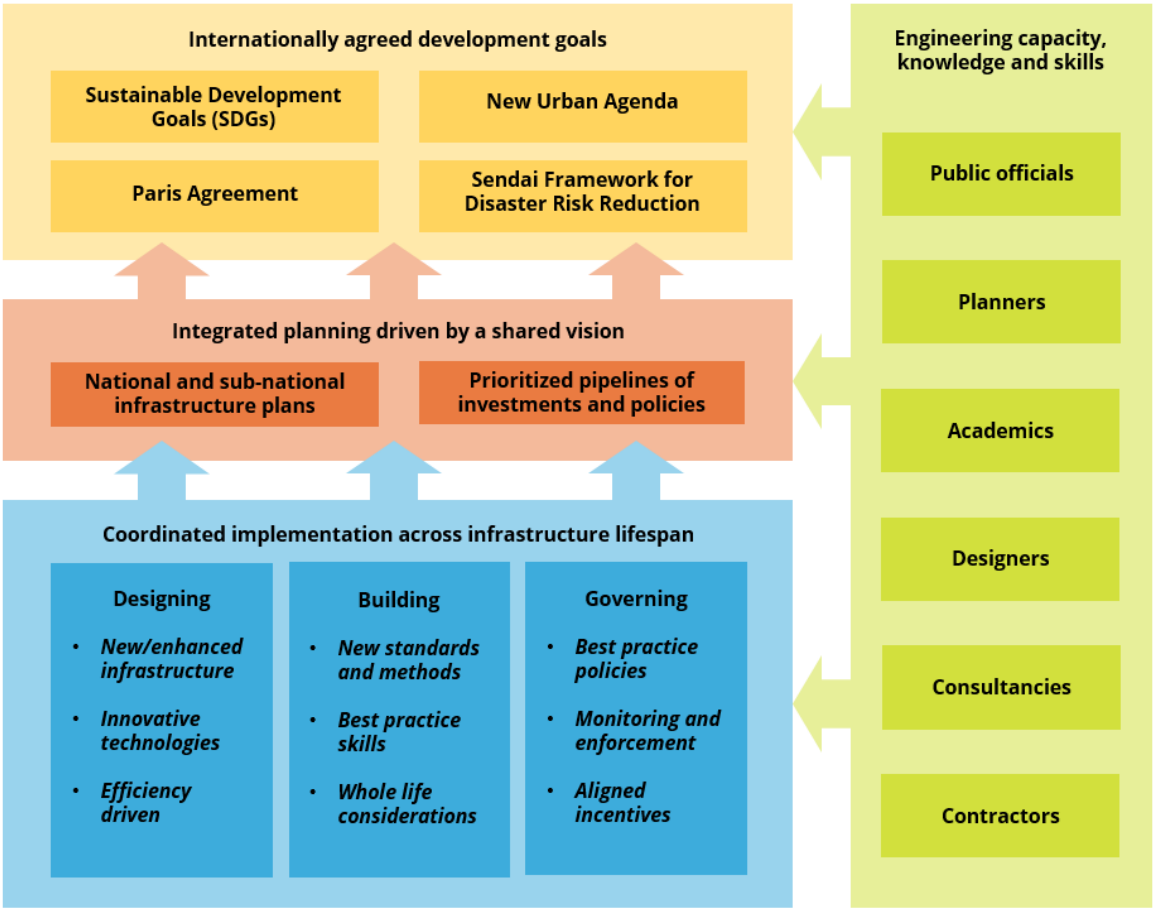

***Figure 2**: Framework for implementing infrastructure for sustainable development. ©UNOPS/ITRC/University of Oxford.*

The everyday choices and actions of engineers have the ability to address societies' grand challenges and ensure we leave a world in which future generations can prosper. Delivering this agenda will require coordinated action by individuals and organizations, across local, national and global scales. It will require capacities, knowledge and skills to be developed and grown, as well as leadership and communication, beyond traditional silos. Despite the magnitude and complexity of this challenge, the engineering community is well placed to lead on the solution, helping to ensure a sustainable future for all.

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Further details

UNOPS and the Infrastructure Transitions Research Consortium (ITRC) are committed to supporting partners across the globe to achieve their development goals through practical infrastructure solutions, which are underpinned by the best available evidence.

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