THE CONTRIBUTION OF MEGA INFRASTRUCTURE PROJECTS TO SUSTAINABLE DEVELOPMENT

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Abstract
Infrastructure projects are undeniably crucial in the global economy as one of the primary drivers of sustainable development. Energy projects, drinking water supply, waste recycling, mass transportation projects, and, of course, telecommunications are all examples of major infrastructure projects that provide essential services to society. When large infrastructure projects, on the other hand, are not designed and built with the goal of sustainability in mind, they cannot be sought in society, the environment, or the economy, increasing the risks of natural disasters and the creation of large economic debts and social inequalities.

Globally, infrastructures are critical to the planet's future, and as such, they must be designed and built with sustainability in mind in order to protect future generations and create conditions for sustainable development. Therefore, infrastructure resilience and green design are critical components of global sustainable development.

Sustainable infrastructure must be designed and managed in such a way that adverse decisions are minimised while positive decisions are maximised. Closing the infrastructure gap between Sub-Saharan Africa and the world's top performers could result in a 2.6% annual GDP per capita increase.

The infrastructure built in the coming years will determine whether or not we meet the Paris climate goals. As the risks to communities and their environments increase, resilient infrastructure will be critical in supporting energy and water systems and ensuring that communities can survive and recover from shocks more quickly. In this way, infrastructure becomes more than just a conduit for essential services and a safeguard for long-term development.

Key words: *Mega Infrastructure Project, Sustainable Infrastructure, Green Infrastructure, Smart infrastructure, Infrastructure Management, Resilience, Sustainable development, Pillars of sustainable development.*

Introduction

Mega infrastructure projects are critical to Sustainable development. It offers essential services that keep society and economies running smoothly, ranging from road construction and bridges to power plants and water and sewage networks. As a result, mega infrastructure projects are essential in attempts to meet Sustainable Development. From universal healthcare and education to electricity, safe drinking water, and hygiene, the majority of sustainable development goals need states to upgrade their technological infrastructure.

Infrastructure is vital to the **economy**, the **environment** and society, representing the **three fundamental pillars of Sustainable Development** (Figures 1, 2). And now, as the world works toward lofty goals such as the Sustainable Development Goals, as outlined in the 2030 World Agenda (UN, 2015b) and the Paris Climate Agreement (UN, 2015a) , infrastructure is increasingly being acknowledged as a critical engine of sustainable development. In order to achieve the completeness of three aspects of sustainable

development, mega Infrastructure projects should not be viewed as standalone infrastructural investment, such as power stations, hospitals, or water supply infrastructure, but rather as a component in a network of crucial assets that cooperatively have a high potential for success.

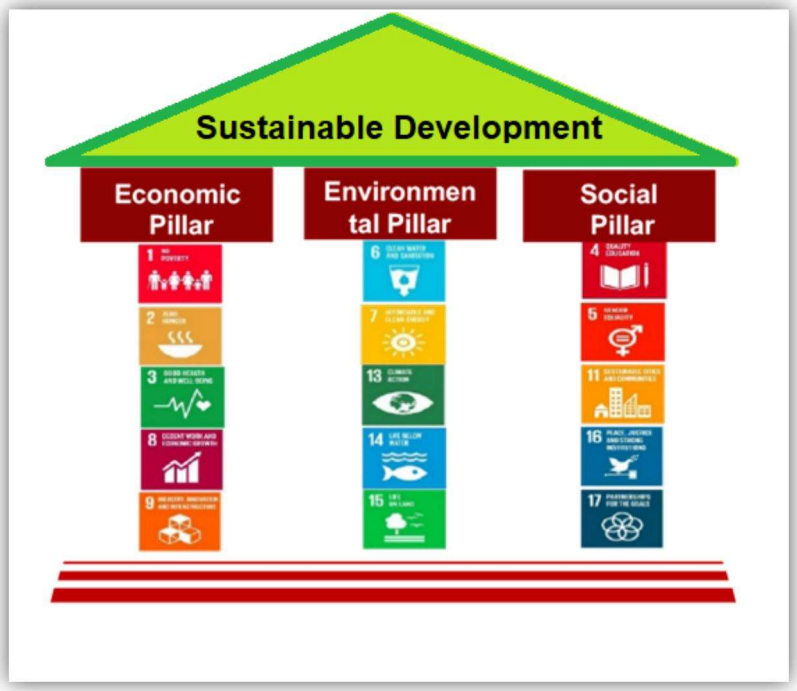

Figure 1: Fundamental Pillars of Sustainable Development

In **economic** terms, mega infrastructure projects' returns vary from the employment produced during creation and maintenance to the infrastructure's ability to stimulate business growth. Transportation and telecommunications infrastructure that connect communities to cities, education, and jobs help achieve national economic objectives. As a result, it is predicted that the effect could be more significant in larger countries that are already experiencing infrastructural deficiencies (McKinsey Global Institute, 2016).

Infrastructure assets are critical in **environmental protection** because they help conserve natural resources while also lessening the effects of climate change. Renewable tech facilities, for instance, are crucial throughout the quest to reduce the energy mix's reliance on fossil fuels. In addition, because they remove automobiles from the road, public transportation systems help reduce pollution and the production of greenhouse gases. Estimates indicate that switching from driving to public transportation for a single 20-mile commute each day would reduce one's overall carbon footprint by around 2,4 tons per year in the United States, according to experts (C2ES, 2021).

When fair access to infrastructure is ensured, **society** benefits because it provides the services, and infrastructure promotes gender equality worldwide through the development of mass transit, which allows women in remote areas to engage in the labour force. Moreover, infrastructures related to clean drinking water and hygiene reduce the mortality of infants. Jim Hall, professor of climate and environmental risk at the University of Oxford, believes in critically examining requirements when conceptualising projects (The Economist Intelligence Unit, 2019). It should be evaluated who needs what from infrastructure and who benefits from it. The equity dimensions of infrastructure should play a vital role in considering the new reality of mega infrastructure projects.

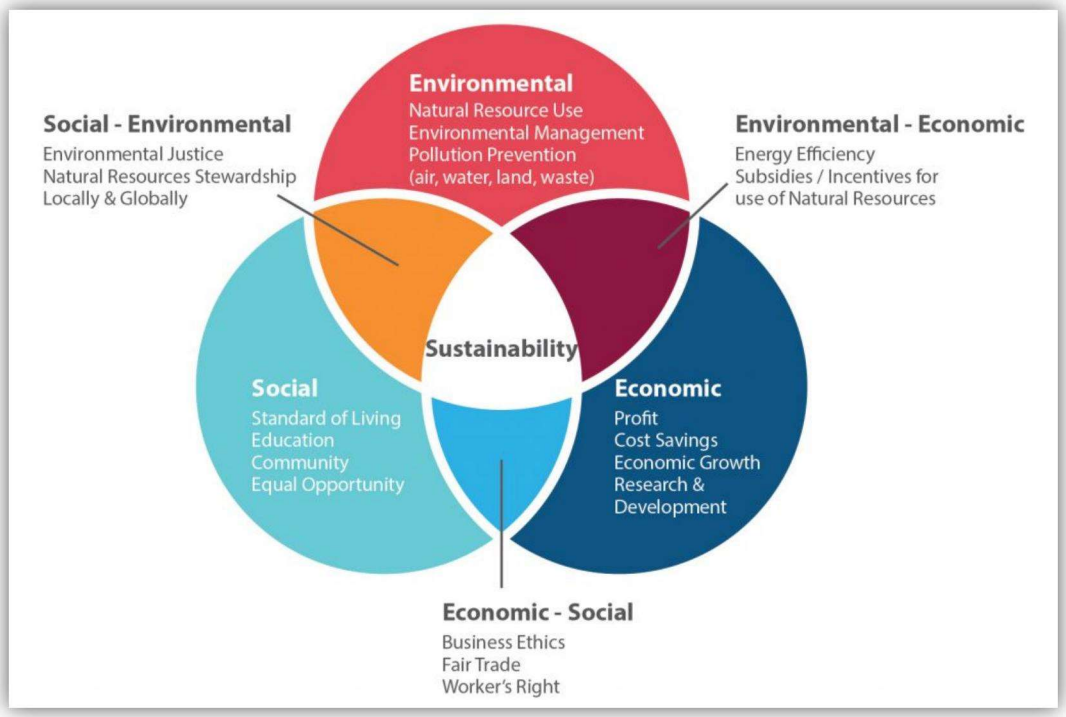

Figure 2: Interaction between Fundamental Pillars of Sustainable Development

One of the most critical infrastructure functions is increasing **resilience** and connecting the three key pillars of sustainable development. First, infrastructures must withstand the stresses and pressures they will encounter. Minimising the infrastructure's susceptibility to catastrophic disasters and disruptions contributes to sustainable growth and general social strength. However, people care about services (The Economist Intelligence Unit, 2019). Therefore, infrastructure projects should be examed through the lens of delivering services to the general population. That is the ultimate aim, and the hope is that we will achieve it in a robust and long-term manner in all three pillars of sustainable development the economy, environment, and society. While infrastructure's economic, environmental, and social benefits are substantial, governments have significant obstacles in meeting the fast-increasing demand for infrastructure due to governance and financial deficits.

Additionally, the problems of compartmentalised methods, both within governmental authorities and within fields and sections of the infrastructure's environment, are added to this. Therefore, it is necessary to be examined overall. At the same time, the three aspects of sustainable growth are the economy, environment, and society, and only then the sustainable infrastructure aim can be achieved. Additionally, infrastructure services must be robust and equally accessible. In addition, all parties involved in the process should work together to plan, create, deliver, and manage the project. To sum it up, infrastructure should not be considered a goal in and of itself but rather a tool for providing critical services to the general public. Instead of focusing on what infrastructure is, we should consider what it does, such as protecting, connecting, or providing essential services. People's demands can only be met with limited funds, and the infrastructures are brokering our capacity to address those resources and deliver them to those requirements (The Economist Intelligence Unit, 2019).

The challenges

Whether we go to the office or to shops or how we get our electricity, infrastructures impact every facet of human existence. Mega infrastructure assets have the ability to change the surrounding ecosystems for the better or, the worse. Large scale infrastructure demand is increasing fast as the world's population grows, urbanisation continues to speed up, and expanding working classes in developing nations expect more services. However, with the rising oceans and more severe storms, critical infrastructures and the essential services they offer are directly affected by global warming, making the long-term strategy more challenging due to uncertainty.

The solution rests in rethinking how sustainable infrastructure is developed. Investing in sustainable infrastructure is essential to restoring development, reaching the Sustainable Development Goals, and reducing climate risk in line with the 2030 Agenda (The New Climate Economy, 2016). Undoubtedly, the Paris Agreement, the 2030 Agenda for Sustainable Development which incorporates the United Nations' Sustainable Development Goals (SDGs), the New Urban Agenda, and the Sendai Framework (UN 2015c) for disaster risk reduction, all call for investments in climate-resilient infrastructure that supports sustainable development moreover, resilient infrastructure is addressed explicitly in the Sustainable Development Goals, including SDG 9. Furthermore, every one of the aims is based on the required infrastructures. Therefore, the achievement of the SDGs relies heavily on the availability of adequate infrastructures.

Moreover, building the proper infrastructure is a great way to help the environment accomplish climate change targets. Still, we should be ensured that sustainable infrastructures also help eliminate inequality in society, which is crucial in our ties to succeed in sustainability demands (The Economist Intelligence Unit, 2019). Building the proper infrastructures, reducing inequality, and helping to accomplish climate targets are just some of the ways that we can contribute to a better world. SDG 10's goal of eliminating inequality necessitates the fulfilment of many other SDGs. According to the World Bank (World Bank, 2016), SDG 6 requires investments in infrastructures of at least US$114 billion a year to increase the sustainability and appropriate safe and affordable drinking water. At least US$52 billion per year is required by the SDG 7 target by 2030, ensuring access to affordable, reliable, sustainable, and modern energy for all. However, only half of this amount is expected to come from planned investments (UNDP-Goal 7, 2021). In addition, the infrastructure helps achieve SDG 5's goals by assisting in ending all forms of discrimination against all women and girls everywhere. Furthermore, this is achieved by increasing participation in women's employability in the infrastructure industry.

To summarise the above, we understand that Sustainable Infrastructure is the new term in Sustainable development tools. Moreover, in attempting to define this term, we can state that while infrastructure initiatives may benefit long-term growth, they may also have unintended consequences. More than 60% of the world's greenhouse gas emissions come from infrastructure (World Economic Forum, 2016). Infrastructure projects on a large scale, such as dams and railroads, have the potential to uproot and displace entire towns and villages. Additionally, sustainable infrastructure must be carefully designed to minimise negative consequences while maximising positive ones. Infrastructure projects should benefit the economy, society, and environment in the long - term.

BOX 1 Term - Sustainable Infrastructure
Sustainable infrastructure is defined as the design, construction, and operation that does not compromise the fundamental three pillars of sustainable development: the society, the economy, and the environment necessary to preserve human fairness, diversity, and ecological environment functioning (CRC Research, 2022).

Contributing to economic growth

Providing economic benefits Infrastructure investments will be critical to achieving the SDGs. Infrastructure facilitates growth by creating employment and stimulating the economy. Additionally, it provides the services that enable individuals to be economically productive, such as transportation. For example, the transportation sector plays a critical role in linking populations to places of employment (The Economist Intelligence Unit, 2019). Furthermore, infrastructure investments reduce economic losses caused by issues such as power outages or traffic congestion. According to the World Bank, narrowing the infrastructure gap between Sub-Saharan Africa and the world's best performers could boost GDP per capita by 2.6 percent each year (World Bank, 2017).

Furthermore, around 63 million full-time jobs in areas such as tourism, retail, agriculture, and manufacturing are dependent on the quality, safety, and reliability of transportation infrastructure in the United States (TRIP, 2018). Additionally, McKinsey Global Institute data indicates that boosting infrastructure investment by 1% of GDP might result in significant additional job opportunities globally (McKinsey Global Institute, 2013). Infrastructures' failure also serves as a helpful metric of their financial value. For instance, in 2013, when storms wrecked the Dawlish Sea wall in southwest England, the wall's repairs cost £35 million, but the loss of a vital transit link to the southwest of England was predicted to cost the UK economy £1.2 billion (Resilience Shift, 2018). Additionally, infrastructure may be made more economically productive. According to the McKinsey Global Institute, enhancing infrastructure productivity can result in a 40% reduction in spending requirements. It recommends several steps, including portfolio optimisation to prevent investing in initiatives that do not satisfy demands or provide sufficient benefits, process streamlining, and applying measures to improve the effectiveness of current assets (McKinsey Global Institute, 2013).

Environment and Infrastructures

Infrastructure has numerous environmental benefits, ranging from renewable energy to transportation networks. As mentioned in the introduction, in the United States, it is estimated that switching from driving to public transit by someone commuting 20 miles per day would reduce their carbon footprint by 2,3 tons per year (C2ES, 2021). By reducing global GHG emissions and pollution, preserving ecological integrity, and improving renewable energy supplies' effectiveness, sustainable infrastructure projects can contribute to the fight against global warming and natural disasters. The mega infrastructure projects constructed over the next few years will define our future, regardless of whether we fulfil the Paris climate goals. It is a threat and a tremendous opportunity for governments to accelerate their transition to climate-resilient infrastructure (The Economist Intelligence Unit, 2019).

Moreover, transportation is a means of reducing fossil fuel consumption. The transportation sector must be extensively electrified, and this is critical whether we bank on electric automobiles or invest in urban mass transit. Significant environmental advantages will be made possible by technology. For example, smart metres enable energy utilities to manage consumption patterns by creating price incentives to use electricity outside of peak hours, reducing their reliance on more polluting "peaker plants" that supplement supply during peak

demand periods and are typically powered by fossil fuels (Longe M. et al. 2015). Mixing natural environment infrastructures into the existing ‘'grey" infrastructures network, such as trees, plants, and forests, may help to enhance air quality and reduce carbon emissions. Mangroves, for example (Wikipedia contributors, 2022), may guard against flooding and reduce soil erosion. In addition, building green roofs in urban areas acts like giant absorbers, soaking up rainwater before harming the underground water table.

Moreover, aiding with flooding prevention and, at the same time, helps urban areas to reduce the temperature. It is a common phenomenon wherein in cities the temperature is concentrated and multiplied by the "grey" infrastructures, during the summertime and acting additionally the over warming of the planet. For instance, a computer study determined that covering half of the available surface area in downtown Toronto with green roofs would chill the city by up to 2 degrees Celsius in some locations (Pompeii II W., 2010). However, efforts to boost investment in green infrastructure should not trump efforts to preserve the sustainability of existing infrastructure. This involves mitigating emissions associated with the construction and operation of infrastructure (The Economist Intelligence Unit, 2019). International Energy Agency estimates that buildings use 36% of world energy and produce 40% of all carbon emissions linked to energy use and consumption. Even though many governments are establishing regulations to reduce the negative environmental effect of structures, existing infrastructure must be controlled as well. For example, in the advanced economies, just one out of every hundred houses are rebuilt each year (Economist, 2019). If we focus exclusively on green infrastructure, we overlook the amount spent on "grey" infrastructure and the possibility of stifling development patterns that may or may not be sustainable (The Economist Intelligence Unit, 2019).

Providing the foundation for social growth

The basis for advancement in society is only via the development of green sustainable infrastructures. Governments and the private sector can deliver services that benefit both individuals and the economy while raising living standards and boosting people's poise. Among the numerous SDGs calling for universal access to essential services like healthcare, education, housing, clean drinking water, and hygiene, ensuring that everyone has an equal opportunity to benefit from these necessities is a top priority. Regarding gender equality, infrastructure plays a critical role in protecting and advancing women. For instance, public transportation networks enable women to enter the workforce and, when appropriately constructed, assure their safety and security and equal access to opportunities and services. Sanitation infrastructures are also critical for guaranteeing fair participation in economic and educational possibilities. A well-functioning sanitary infrastructure is also necessary for equal access to socio-economic benefits. Women and girls are often forced to stay at home or give up their education or jobs.

Furthermore, suppose sufficient and secure hygiene facilities are not available in schools or workplaces during women's menstrual times. In that case, at least 500 million women and girls worldwide do not have access to good feminine hygiene services (World Bank, 2018). Women and girls may be harmed as a result of this. The drinking water quality and sanitation have an impact on infant death rates. Girls usually do not receive an education because they must gather clean water. Gender has a definite influence on how the services mentioned above are delivered. Infrastructures are instruments that help people move up the social ladder. For example, adding solar electricity to Sudanese and Tanzanian schools increased primary and secondary school completion rates from less than 50 percent to almost 100 percent (World Bank, 2018). We may argue that the social influence of infrastructure is becoming more prominent. If we are planning to build a wind farm, we should think about it through the eyes

of the community to ensure that the advantages are shared. That is the way things will be in the future. The protection of the environment will always be necessary, but the social effect becomes the next battleground (The Economist Intelligence Unit, 2019).

The significance of resilience

In a natural disaster, such as a strong storm, the economy is protected by a resilient infrastructure that minimises industrial downtime. Similarly, when vital services like electricity and water are maintained during a crisis, it provides more stability to communities and lessens the impact on their economic wellbeing. For example, bridges in the Caribbean are destroyed during severe tropical storms; therefore, strengthening the most important ones would help keep the flow of traffic moving and reduce the amount of damage. In addition, governments save money and consume less environmental capital if they have to restore or renovate their critical infrastructures less regularly. Thus, if these critical bridges had been strengthened, they could have remained a safe corridor, resulting in less suffering for citizens and consequently for society and the economy (The Economist Intelligence Unit, 2019).

Additionally, using natural green infrastructures to mitigate the consequences of climate change-related floods and severe storms aids communities in adapting to the climate crisis. Examples vary from urban street landscaping, parkland, and green roofs to ponds and mangrove forests that safeguard coastline populations from tropical storms and rising seas. Japan is well-known for its capacity to construct a robust infrastructure capable of withstanding severe earthquakes. This involves the development of new energy infrastructure in several urban areas and communities based on microgrids groups of linked and dispersed power sources that operate as a singular, controlled entity and regional energy sources. The country's National Resilience Programme, launched in the aftermath of the 2011 earthquake and tsunami, fosters such innovations (power-technology.com, 2018).

Furthermore, resilient infrastructure encompasses all systems that sustain civilisation, such as electricity, transportation, and water and their interconnections. Thus, while considering the concept of essential infrastructure, it is crucial if its failure has a severe negative impact on human welfare and economic growth. However, due to the complicated of current infrastructures and the strains on infrastructure systems due to growing demand, ageing, and/or environmental degradation, failure is a possibility. As a result, infrastructure must be robust, or it will have a devastating impact on people's lives and wellbeing (power-technology.com, 2018).

Increasing demand

Providing essential services will become more difficult as the world's population grows. Furthermore, as the world's population grows, metropolitan infrastructure is under increasing strain. Between now and 2030, infrastructure investment of up to US$3.2trn-US$3.7trn per year is required, according to one estimate (World Bank, 2015). Infrastructure investment shortfalls are already a problem in many emerging and developing nations, costing a total of US$452 billion between 2014 and 2021, with the actual expenditure of US$259 billion dwarfed by needs of US$711 billion. By 2040, the G20-backed Global Infrastructure (GI) Hub forecasts that infrastructure investments of US$94 trillion would be required. According to GI Hub, Asia accounted for nearly half of these investment demands. China will have the highest demand throughout this time, with US$28 trillion covering 30% of globally infrastructure spending demands. However, several of the gaps seem to be intimidating. Consider the infrastructure for safe drinking water and hygiene. According to the World

Health Organization, 844 million people were without access to even essential drinking water in 2015, and an estimated two billion people drank water tainted with waste (WHO, 2018).

Meanwhile, if present expenditure trends continue, the United States - where an estimated US$3.8 trillion in infrastructure investment is required (Infrastructure Outlook, 2021) - is projected to have the world's most significant spending deficit by 2040, according to the GI Hub (Global Infrastructure Hub, 2017). This exacts a high price on Americans, with one estimate placing the cost of poor road infrastructure at US$599 per year on the average motorist, or US$130 billion nationally in repair costs, accelerated vehicle deterioration and depreciation, increased maintenance and increased fuel consumption (TRIP, 2018). In addition, climate change's increased hazards and vulnerabilities will also raise the demand to update infrastructure and repair or replace assets destroyed by extreme weather. For example, Hurricane Sandy in 2012 caused tens of billions of dollars in damage to New York and New Jersey's infrastructure, necessitating the formation of the Hurricane Sandy Rebuilding Task Force (Hurricane Sandy Rebuilding Strategy, 2013).

Financing and resource limitations

In light of the rapidity with which countries must construct infrastructures, many of them find it challenging to get the required funding. Due to constrained public sector budgets, governments will be forced to tap trillions of dollars in global capital markets, particularly in emerging countries. Nonetheless, the numerous risks associated with infrastructure investments dissuade international investment, ranging from complicated approvals and missed deadlines to the long period it takes for infrastructure to create an income stream and deliver a financial return. Infrastructure accounts for less than 5% of the more than US$120 trillion in assets managed by banks and institutional investors worldwide (World Economic Forum, 2016). Additionally, it is frequently challenging to create a business model for assets that provide a public good that generates the types of financial returns private investors seek. In some instances, leveraging private-sector investment is straightforward. For example, while power plants have a predictable revenue stream, water is more challenging to monetise.

Additionally, economies often have a deficiency in the human capital necessary to design, build, and ensure continued, resilient infrastructure at the scale necessary to fulfil demand, especially in emerging countries that have more needs for infrastructure projects. Numerous countries lack sufficient engineers, town planners, and technical personnel to address infrastructure shortfalls. Thus, capacity is measured in terms of money, but it also refers to the technical experience and personnel necessary to handle projects, financing, and procurement. Governments must be responsible for a large portion of skill development. However, around 85 percent of global infrastructure is still financed by public funds, and not nearly enough attention is paid to growing that capacity as it should be (Civil 20, 2018). In many circumstances, insufficient governance exacerbates the skills deficit, as the codes and laws necessary to guide hiring and training decisions are absent.

Future Success Direction

Developing a sustainable infrastructure is becoming more accessible thanks to the emergence of new financial instruments and the application of digitalisation. Efforts to shift away from perceiving infrastructural development as standalone investments and consider them part of a network of interconnected investments that offer vital services for people and communities are equally significant. When we speak about bridges and roads, it is wiser to discuss mobilisation connection and security so that the goods, services, and humans can move freely.

Utilising novel financial instruments

Since governmental resources may be inadequate to fund the mega infrastructure projects countries want, a few are exploring innovative methods to access global financial markets and attract greater private-sector participation in the field. For instance, governments might adopt a first loss position by using concessional climate funding from sources such as the Green Climate Fund and Climate Investment Funds, therefore minimising risk for investors. (Meltzer J., 2018). In addition, strong demand for investment opportunities that provide economic, environmental, and societal benefits and ecological, sociable and governance criteria to choose investment opportunities may potentially open up new financing sources for infrastructure projects. This increased interest is mirrored in the green bond market's modest growth over several years.

Additionally, since stakeholders, ranging from private to organisations, are often willing to invest for extended periods or receive low gains than market rates in exchange for a more significant effect, they might play a critical role in finance infrastructural sustainable development. Policymakers have the ability to pave the path for such investments. For instance, in the United States, New York established the NY Green Bank in 2014 to spur investment in the renewable energy sector. The bank has gained competence in identifying renewable energy initiatives and assessing their risk, making it easier to attract investors.

Many of these ventures involve untested business models or nascent technologies. However, some contend that increasing access to money is not the only way to ensure infrastructure sustainability, especially in developing countries. We frequently prioritise obtaining additional financing to increase our spending rather than improve our spending. Enhancing planning and procurement efficiency is more cost-effective. Countries must leverage their financing more effectively.

Additionally, governments can leverage current regulations to encourage private sector investment in sustainable infrastructure. For example, Washington, DC, has legislation requiring developers in some areas to incorporate green infrastructure (such as parks, grass roofs, and plantings) into their developments, which absorbs untreated stormwater and keeps it out of rivers and other waterways (DC Department of Energy & Environment, 2022). Infrastructure developers if sustainable infrastructure development is not achievable. May obtain stormwater management credits from other companies that have invested in environmentally friendly and energy-efficient infrastructures in areas not governed by by-laws. This case example demonstrates not just the efficacy of green infrastructure in mitigating the negative consequences of heavy storms. Additionally, it provides a unique financing structure for green system investments.

The Flow of Projects

The primary impediment to infrastructure development in several countries is a lack of suitable projects. One of the challenges with sustainable infrastructure is the absence of bankable projects, particularly in the world's poorest countries (The Economist Intelligence Unit, 2019). The issue manifests itself in a variety of ways. Governments cannot frequently build a flow of sustainable projects or a strategic collection of projects that they will design, program, and manage. So instead, governments should create an early programming plan which enables them to prioritise infrastructure projects that will most effectively assist them in achieving their development goals. The failure to achieve something like that makes it challenging to develop a flow of infrastructure projects and be attractive to new investors. To address the flow issue, the UK Infrastructure Transitions Research Consortium (ITRC), a

consortium of seven major UK universities led by the University of Oxford, is assisting US, Australian, and Dutch infrastructure planners. The ITRC has established a framework for establishing long-term infrastructure projects, which involves a modelling system and dataset called NISMOD. (National Infrastructure Systems Model), which will enable the academia, industry, and policymakers to access infrastructure datasets, simulations, and modelling results (ITRC, a, 2022). In developing countries, an identical tool, NISMOD-Int, will be available (ITRC, b, 2022).

Second, a lack of funding impairs the project development cycle -from feasibility studies to design, delivery, and operation. Toward this end, the World Bank Group launched a US$150 million worldwide infrastructure project investment fund titled InfraVentures, which aims to secure infrastructure projects finance, which came true. However, financing alone is rarely sufficient to enhance the project flow. This is something that InfraVentures considers in its work as a co-developer of the Nachtigal Hydropower project in Cameroon, which contributes to the country's objective of providing access to energy to 88 percent of the population by 2022 (World Bank, 2018). As a result, InfraVentures was compelled to add an extra cost to venture capital by spending 2,000 hours of IFC environmental specialists' work assessing the project to ensure it met their criteria and baking everything they wanted to see as an investor into the design stage. In addition, the G20's Global Infrastructure (GI) Hub has designed open access digitalised database that contains information on national infrastructure projects worldwide needed to aid countries to recruit private sector finance for their infrastructure projects. The Global Infrastructure Project Pipeline platform, established in 2016, enables shareholders to seek projects at various phases, from the first government announcement and feasibility studies to projects in the final stages of development or currently in operation. Investing in the private market is accessible by a platform that provides investors with comprehensive data on possible projects and lets them follow such projects from conception to completion. With the GI Hub, investors may more easily assess opportunities to invest in infrastructural development across various countries and regions, all of which are available for free (Global Infrastructure Hub, 2016).

Green infrastructures solutions

Green infrastructure has enormous potential for mitigating the consequences of climate change and assisting society in adapting to it by restoring wetlands and floodplains and installing grass roofs, rain gardens, parks, and street plantings in cities (The Economist Intelligence Unit, 2019). Compared to traditional grey infrastructure, green infrastructure can frequently reduce the cost of infrastructure development. For instance, research conducted on the cost savings associated with Lancaster's green infrastructure investments in south-central Pennsylvania in the United States discovered that the green infrastructure plan would save the city an estimated US$120 million over the next 25 years when compared to grey infrastructure (Environmental Defence Fund, 2017). Environmental and natural infrastructures can also be used with regular grey infrastructures. In southwestern Pennsylvania, for example, regular rainfall and ageing sewer infrastructure degrade streams and pose health risks. Rather than investing in the costly expansion of the underground pipes and tanks that transport wastewater to sewage treatment facilities, it is utilising green infrastructure approaches to manage stormwater where it falls, ranging from permeable paving to bioswales (vegetation and layers of gravel and soil that slow stormwater movement and filter pollutants) (Washburn M, 2015). In New York, a plan called BIG U developed by the Bjarke Ingels Group in the aftermath of Hurricane Sandy aims to protect the city from flooding by designing and building a series of embankments, floodwalls, and a park that will not only defend the island from flood events but also provide new parkland for citizens

(Rebuild By Design, 2019). In San Francisco, the Public Utilities Commission will deploy both green (ecological management technologies that lessen rainwater effects and beautify community areas) and "grey" infrastructure when it improves its sewage system over the next twenty years (For safety, resilience, and compliance with regulations, modifications to pipelines and treatment plants).

Smart infrastructures

New infrastructures will benefit from the use of sensors, databases, and Artificial Intelligence (AI) to develop sustainable infrastructure projects. These technologies will help with infrastructure projects planning, management quality, and ecological impact reduction. The efficiency, quickness, and precision of decision-making are improved due to intelligent infrastructure, which integrates physical and digital infrastructure. Before commencing construction, it is possible to examine many design options using 3D modelling and BIM software. Architects and Engineers can now visualise projects early on to simulate their vulnerability to environmental stress and quantify their ecological effects thanks to advancements in virtual and augmented reality, simulation software and BIM (The Economist Intelligence Unit, 2019). Infrastructure projects can be programmed, designed and simulated in detail with artificially intelligent software and BMI years earlier before being constructed. Their performance and behaviour can be monitored after they are in use. We can learn more about how the users interact with those infrastructures by using intelligent monitoring data tools. When these new tools are combined, they are potent for improving infrastructure efficiency, value for money, and ecological responsibility. Existing infrastructures may be made more environmentally sustainable while at the same time seeing a reduction in maintenance costs thanks to technological advancements. Singapore's WaterWiSe system aims to achieve this by using an intelligent system of analyses of the city's piping system, combined with hardware and software. A wide range of parameters, including pressure, flow rate, pH, turbidity, and organic contaminants, are monitored using sensors. As a result of the water distribution network, it is easier to plan for future maintenance and extension (National Research Foundation, 2022).

Public investments in infrastructure become more attractive thanks to technological solutions that maximise the value of essential assets. It is estimated that AI infrastructures cost more than £4.8trillion worldwide, according to the University of Cambridge's Centre for Smart Infrastructure and Construction (Bowers K et al., 2022). However, if we want to develop an intelligent, sustainable infrastructure, we do not have to rely only on cutting-edge technology. In specific scenarios, a little innovation may save much money. For example, the increasing urbanisation of Curitiba, Brazil, required the development of a metro network, as had been initially planned. However, the city innovated the construction of BRT systems, where buses travel across specialised lines not exploited by other transportation, eliminating the costly investment of developing an underground metro network (The Guardian, 2015).

Infrastructures management

Rising environmental instability, rising demand, and tighter budgetary constraints need a more elastic, adaptable strategy for infrastructural development than previously observed. Consequently, humans are paying more attention to how various infrastructures interact to form infrastructure systems. Urban areas are seeing much improvement in doing this. More sceptical authorities work among these lines and encourage their organisations to bridge the gaps (The Economist Intelligence Unit, 2019). It is crucial to take a multi-faceted approach to infrastructure planning when using a systems perspective. For instance, if communities site

waste-management factories near cement industries, they may be utilised as crematoriums with astonishingly high temps. Rail lines may be run using fibre optic cables. With sensing devices and motion sensors, Lampposts can monitor and regulate traffic and pollution while also reducing power consumption by only lighting up when a car or walker comes. This network framework needs robust mechanisms, the demolition of watertight compartments and the detachment of strategy from guiding policies. This includes implementing long-term plans such as the Investing in Canada infrastructure plan, which aims to spur long-term economic growth, establish a low-carbon, green economy, and create strong societies (Infrastructure Canada, 2022). Others have created distinct infrastructure agencies that operate independently of political cycles. In Australia, the Department of Infrastructure, Regional Development, and Cities is the most recent incarnation of such a dedicated department (founded in 2017).

Additionally, the United Kingdom established an independent National Infrastructure Commission in 2015 (UK government, 2015). That would be a good idea if we could begin to reproduce that thinking in some places. Infrastructure requires resource allocation and judgments about what to build in people's backyards and hence cannot be depoliticised. However, these are more technocratic groups responsible for thinking long term. For instance, to act as a link between different political administrations so that initiatives do not come to a halt if a government changes. Another benefit of developing an effective multi-sectoral strategic programme procedure and a lengthy government plan is that it boosts investor trust, allows alternative revenue smoother to come by, and is able to strengthen a project flow of feasible and financially sustainable developments.

Infrastructure for the future

Taking a systems perspective on infrastructure can help ensure the long-term viability of both the infrastructure and society as a whole. An aspect of sustainable development is tied to the idea of a limiting number of resources on a single planet. On the other hand, resiliency is an important consideration. As we have learned more about the interconnectedness of the planet and ourselves during the last years, we have grown to appreciate how complicated and intertwined we all are (The Economist Intelligence Unit, 2019). Critical infrastructure must be able to operate and deliver crucial benefits to citizens, regardless of what occurs in the future.

Furthermore, infrastructure assets must be "future-proofed" since they may exist for decades. This may be accomplished by predicting fluctuations in climate, user behaviour, and demand increases throughout the course of their lifecycles and by including flexibility and the ability for generation capacity through the future. In order to reduce the coastal risk of flooding in the Thames River throughout the next hundred years, London's Thames Estuary 2100 agenda is a model of design development that applies a resilience framework to present threats and climatological adaption. Every year, there are set milestones and evaluations and an overall goal to improve not just one single flooding shield but the whole infrastructure network over the next era (Resilience Shift, 2018). This strategy, which focuses on resilience inside and across different types of essential infrastructure, is not widely accepted. It is vital to consider about not just how to provide services or even how to avoid collapse. To imagine failure is amongst the most fundamental transformations in the mindset. Resiliency engineering aims to ensure that assets can keep operating in the face of a wide range of adverse conditions. It combines creating for every day and then imagining the impossible.

Conclusions

When considered separately, sustainable infrastructure assets play a critical role in delivering essential services to the community, enhancing their wellbeing, and reducing environmental impact. The development of new infrastructure projects is one method of achieving some of this. Smart metres, for example, may improve present networks' efficiency without requiring new projects to be disruptive and resource intensive. As a method of achieving those infrastructures are sustainable, it is necessary to see it as a system rather than a collection of individual assets. For example, cities with well-developed public transportation networks enhance social flexibility and fairness, making it easy for users for individuals to travel to school, work, and access healthcare facilities. In addition to reducing emissions, transitioning from fossil power production to renewables decreases pollution levels, which improves public health. An infrastructures network strategy may bring cost savings or prevent wasteful expenditures, such as installing motorways to borderlines with nations for which there are no trade agreements or micro-grid solutions in rural regions where citizens can't even buy energy. Curitiba's BRT system is an example of how smart investments in public transportation may avoid the need to develop more highways. By looking at infrastructures as a network of interconnected assets, we can do more to strengthen the system's ability to withstand shocks and disruptions. Some examples include the development of green and grey infrastructure projects such as parks that not only help to keep the air clean and stormwater contained but also offer public facilities that enhance the overall quality of life, where the construction of parks for recreational purposes is encouraged by stormwater retention measures. To be honest with us need to admit that the urgency of establishing resilient and sustainable infrastructure cannot be overstated. Even if humanity succeeds in its climate objectives, changing climate will continue to impact life on the entire planet. Resilient infrastructure is becoming more urgent as the threats to communities and our environment become more severe. This kind of infrastructures projects will be essential for protecting vital water and electricity systems and ensuring that our communities and our urban areas recover more swiftly from disasters.

BOX 2 Conclusion – Mega Infrastructure Projects for the Planet survival
The mega infrastructure projects are more than just another service delivery mechanism in the sustainable development arena; it is a critical component that will help us survive and thrive in the future on an ever-dwindling planet that has been unable to maintain itself without our help.

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