UNIVERSITY OF CAMBRIDGE
INSTITUTE FOR SUSTAINABILITY LEADERSHIP

Sustainable Infrastructure: An Overview

Placing infrastructure in the context of sustainable development

The University of Cambridge Institute for Sustainability Leadership

The University of Cambridge Institute for Sustainability Leadership (CISL) is a globally influential Institute developing leadership and solutions for a sustainable economy. We believe the economy can be 'rewired', through focused collaboration between business, government and finance institutions, to deliver positive outcomes for people and environment. For over three decades we have built the leadership capacity and capabilities of individuals and organisations, and created industry-leading collaborations, to catalyse change and accelerate the path to a sustainable economy. Our interdisciplinary research engagement builds the evidence base for practical action.

Authors

Srinivas Yanamandra[1]

[1] New Development Bank (NDB), China

Citing this report

Yanamandra, S., (2020) *Sustainable Infrastructure: An Overview Placing infrastructure in the context of sustainable development*. University of Cambridge Institute for Sustainability Leadership.

Acknowledgements

This paper is the first in a series of working papers emerging from Dr Srinivas Yanamandra's visiting fellowship at the University of Cambridge Institute for Sustainable Leadership (CISL) with a specific focus on the questions around sustainable finance for sustainable infrastructure projects in developing countries. The author would like to thank the Cambridge Institute for Sustainability leadership (CISL) Sustainable Finance Team, particularly Jake Reynolds and Nina Seega for their comments on the final draft.

Table of Contents

Introduction

This paper focuses on the definitional aspects of sustainable infrastructure. It considers the position of sustainable infrastructure in the overall development debate along with the various definitions of sustainability currently in use and then develops a clear definition of "sustainable infrastructure" that is aligned with the United Nations Sustainable Development Goals (SDGs).

Economic development is traditionally associated with political, institutional, social and cultural aspects of societal change. Political and institutional systems can either facilitate or impede the drivers of economic development. Social issues, such as equality and equitability – including gender equality, economic equality and health equality, are all central to the development discussion. Cultural issues assume relevance, especially where cultural practices are seen as a barrier to social or economic development or human rights.

The academic discipline of large-scale development until recently, however, placed high-level political and social systems at the forefront of the development discussion, with an expectation that economic development would emerge 'naturally' as a result of political stability and social development. Comprehensive focus on grass-root economic development is often studied only with reference to specific (small) localities and groups (e.g. cocoa growers or co-operatives in a given country context) or is interlinked with specific issues such as gender equality (e.g. microfinance schemes aimed at women in Uganda). Consequently, many of the international development initiatives tend to have a rather narrow focus towards transportation, water and sanitation (including access to clean drinking water and toilet facilities), and, increasingly, access to clean energy.

The UN SDGs and the Paris Agreement, however, have enlivened a new and ambitious development agenda globally, since 2015. This agenda seeks to accelerate and intensify actions and investments aimed at eradicating "poverty and hunger everywhere; combating inequalities within and among countries; building peaceful, just and inclusive societies; protecting human rights and promoting gender equality and the empowerment of women and girls; and ensuring the lasting protection of the planet and its natural resources" (UN 2016b p1). Taken together, these actions promise to create conditions for sustainable, inclusive, economic growth with shared affluence and respectful work for all.

This comprehensive agenda has shifted the focus of the discussion from economic development to sustainable development. In this context, the term 'sustainable' refers to social, economic and environmental issues. This creates an expectation that development will not only need to take into account the immediate economic well-being of communities, but should also ensure that it remains environmentally and socially sustainable – e.g. powered by energy from renewable sources and without destroying natural habitats, and carried out in a fair manner that does not increase social inequalities.

This sustainability dimension is also applied to large-scale infrastructure projects, which play a significantly greater role in development bank strategies for poverty reduction and economic development than they do in the traditional development studies approach. The New Climate Economy Report (NCE, 2016) presents sustainable infrastructure as the only way to build cities with better air quality and connectivity, ecosystems that are robust and resilient, and energy systems that can curb climate change. Sustainable infrastructure is further being considered not only as an enabler of sound economic development, but also as a tool to enhance the quality of life for citizens, which can "help protect vital natural resources and environment, and promote a more effective and efficient use of financial resources" (Montgomery, p1 2015). The reasons for such emerging emphasis can be traced to the financial and economic benefits of sustainable infrastructure that can result from reduction in material usage through improved design, focus on pollution prevention with reduction in carbon emissions, improved pricing of environmental services, and better labour and community relations (Montgomery, 2015).

This paper looks to define the concept of sustainable infrastructure as a foundation for further research on the role of financial regulation and policy in promoting such infrastructure. The paper begins with analysis of the current understanding of the term "sustainable infrastructure. Subsequently, a definition is proposed, linked to the UN SDGs. The following sections of the paper dig deeper into this definition to describe various types of sustainable infrastructure terminology and their specific characteristics.

Sustainable Infrastructure: analysis of the current understanding

The term "sustainable infrastructure" is defined by various stakeholders as a set of objectives, principles and criteria applicable to infrastructure projects for enhancing their utility in promoting sustainable development. For instance, the World Bank Sustainable Infrastructure Action Plan 2009–11 (World Bank, 2008) outlines the role of sustainable infrastructure as a) enhancing access in developing countries to the core infrastructure sectors: transport, energy, water, and information and communication technologies (ICT) for development; b) maximizing the effectiveness of infrastructure "through a focused approach to complex cross-sectoral issues (such as the role of infrastructure in climate change mitigation and adaptation efforts, the role of public private partnerships (PPPs) in the provision of infrastructure services, and new ways to provide infrastructure support for rural-urban integration and development)"; and c) focusing on both social and environmental objectives as well as economic and financial aspects and ensuring affordability with good governance (World Bank, 2008 p v) .

According to the Asian Development Bank (ADB, 2009), the basic principles underlying sustainable infrastructure include "*a) promoting low-carbon development and minimizing impacts on local environments (e.g., renewable energy); b) advancing solutions that help communities deal with the unavoidable impacts of climate change (e.g., climate-resilience infrastructure); c) improving the access of poor people to education, health, and basic social protections, as well as to markets and productive assets; d) emphasizing gender equality and the empowerment of women; and f) improving the transparency and efficiency of public resource management (e.g., controlling wasteful public spending and corruption)*" (ADB 2009 p5).

The NCE Report (2016) defines sustainable infrastructure using three criteria: *social, economic and environmental*. Infrastructure is considered *socially sustainable* when it is inclusive – "it serves all, not just a select few – and contributes to enhanced livelihoods and social wellbeing". Infrastructure becomes *economically sustainable* when it does not "burden governments with unpayable debt or impose painfully high costs on users but helps create jobs and boost Gross Domestic Product (GDP), and may include opportunities to build capacity among local suppliers and developers and strengthen livelihoods". According to the report, infrastructure is *environmentally sustainable* when it limits pollution at all stages of a project's life cycle and conserves natural resources (NCE 2016 p22).

The Inter-American Development Bank (IDB) definition of sustainable infrastructure includes *"infrastructure projects that are planned, designed, constructed, operated, and decommissioned in a manner to ensure economic and financial, social, environmental (including climate resilience), and institutional sustainability over the entire life cycle of the project"* (IDB 2018 p13). In order to operationalise infrastructure sustainability, IDB further translates this definition into practical and measurable criteria across the four dimensions: economic and financial, social, environmental and institutional. These criteria are expected to be made applicable "to all project components including elements such as access roads, transmission lines, raw material extraction areas that are necessary for delivering the project" (IDB 2018 p 13).

Based on the review of the above definitions, it can be concluded that sustainable infrastructure is generally approached from social, economic and environmental perspectives – often described as the "triple bottom-line" (Hammer & Pivo, 2016). The key issues and perspectives in defining the sustainable infrastructure are therefore outlined in the next section.

Defining sustainable infrastructure

Following on from the above analysis, this paper aims to define sustainable infrastructure, in terms of UN SDGs and triple bottom-line criteria, as an ***"infrastructure project which is (a) designed to achieve one or more sustainable development goals in the long run, (b) developed with clear social, economic and environmental objectives and commissioned with institutional mechanisms to manage or mitigate the adverse impacts of the project by monitoring the triple-bottom line criteria all through the course of the project life-cycle, and (c) financially sustainable in that it is financed through a robust structure that achieves affordability for consumers without overburdening the Government with long term debt***"

Based on the definition it can be summarised that, while categorizing a project as a sustainable infrastructure project, it is important to outline the following three dimensions:

1. Commitment to achievement of one or more of the UN SDGs at the project design stage;
2. Assessment and monitoring against clear social, environmental, and economic objectives through a triple bottom-line approach;
3. Consideration of financial sustainability and affordability.

The following paragraphs provide key perspectives of sustainable infrastructure emerging from this definition:

Sustainable infrastructure projects are infrastructure projects designed with a view to contributing to one or more SDGs. Infrastructure projects could be considered as sustainable if they are assessed, at their design stage, as contributing to SDGs. They could, for instance, have a positive influence on one or more of the following clusters of SDGs drawn from the United Nations 2030 Agenda for Sustainable Development:

1. SDGs focusing on environmental objectives or protecting the ***planet*** from the adverse effects of climate change. From this perspective, sustainable infrastructure projects include:

a) Climate mitigation infrastructure projects

b) Climate resilient infrastructure projects

2. SDGs focusing on social objectives or promoting the access of ***people*** to better social and economic conditions. From this perspective, sustainable infrastructure projects include:

a) Sustainable transport projects

b) Green infrastructure projects

3. SDGs focusing on promoting societal ***prosperity*** through social governance mechanisms. From this perspective, sustainable infrastructure projects include infrastructure projects that promote:

a) Gender equality and non-discrimination

b) Mechanisms for reduction of income inequalities

c) Peace, justice and stability

Assessment and monitoring against clear social, environmental, and economic objectives through a triple bottom-line approach. Projects should be assessed at inception against social, environmental and economic objectives. Subsequently, institutional mechanisms are needed to ensure achievement of these triple bottom-line criteria at all stages of the project implementation and operation. It is important to prevent cost and schedule overruns which can damage the projects ability to achieve its goals. Such institutional mechanisms vary from project to project depending on the technology, size and location. For instance, in the case of a solar power project, this can include elements such as maintaining quality control standards for protecting the environment, transparent procurement standards for purchasing solar panels, and anti-corruption controls at tariff collection stage. In this context, triple bottom line criteria could be further outlined from a broader context, as follows:

1. *Economic dimension of infrastructure includes economic sustainability as well as ongoing financial sustainability.* Viewed from a broad perspective, sustainable infrastructure not only deals with monetary and financial resources, as well as economic costs and benefits, positively by helping create jobs, promoting access to markets, and contributing to GDP, but can act negatively by diverting vital resources from other projects or sectors (NCE, 2016; Bhattacharya et al, 2016). Infrastructure is therefore considered “economically sustainable if it generates a positive net

economic return, considering all benefits and costs over the project life cycle, including positive and negative externalities and spillovers" (IDB, 2018 p11). Economic sustainability is usually assessed using a framework of cost-benefit analysis that encompasses quantitative metrics to establish whether the present value of benefits of a given project exceeds the present value of costs. Such analysis is usually framed as both a net present value (NPV) calculation and an economic rate of return (ERR) calculation (World Bank, 2010). To be sustainable, the project must have a positive economic NPV and an ERR greater than the minimum rate identified by the government as the hurdle for infrastructure projects to go ahead.

2. *Social dimension of infrastructure includes both "hard" and "soft" infrastructure components.* "Hard infrastructure" refers to the physical assets that promote development of social services, such as schools, hospitals, and community centres. On the other hand, "soft infrastructure" deals with increasing community access to mechanisms for pursuing social rights, and promoting transparency and governance in public services for orderly functioning of the economy in the long run (Danchev 2015). Sustainable infrastructure, from a social perspective, should be able to embrace both "hard" and "soft" infrastructure investments. Social obligations for infrastructure projects should also contribute to local development and mitigate any adverse social impacts caused by the project, such as land acquisition, relocation or changes to resource access (Smyth et al 2015).

3. *The environmental dimension of infrastructure not only deals with environmental protection but also enhances the role of infrastructure in societal transformation.* A simple "do no harm" approach to minimizing the negative environmental externalities of an infrastructure project or providing an environmental offset is not sufficient to ensure that it is sustainable (Vazquez et al 2017). Environmental sustainability needs to extend the role of infrastructure further as a tool for adaptation and resilience to climate change and extreme weather events, where possible, by leveraging natural resources and eco-systems in a sustainable manner.

Consideration of financial sustainability and affordability. Some projects are justified on economic, rather than financial, grounds. It is vital that such projects are assessed to ensure that they result in sustainable, affordable infrastructure for consumers without overburdening the government with debt (NCE, 2016). Many infrastructure projects, such as electricity generation or mass transit projects, do have the potential to be financed either entirely by the private sector or by a combination of public and private sources. Such infrastructure projects can attract wider financing options, if they generate an adequate financial risk-adjusted rate of return for project investors. Sustainable Infrastructure projects must therefore generate a sound revenue stream, based on adequate cost recovery and be supported, where necessary, by well-targeted subsidies (to address affordability) or availability payments (when users cannot be identified or where there are large spill over effects) (IDB, 2018).

With increased financial sophistication and availability of innovative financial instruments, infrastructure projects could be made financially sustainable at the design stage. For instance, metro-rail projects are usually capital-intensive and governments may not be able to recover these investment costs if they purely rely upon passenger fares as operational cash flows. It is therefore financially unsustainable if governments end up heavily in debt for building metro-rail projects - and endeavour to pass on these costs to customers in terms of unaffordable train fares. However, through carefully designed schemes, governments can generate a more sustainable financial package in the long-run by creating and sharing higher land values, driven by improved connectivity, with project developers. The project developer can then include in the financial calculation, not only revenues from higher ridership, but also from new retail shops, parking garages, leisure facilities and residential buildings around the station. The "rail-plus-property model" adopted for the financing of the Hong Kong Metro Rail project represents a case in point in this context (Ollivier and Wei, 2015). Similarly, electronic vehicles aimed at reduction of carbon emissions may not be commercially successful projects without public policy support (such as through tax incentives, interest subsidies for debt financing) in the initial years to promote its wider adoption. Financial sustainability of innovation in such contexts should consider scenarios of project outcomes, both with and without policy support, to enable governments to understand the value of support mechanisms.

Sustainable infrastructure is described by a range of terms with overlapping intentions. Subsequent sections of the paper deal with the definition of sustainable infrastructure at the design stage, analysing various common terms, such as, climate mitigation infrastructure, climate resilient infrastructure, sustainable transport infrastructure, green infrastructure and social infrastructure.

At this juncture, the reader is however reminded about a key limitation of the paper. While the focus on SDGs is the first step in approaching the concept of sustainable infrastructure at the design stage, the paper acknowledges that achievement and implementation frameworks across SDGs are still part of an evolutionary framework. As SDGs depend upon each other, in order to make coherent policies and strategies, policymakers need a rubric for thinking systematically about how the goals and interventions of one sector interact with another. There are discussions in SDG literature on the ways to identify and test development pathways that minimise negative interactions and enhance positive ones (see for instance Nilsson et al 2016). Discussion of these mechanisms is kept outside the scope of the paper, but it is acknowledged that it would be important for infrastructure planners to understand the possible unintended consequences of focusing solely on any one SDG without considering the impact of the project on other SDGs.

Climate Mitigation Infrastructure

What is climate mitigation infrastructure?

The Joint Report on Multilateral Development Banks' Climate Finance (2016) identifies the climate mitigation infrastructure project as one which "*promotes efforts to reduce, limit or sequester greenhouse gas (GHG) emissions to reduce the risk of climate change*" (Joint Report, 2016 p 6). These include a range of projects that show emission reductions and are consistent with a pathway towards low greenhouse gas emissions development.

How can climate mitigation infrastructure contribute to sustainable development?

Classification of climate mitigation projects as sustainable infrastructure projects stems from their contribution to the SDGs relating to climate action (SDG-13), life below water (SDG-14) and life on land (SDG-15). A brief description of these goals, the relevance of infrastructure projects to promote these goals, and further context of sustainable infrastructure is provided below:

SDG-13: Climate Action

Take urgent action to combat climate change and its impacts

SDG-14: Life Below Water

Conserve and sustainably use the oceans, seas and marine resources

SDG-15: Life On Land

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss

Climate change is now disrupting national economies and affecting lives, costing people, communities and countries dearly. The impact of climate change is being felt in the form of changing weather patterns, rising sea levels, and more extreme weather events. Climate change has becoming more pronounced in recent times, whilst human activities such as the GHG emissions continue to rise to their highest levels in history. Climate action, therefore, becomes imperative to manage the impact of climate change, especially for the poorest and most vulnerable people, as the world's average surface temperature is projected to surpass 3 degrees celsius by the end of this century (Meltzer, 2016, Christiansen et al, 2018, Lagos & Wirth 2009).

Reviewing the implications of climate change on life underwater is also relevant in this context because the world's oceans (their temperature, chemistry, currents and life) drive global systems that make the Earth habitable for humankind. Oceans "absorb about 30 percent of the carbon dioxide produced by humans" and the world is currently "seeing a 26 percent rise in ocean acidification since the beginning of the industrial revolution" (UNDP 2015). Marine pollution, an overwhelming majority of which comes from land-based sources, is reaching alarming levels, with an average of 13,000 pieces of plastic litter to be found on every square kilometer of ocean (UNDESA 2017). Similarly, flourishing life on land has been damaged over the last few years through deforestation, loss of natural habitats and land degradation. Promoting a sustainable use of ecosystems and preserving biodiversity is therefore not a goal, but a key to the survival of human life.

SDG-13 on climate action, therefore, focuses on stakeholder contributions to decarbonizing processes through investments in energy efficiency projects, reducing the carbon footprint of products/services/processes, and setting ambitious emissions reductions targets in line with climate science, as well as scaling up investment in the development of innovative low-carbon products and services. Similarly, **SDG-14** aims to sustainably manage and protect marine and coastal ecosystems from pollution, as well as address the impacts of ocean acidification. **SDG-15** focuses specifically on managing forests sustainably, restoring degraded lands and successfully combating desertification, reducing degraded natural habitats and ending biodiversity loss.

In addition to the SDG goals, in order to address climate change, countries adopted the Paris Agreement at the COP21 in Paris on 12 December 2015 (Meltzer, 2016). "In the agreement, all countries agreed to work to limit global temperature rise to well below 2 degrees Celsius, and given the grave risks, to strive for 1.5 degrees Celsius. Implementation of the Paris Agreement is essential for the achievement of the SDGs, and provides a roadmap for climate actions that will reduce emissions and build climate resilience" (UN 2019). The world has to reduce GHG emissions, not to zero, but to a point where there is a balance between emissions and sequestration, referred to as "net zero" (Levin et al 2015). Through Nationally Determined Contributions (NDCs) drawn up under the framework of the Paris Agreement, developed countries should adopt economy-wide absolute emission reduction targets immediately and developing countries should aim for this over time.

Climate mitigation infrastructure projects promote this component of SDGs and, hence, can be classified as sustainable infrastructure projects for the purpose of this paper if implemented in a financially, economically, socially and environmentally sustainable manner.

What are the examples of climate mitigation infrastructure?

As per the Joint Report (2016), climate mitigation infrastructure projects include both green-field and brown-field projects. Green-field projects (investments into entirely new infrastructure projects) are included when they enable prevention of a long-term lock into high-carbon infrastructure. Brown-field projects (investments in upgrading existing infrastructure projects) are considered as climate mitigation projects when "old technologies are replaced well before the end of their lifetime with new technologies that are substantially more efficient" in terms of carbon emissions (Joint Report 2016 p29).

Climate mitigation infrastructure projects often appear to be concentrated around renewable energy. This is because the cost of reducing GHG emissions in the electricity sector appears to be lower than in other sectors. However, there are projects outside the electricity sector that could constitute climate mitigation infrastructure considering their contribution towards low carbon emission pathways. Examples of all categories of climate mitigation infrastructure are provided below (Joint Report 2016):

- *Energy infrastructure projects* assist climate mitigation by phasing out fossil fuels usage in energy generation and promoting efficiency in distribution. These include: a) energy generation infrastructure projects using nuclear power and renewable energy sources such as biomass, hydropower, wind power, solar power, geo-thermal power, ocean energy, as well as the use of carbon sinks and carbon capture and storage; and b) energy distribution infrastructure projects such as retrofitted transmission lines or substations and/or distribution systems to reduce energy use and/or technical losses including improving grid stability/reliability. Box 1 provides an illustrative case-in-focus of a renewable energy infrastructure project.

- *Infrastructure projects aimed at promoting energy efficiency* include buildings with climate mitigation design elements such as: a) passive solar building design through use of insulation, double - or triple-glazed gas-filled windows, external window shades, and building orientation and siting; b) low-energy building or zero-energy building techniques; and c) buildings deploying renewable heat sources (such as shallow geothermal and passive solar energy) and high-efficiency appliances (particularly boilers).

- *Sustainable urban transport projects* that promote mass urban transit (such as metro rail/bus rapid transit projects), better road infrastructure, manufacturing technologies leading to increased fuel economy in automobiles (such as electric cars and their battery charging infrastructure) and digital technologies leading to lifestyle changes in an urban mobility context (such as cycling instead of driving) - thereby contributing to reduced carbon emissions in the transportation sector.

- *Sustainable urban development projects* with efficient land use development practices having a visible impact in terms of decreased Vehicle Miles Travelled (VMT). These projects help to reduce infrastructure costs as well as the amount of energy needed for transportation, community services, and buildings - thereby contributing to reduced carbon emissions in urban development contexts.

- *Carbon sequestering projects,* that aim at increasing carbon stocks*, such as:*

- *Forest projects* for capturing the carbon stored in forest areas such as living trees above ground and roots below ground; in dead matter including standing dead trees, woody debris and litter;

- *Agricultural projects* that improve existing carbon pools (such as range-land management, reduced tillage techniques that increase carbon contents of soil); and

- *Other projects* for carbon capture and storage technology that prevent the release of large quantities of CO_2 into the atmosphere from fossil fuel use in power generation.

- *Other agricultural projects* that aim to reduce non-CO_2 GHG emissions through specialised practices and technologies (for example, improving paddy rice production, reduction in fertilizer use);

Box: 1

Case in focus

Shanghai Lingang Hongbo New Energy Development Co. Ltd.

A 100 MW roof-top solar photovoltaic power project currently being set up in the Shanghai Lingang Industrial Area (SLIA), an industrial development zone in the Shanghai municipal area.

The Project has one of the largest installed capacities among projects with such a design in China. It is expected to result in increases in operational solar power capacity by generating 110 million kWh of electricity in 2019, the first full year of operations, with the entire capacity installed. Average annual generation over 20 years is estimated at some 98.6 million kWh of electricity. The Project is funded by the BRICS New Development Bank.

Photo Credit: NDB Annual Report 2017

The Project aims at generating electricity from a renewable energy source (i.e., roof-top solar power) and is considered as a climate mitigation project for the following reasons: -

- Contributing to a decrease of ~ 73,000 tons of CO2 emissions annually;
- Facilitating the China's transition towards a low carbon economy consistent with its goals to achieve peak carbon dioxide emissions by 2030. China announced that its carbon dioxide emissions per unit of GDP will be reduced by 60 to 65 percent by 2030 from 2005 levels.
- Promoting generation of clean energy near the load center in Shanghai and thereby assisting the avoidance of current energy loss in transmission channels from Western China to Shanghai.

Source: https://www.ndb.int/

How to assess the contribution of climate mitigation infrastructure towards sustainable development?

Assessing the contribution of climate mitigation infrastructure is usually undertaken through ex ante GHG accounting according to commonly agreed methodologies. Relevant standards that are deployed in project appraisals relating to climate mitigation include the ISO 14064-1: 2018 (ISO 2018) - International Standard for GHG Emissions Inventories and Verification and GHG Protocol Corporate Accounting and Reporting Standard (covering the accounting and reporting of seven greenhouse gases covered by the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3)).

ISO 14064 specifies principles and requirements at the organisation level for quantification and reporting of greenhouse gas (GHG) emissions and removals. It includes requirements for the design, development, management, reporting and verification of an organisation's GHG inventory (ISO 2018). The GHG Protocol Corporate Accounting and Reporting Standard helps companies and other organisations to identify, calculate, and report GHG emissions (WBCSD & WRI 2004). It is designed to set the standard for accurate, complete, consistent, relevant and transparent accounting and reporting of GHG emissions by companies and organisations, including information on setting organisational and operational boundaries, tracking emissions over time, and reporting emissions. It also provides guidance on GHG accounting and reporting principles, business goals and inventory design, managing inventory quality, accounting for GHG reductions, verification of GHG emissions, and setting a GHG target.

When is climate mitigation infrastructure not classifiable as sustainable infrastructure?

Climate mitigation infrastructure is however not construed as sustainable infrastructure if it merely uses alternative energy sources but does not mitigate emissions. Some examples in this context include: a) certain hydropower plants, which have high methane emissions from reservoirs exceeding their associated renewable energy GHG reductions; b) certain geothermal power plants with high CO_2 content in the geothermal fluid that cannot be reinjected; and c) certain biofuel projects with net high emissions taking into account production, processing and transportation.

Climate resilient Infrastructure

What is climate resilient infrastructure?

Apart from climate mitigation, infrastructure projects compatible with SDG-13, SDG-14 and SDG 15 and the Paris Agreement also address climate adaptation and resilience. Climate mitigation deals with the *causes* of climate change and works to reduce manmade effects on the climate system. In contrast, climate resilience projects (or adaptation projects) prepare for and negate the *effects* of climate change, thereby reducing the vulnerability of communities and ecosystems. By adapting to cope with the effects of climate change, communities, enterprises and institutions can build up their climate resilience. Climate resilience and adaptation are therefore intrinsically linked to development (Valerio et al 2018).

How can climate resilient infrastructure contribute to sustainable development?

As outlined earlier, climate change threatens human health in ways that are numerous and profound. At the same time, it also provides both an obligation and an opportunity to reconfigure sustainable development strategies so that they meet the needs of the present generation without compromising future generations' abilities to meet their needs (United Nations General Assembly 1987 p.43). For instance, if low-income countries could adapt to the health threats from climate change by improving basic health services, it will also help those countries address challenges that have been an ongoing scourge to their economies and their people.

The two approaches to tackling climate change, mitigation and adaptation, are intricately linked - the more we can mitigate the risks of climate change through committed reduction of greenhouse gas emissions, the less we have to adapt to the ill-effects of climate change later. Three different perspectives elucidate the linkage. Firstly, adaptation would be powerless to prevent catastrophic climate change if emissions targets are not implemented – thereby making mitigation, rather than adaptation, a crucial first step in the fight against risks of climate change. Secondly, the delayed impacts of past and current green-house gas emissions mean that, even if global warming targets are achieved, adaptation measures will be necessary. Thirdly, despite substantial efforts being taken to reduce further greenhouse gas emissions, some degree of climate change is unavoidable and will lead to adverse impacts, some of which are already being felt. Given the above, climate adaptation should not be considered as an alternative to mitigation but must be viewed as an integral component of an effective strategy to address climate change, along with mitigation (IPCC 2014).

Climate resilient infrastructure facilitates the adaptation of individuals and communities to climate change in the long-run and, therefore, remains inextricably linked to sustainable development (Valerio et al 2018). Climate resilient infrastructure projects could therefore be construed as sustainable infrastructure given their contribution to SDGs (such as SDG-13, SDG-14 and SDG-15). Firstly, they promote climate resilience in existing infrastructure projects thereby becoming vital to their successful adaptation to the inevitable impacts of climate change. Secondly, climate resilient infrastructure helps build the resilience of vulnerable communities and provides protection against exposure to extreme climate events.

What are the examples of climate resilient infrastructure?

Climate resilient infrastructure projects could broadly include (Joint Report 2016):

- *Water infrastructure projects* that facilitate enhancing water supply and storage provision consistent with climate change uncertainties in the particular location and context;

- *Landscape infrastructure projects* that increase resilience/connectivity supporting community-driven landscape restoration, increasing connectivity and linking areas of ecological value across all land tenures, better understanding of the links between biodiversity and landscape resilience and improved approaches to managing threatened species. Box 2 provides an illustrative case-in-focus of a climate change project through landscape management;

- *Coastal and riverine infrastructure* (including built flood-protection infrastructure) projects that promote resilience and facilitate natural disaster risk management;

- *Supporting infrastructure* (such as information and communication technology) for building common understanding of scenario based strategies to inform climate change adaptation on critical public infrastructure assets (such as water supply and bridges).

Box: 2

Case-in focus

Republic of Moldova Project

A World Bank Project, which will help Moldovans protect their farms, forests and pastures from climate change in specific zones, and strengthen national disaster management systems.

Photo Credit: World Bank (Project Resettlement Policy Framework Document)

A World Bank study of the economics of climate change in Moldova found that the biggest challenges and investment opportunities are in agriculture. The Project is expected to help reduce the vulnerability of rural households, which represent a disproportionately high share of the poor, to the impacts of climate change and enhance the capacity of government institutions, key stakeholders, communities, and the public to manage climate change risks.

The project could be considered as a sustainable infrastructure project as it supports the Moldovan Government Action Plan for the Implementation of the Climate Change Adaptation Strategy to 2020 in the following manner:

- Enhancing the climate resilience of Moldova's forest and pasture lands through restoration of degraded lands at the community and village level, and improved climate-smart management of forest reproductive material;
- Enhancing the adoption of climate-smart practices in selected rural landscapes by supporting the scale-up of farmers' climate-smart technologies and agricultural practices;
- Strengthening Moldova's climate and disaster risk management systems and, in the event of an eligible crisis or emergency, provide immediate financing to respond quickly to any crises or emergency.

Source: https://www.worldbank.org/

How to assess the contribution of climate resilient infrastructure towards sustainable development?

As described above, climate mitigation projects contribute towards sustainable development with reduction of carbon emissions, which is measurable by established standards (ISO 2018). However, assessment of the contribution of climate adaptation / resilient projects towards sustainable development is more difficult. One approach uses a three step process (Joint Report, 2016):

- Setting out the climate change vulnerability context of the infrastructure project.
- Making an explicit statement of intent to address climate vulnerability, as part of the infrastructure project.
- Articulating a clear and direct link between the climate vulnerability context and specific infrastructure project activities.

As can be observed, a key challenge in assessing the climate adaptation / resilience projects would be to define the climate vulnerabilities that the project is going to deal with. Climate vulnerabilities are not currently amenable to standard definitions as they deal with several uncertainties. These uncertainties stem from the fact that there is less data about secondary climate variables like precipitation, wind speeds, seasonal variations and weather extremes than there is about global mean temperature.

These uncertainties can, therefore, be grouped further, into three categories: "*First,* uncertainties about the development of our future climate, which include the climate sensitivity of the earth's climate system to anthropogenic greenhouse gas emissions, the reliability of emission scenarios and underlying storylines, as well as inherent uncertainties in climate models. *Second*, uncertainties about anthropogenically induced climate impacts (e.g., long-term sea level changes, changing weather patterns, and extreme events). *Third*, uncertainties on the future socioeconomic and political development, including policies related to climate change mitigation and legislative frameworks" (Schmidt-Thomé, 2017).

While there are uncertainties, this data is required for any assessment of climate vulnerability. To address this problem, researchers use uncertainty models in decision making contexts where it is not possible to describe the full state space or assign credible probabilities to different states of the world. Usually, in situations where there is less uncertainty (for example with respect to sea level rise) a traditional cost-benefit assessment may be possible (Li et al. 2014). However, for decisions under deep uncertainty, various decision-making heuristics and tools such as the following are considered useful in the literature (Hallegatte et al. 2012; Ranger et al. 2010; Watkiss and Hunt 2016):

- *Integrated assessment models* that seek to represent in full the economic and biophysical processes associated with climate change, from economic activity to emissions, atmospheric concentration, temperature change, physical impacts and socio-economic consequences. They try to simulate not just the climate, but also how the global economy will evolve over time as a consequence of population dynamics, capital accumulation and technical progress.

- *Adaptation econometric analysis* that attempts to understand and document how economic agents respond to current climate and weather events. The analysis is carried out by identifying climate effects both cross-sectionally - comparing impacts and/or adaptation behaviours across different climate regimes - and inter-temporally - by measuring the impact of particular weather events, such as floods, over time.

- *Economy-wide simulation models,* such as computable general equilibrium models, macroeconomic models and input / output analysis, to obtain, within a consistent framework, an estimate of the combined effects of adaptation to multiple climate risks at once on the system as a whole (and not just on the section of economy).

Assessing climate adaptation / resilient infrastructure is therefore complex as it involves model-based assessment of climate vulnerability and defined project specifications to address these vulnerabilities in the long-run.

When is climate resilient infrastructure not classifiable as sustainable infrastructure?

Classification of climate resilient infrastructure should be undertaken only through careful consideration of a) existing analysis and reports, b) original, bespoke assessments of climate vulnerability such as those carried out as part of project preparation using existing analyses or reports[1] and c) original, bespoke analysis conducted using records from trusted sources which document the vulnerability of communities or ecosystems to climate change. It is therefore appropriate to keep climate resilient projects, which do not meet the scientific criteria of climate vulnerability assessment, outside the scope of sustainable infrastructure classification.

1 Citing authoritative, preferably peer-reviewed sources, such as academic journals, national communications to the UNFCCC, Nationally Determined Contributions (NDCs), reports of the Intergovernmental Panel on Climate Change, or strategic programmes for climate resilience.

Sustainable Transport Infrastructure

What is Sustainable Transport Infrastructure?

United Nations Secretary-General's High-Level Advisory Group (2015) refers to sustainable transport as the "*provision of services and infrastructure for the mobility of people and goods—advancing economic and social development to benefit today's and future generations—in a manner that is safe, affordable, accessible, efficient, and resilient, while minimizing carbon and other emissions and environmental impacts*." A valid case for sustainable transport infrastructure stems from the challenges (such as greenhouse gas emissions and intolerable traffic congestion levels) faced by the transport sector in recent times. Sustainable transport infrastructure represents the future direction of the profound transformation in the transport system in order to address these challenges.

How can sustainable transport infrastructure contribute to sustainable development?

Classification of sustainable transport projects as sustainable infrastructure stems from their contribution to all SDGs in general and in particular to good health and well-being (**SDG-3**), quality education (**SDG-4**), decent work and economic growth (**SDG-8**), and sustainable cities and communities (**SDG-11**). A brief description of these goals is provided below. The relevance of sustainable transport in the pursuit of these goals is provided in the subsequent paragraphs:

SDG-3: Good health and well-being

Ensure healthy lives and promote well-being for all, at all ages

SDG-4: Quality Education

Ensure inclusive and quality education for all and promote lifelong learning

SDG-8: Decent Work and Economic Growth

Promote inclusive and sustainable economic growth, employment and decent work for all

SDG-11 Sustainable cities and communities

Make cities inclusive, safe, resilient, and sustainable

SDG-13 Climate Action

Take urgent action to combat climate change and its impacts

Transport is fundamental to development as it assists in linking people, connecting local communities to the world, building markets, and facilitating trade. Although there is no single SDG exclusively dedicated to transport, sustainable transport can drive sustainable development goals. For instance, SDG Goals (viz., SDG-3, SDG-4, SDG-8, SDG-11 and SDG-13) focus on affordable and equitable transportation as a means to allowing people to access what they need: jobs, markets, social interaction, education, and a full range of other services and amenities contributing to healthy and fulfilled lives. Access empowers a) countries to provide food security or healthcare, b) young people to attend school, c) women with assured opportunities for employment and empowerment, d) people with disabilities and elderly people to maintain their independence and dignity, and e) passengers with personal security (United Nations 2015). Sustainable transport projects also assist SDGs in the fight against climate change and reducing air pollution.

Sustainable transport therefore qualifies as sustainable infrastructure as it transforms the current transport systems into ones that are safe, affordable, accessible, efficient, and resilient. Through this transformation, sustainable transport contributes to the achievement of the SDGs with sustainable livelihoods, safe communities and spaces, and opportunities for sustainable economic growth.

What are the examples of sustainable transport infrastructure?

Sustainable transport infrastructure projects could be classified broadly into seven categories: a) rural and urban highways, b) public transport systems (bus, train, and other shared transport mechanisms), c) non-motorised transport facilities (including bicycles and sidewalks), d) institutions that manage and operate the system, e) traffic management - including intelligent transport systems (ITS) to improve traffic performance on the road network, f) technology to improve system performance (such as electronic payment systems, electronic ticketing, and fleet management control systems for hierarchical integrated transport systems), and f) education and enforcement mechanisms for maintaining existing transport infrastructure in a sustainable manner (Ardila-Gomez & Ortegon-Sanchez 2016).

Given their potential contribution to sustainable development, certain additional transport infrastructure projects that could qualify as sustainable infrastructure are detailed below (AIIB 2018):

- *Urban mobility infrastructure projects* involving construction and extension/rehabilitation of public transport networks such as metro and tramway lines, and rapid transit bus systems; development of intelligent traffic management and information systems to improve public transport. Box 3 provides an illustrative case-in-focus of an urban mobility infrastructure project.

- *Improved transport capacity projects* that remove transport bottlenecks between major urban centres or key economic areas, such as national or provincial highways and railways.

- *Integrated transport infrastructure projects* that enhance seamless transport across different modes or within a network (such as integration of inter-city railways with the urban transport systems through integrated transport hubs, and integration of ports and airports with good road and/or rail connection to the hinterlands).

- *Infrastructure upgrade projects* with the potential additional benefit of reducing resource intake (such as land), increasing safety, reducing longer-term operating and maintenance costs, and opening up new opportunities to improve accessibility.

- *Other rail, road, aviation, and maritime / waterborne construction projects with improved safety / service standards, and environmental benefits in the long run.*

Box: 3

Case in Focus

Urumqi Urban Transport Project II

An urban transport project to improve mobility in selected transport corridors in Urumqi, the capital city of Xinjiang Uyghur Autonomous Region in northwest China.

With rapid urbanization and rising incomes, Urumqi has witnessed, during 2010-2016, a significant increase in private car ownership (with number of private cars being quadrupled from 177,700 in 2010 to 747,100 2016, or about one car for every five people). More private cars on the road has caused increasing traffic congestion and air pollution. Regular buses cannot fully meet the travel needs of residents. Buses are usually packed during peak hours. Waiting times are long, getting on board is hard, and they often get stuck in traffic. To address the problems, the Urumqi Municipal Government turned to an efficient, low pollution, cost effective and high capacity mode of public transport--the Bus Rapid Transit or BRT.

Photo Credit: World Bank Website (Project Press Release)

The project is classifiable as sustainable transport infrastructure as it achieves the following objectives: a) development of the Urumqi Comprehensive Transport Information Management System, b) construction of a public transport hub, terminals, and parking and maintenance facilities, c) improved information sharing in urban transport, and d) enhanced quality and efficiency of public transport services.

Source: www.worldbank.org

How to assess the contribution of sustainable transport infrastructure towards sustainable development?

Tools for assessing the contribution of sustainable transport towards sustainable development should take into account (apart from the social, environmental, economic and financial aspects) the following two important considerations (Ardila-Gomez & Ortegon-Sanchez 2016): a) economic distortions in the absence of such a transport system and b) the sustainable nature of transport in terms of safety, accessibility, efficiency, and resilience.

In more operational terms, the contribution of sustainable transport towards sustainable development is assessed using the **Avoid–Shift–Improve** principles (GIZ 2019), which is the most widely adopted approach to managing traffic demand in modern cities. ***"Avoid"*** actions seek to reduce the need to travel, for instance, through improved online shopping, telecommunication, and city design that emphasise reduced motorised travel. The impact of avoid actions could be ascertained through metrics such as reduction in the average number of trips per person, reduction of average length per trip. ***"Shift"*** actions seek to persuade people to move away from their personal motor vehicles to public transport and non-motorised modes, known for space economy, fuel efficiency and reduced pollution impacts. Shift actions could be measured both on the supply-side (in terms of metrics relating to enhanced convenience, attractiveness, and supply of public transportation choices) as well as on the demand side (in terms of metrics relating to number of deterrents for reducing the use and/or discouraging the ownership of personal motor vehicles, such as through fuel taxes, road user fees, congestion charges, parking charges, and/or personal vehicle license charges). "***Improve***" actions seek to reduce the negative effects of whatever motor vehicle use inevitably occurs. Measurable metrics in this regard include measures for managing the quality of existing infrastructure (potentially through improved road and intersection design facilitating smooth vehicle movement with few barriers or synchronised traffic light signalling to reduce vehicle idling at traffic intersections) and technological measures to improve fuel and vehicle efficiency.

Use of these tools would enable assessment of the contribution of the sustainable transport projects to three types of benefits in the context of sustainable development (World Bank, 2016): a) general benefits, which are received by society broadly, b) indirect benefits, which are received by people that are nonusers of the system but still perceive benefits from the improvements in accessibility and mobility, and c) increases in business opportunities associated with the development of transport projects. A holistic assessment of all these benefits would also be relevant in the context of arriving at an affordable pricing solution given the significant investments involved in sustainable transport systems.

When is transport infrastructure not classifiable as sustainable infrastructure?

The key qualifying criteria for sustainable transport as sustainable infrastructure is its contribution towards sustainable development. Therefore, any transport infrastructure that limits the effectiveness of the steps being taken for sustainable development does not ordinarily qualify as sustainable transport systems. Some such transport projects are often characterised by a) increased transportation-related carbon emissions, b) lower energy efficiency, and promotion of greater use of fossil fuels in the transportation sector, c) increased water and noise pollution and impacts on ecosystems, d) design limitations that do not take into account environmentally sustainable practices and materials, and e) disregard the access requirements for pedestrians, bicycles, people with disabilities or older adults. Such transport projects are not typically classifiable as sustainable infrastructure projects.

Green Infrastructure Projects

What is green infrastructure?

The glossary of terms used on the US Environmental Protection Agency website defines the term green infrastructure as "*an array of products, technologies, and practices that use natural systems - or engineered systems that mimic natural processes - to enhance overall environmental quality and provide utility services*". Green infrastructure is thus the integration of the natural environment and ecosystem directly into infrastructure engineering solutions, thus replacing traditional solutions. It is stated to produce a variety of environmental benefits by effectively retaining and infiltrating rainwater, and by simultaneously helping absorb air pollutants, "reducing energy demands, mitigating urban heat islands"[2], "and sequestering carbon while also providing communities with aesthetic and natural resource benefits" (USEPA 2019).

At an operational level, green infrastructure, in the "context of rural areas, provides a more flexible infrastructure-like function, such as healthy watersheds purifying water or mangroves protecting the shore from extreme storms" (Gartner and Difrancesco 2015) (see also Talberth & Hansen, 2012). In the urban context, it can translate into creation of green spaces that focus on land-use planning and practices promoting sustainability (such as green ways/roofs/walls, biodiversity-rich parks and fresh corridors to promote clean air and better sanitation). Green infrastructure thus represents a cost-effective, resilient approach to managing the natural water cycle for providing many community benefits (USEPA 2019).

[2] Urban areas generally have a lower humidity level and are often many degrees warmer than their surroundings. This phenomenon known as the *urban heat island effect*, which arises "due to the absence of vegetation and the increased absorption of energy from the sun caused by dark asphalted or concrete surfaces" (European Union, 2013 p13). The urban heat island results in the recirculation of pollutants thus making the pollution problems more serious. "Heat island coupled with heat wave conditions during summer season causes human discomfort and higher death rates" (Devi, 2016). The heat island effect thus can have serious consequences for vulnerable people, such as those who are chronically ill or the elderly, particularly during heat waves.

How can green infrastructure contribute to sustainable development?

Classification of green infrastructure projects as sustainable infrastructure stems from their contribution to the SDGs relating to clean water and sanitation (**SDG-6**), industry, innovation & infrastructure (**SDG-9**), and sustainable cities and communities (**SDG-11**). A brief description of the goal, relevance of infrastructure projects to promote these goals and further context of sustainable infrastructure is provided below:

SDG-6: Clean Water and Sanitation

Ensure access to water and sanitation for all

SDG-9: Industry, Innovation and Infrastructure

Build resilient infrastructure, promote sustainable industrialization and foster innovation

SDG-11: Sustainable Cities and Communities

Make cities inclusive, safe, resilient and sustainable

From the perspective of sustainable development, green infrastructure facilitates the pursuit of SDGs relating to environmental, economic, and human health objectives, many of which go hand-in-hand with one another, as follows:

SDG-6 for instance deals with provision of clean, accessible water for all, as it is an essential part of the world we want to live in. There is sufficient fresh water on the planet to achieve this but, due to bad economics or poor infrastructure, every year millions of people, most of them children, die from diseases associated with inadequate water supply, sanitation and hygiene. Water scarcity, poor water quality and inadequate sanitation negatively impact food security, livelihood choices and educational opportunities for poor families across the world. Drought disproportionately afflicts some of the world's poorest countries, worsening hunger and malnutrition.

Against this background, green infrastructure contributes to **SDG-6** through mechanisms such as: a) reducing storm water runoff volumes and reducing peak flows by utilizing the natural retention and absorption capabilities of vegetation and soils, b) improving the rate at which groundwater aquifers are 'recharged' or replenished using its natural infiltration capabilities, c) infiltrating runoff close to its source and help prevent pollutants from being transported to nearby surface waters, and d) limiting the frequency of sewer overflow events by reducing runoff volumes and by attenuating or rerouting storm water discharges.

SDG-9 deals with promotion of resilient infrastructure. Green infrastructure could contribute to this objective by a) enhancing storm water management capabilities in natural and constructed infrastructure in ways that reduce vulnerabilities to flooding, b) providing migration corridors that offer additional benefits to flora and fauna as well as the human communities, c) enabling energy resource management through identified opportunities for replacing energy requirements with natural interventions, and d) leveraging on natural features (such as urban forests and vegetative barriers planted near roads, parking lots, and city centres) for reducing the impact of vehicle emissions and improving local air quality.

SDG-11 deals with sustainable cities, viewing them as hubs for ideas, commerce, culture, science, productivity, social development and much more. However, many challenges exist to maintaining cities in a way that creates jobs and prosperity while not straining land and resources. Common urban challenges include congestion, pollution, lack of funds to provide basic services, a shortage of adequate housing, and deteriorating infrastructure. In this context, green infrastructure facilitates the creation of sustainable cities with opportunities for all, with access to basic services, energy, housing, transportation and more through mechanisms such as: a) providing green spaces as sources of carbon sequestration (where carbon dioxide is captured and removed from the atmosphere via photosynthesis and other natural processes), b) providing increased amounts of urban green space and vegetation to help mitigate the effects of urban heat islands, c) promoting increased use of green roofs for clean air, thereby decreasing emissions from power plants, d) contributing to improved air quality using trees and vegetation in urban landscapes, e) creating greenways, parks, urban forests, wetlands, and vegetated swales that provide increased access to recreational space and wildlife habitat, and f) creating a positive impact on human health through enhanced neighborhood greenness.

What are the examples of green infrastructure?

Green infrastructure projects help in protecting human health and safeguarding the environment. In urban areas, they have significant potential to increase resilience by keeping cities cooler in a warmer climate and limiting the impacts of flash flooding. In rural areas, green infrastructure projects with safe and sustainable water sources (such as storm water or recycled water) will further improve vegetation, health and the effectiveness of cooling. Further examples of green infrastructure projects are provided below (Klausing 2016):

- *Clean Water Projects* that approach water management in a manner that protects, restores, or mimics the natural water cycle and promotes treatment of drinking water, and thereby helps in preventing the spread of waterborne diseases, ensure proper waste treatment and improve water disposal practices to prevent degradation of ecosystems and neighborhoods. Box 4 provides an illustrative case-in-focus of a clean water project.

- *Clean Air Projects* that attempt to address the air quality problems in urban areas. These projects further include large-scale investments in developing technological capabilities and upgraded machinery capable of cleaning the air of pollutant gases and particles as they are generated.

- *Rain garden projects* that a) absorb rainwater and allow it to percolate rather than putting stress on storm water systems, b) filter contaminants, and c) remove sedimentation and debris from storm water run-off to improve water quality. Rain gardens are a natural, sustainable solution for dealing with boggy areas, flooding and the landscape damage these issues cause.

- *Eco roof projects* aimed at responding to two primary climate drivers: extreme precipitation and temperature. These include vegetated (or green) roofs, cooling (or white) roofs, and water managing (or blue) roofs. While typical black roofs, which are meant solely to provide shelter, eco roofs are for communities interested in energy savings or reducing air pollution and promoting a cooler environment.

- *Paver parking lot projects* (designed as an alternative to asphalt and traditional pavements) with permeable surfaces that absorb water run-off, reduce the stress on storm water systems, and decrease or eliminate flooding. The surfaces stay cooler and do not negatively impact the natural surroundings.

- *Urban forestry projects* that establish trees in public spaces such as parks, along streets and alleys, or in any available open areas that local governments manage (along stream rights-of-way, around public buildings, or in city-owned vacant lots). Urban forestry can extend to green-belts around cities that buffer waterways and regulate development, and even to acquisition and management of lands to preserve urban watersheds so that drinking water supply and quality is protected.

Box: 4

Case in focus

Madhya Pradesh Water Restructuring Project

A water-restructuring project to address the problems of severe water contamination in Madhya Pradesh, a provincial state in India.

Photo Credit: NDB Annual Report 2017

The project covers 9 drinking water supply schemes across ~ 3,400 villages with expected benefit to over 3 million people in rural areas. This could be classified as a sustainable infrastructure project as it:

- ensures quality of the supplied water using pipes of material with suitable technical specifications
- promotes quality control with a water testing laboratory at each water treatment plant site ensuring residual chlorine level of minimum 0.2 ppm at the consumer end;
- providing clean and safe water available thereby maximizing the potential of sanitation coverage in villages and (coupled with the rural sanitation program) enables toilet facilities at the household level.

The project further qualifies as a green infrastructure project as it:

- Reduces dependence on groundwater sources and promotes usage of surface water, thereby promoting drinking water sustainability at village and habitation level.
- Promotes community-based participatory management through increased awareness among the rural community about safe drinking water, improved citizen participation and ownership;

Source: www.ndb.int

How to assess the contribution of green infrastructure towards sustainable development?

Green infrastructure projects help to achieve sustainability and resilience goals over a range of outcomes, including tackling the problems of climate change. They promote the creation of a dynamic urban growth vision based on four principles (Shaheen et al 2016): a) mobility - getting where we want to go, b) livability - creating positive communities, c) prosperity - long-term health for the area, and d) sustainability - ensuring that today´s decisions do not compromise future generations. The green infrastructure benefits can be further divided into five categories of environmental protection which are namely land-value, quality of life, public health, hazard mitigation, and environmental regulatory compliance.

The value of green infrastructure can therefore be calculated by comparing the costs of green practices to traditional "hard" infrastructure alternatives, the value of avoided damages, or market preferences that enhance value, like property value. Various green infrastructure rating frameworks are used by financial institutions for measuring these benefits. One such prominent rating framework is the Driving force–Pressure–State–Impact–Response (DPSIR) framework (Kristensen 2004).

The DPSIR is a conceptual framework to analyse the cause–effect relationships existing between society and the environment and to support decisions in response to environmental issues. In accordance with its terminology, the DPSIR framework considers driving forces (D) (e.g. human activity) that exert pressures (P) (e.g. land-use change) on the environment, leading to changes in the state (S) (e.g. ecological processes) of the environment. In turn, these changes give rise to impacts (I) on ecological systems, human health and society that may elicit a societal response (R). Depending on the measure(s) taken, responses can be directed to any component of the DPSIR framework and control drivers, reduce pressures, improve the state and mitigate impacts (Gabrielsen and Bosch, 2003). The causal chain of the DPSIR framework functions as a tool to integrate knowledge from diverse disciplines and has been widely adopted in environmental assessments, e.g. the State of the Environment in Europe. In the US, the Environmental Protection Agency (EPA) used the framework to discuss the social, cultural, and economic aspects of environmental and human health (Yee et al., 2012).

When is green infrastructure not classifiable as sustainable infrastructure?

While green infrastructure could be considered as sustainable infrastructure, providing similar benefits with respect to the provision of clean air, clean water and lesser environmental pollution could be obtained through other human-engineered infrastructure solutions that often involve concrete and steel (such as pipes, pumps, ditches, and detention ponds engineered by people to manage storm-water) (SSSA, 2018). Popularly referred to as “grey infrastructure”, these projects often lack flexibility in adapting to uncertainties in climatic or socio-economic conditions. Grey infrastructure projects could qualify as sustainable infrastructure projects, though only if their contribution to the SDG is contextualised in clear terms or there is a justifiable technical engineering and continual maintenance/upgrade with further cost to achieve the potential benefits of green infrastructure.

Social Infrastructure

What is social infrastructure?

OECD defines social infrastructure (often referred to as social or intangible capital) as "*networks, together with shared norms, values, and understandings which facilitate cooperation*" (OECD, 2001). It is also often described as the degree of trust in a society and the ability of people to work together for common purposes (Fukayama, 1995) or as the features of social organisation, such as trust, norms and networks that can improve the efficiency of a society by facilitating coordinated actions (Putnam et al, 1993). The primary purpose of *soft social infrastructure* is therefore to provide for "personal security, establish a basis for public health, and institutionalise a quality of life equal to the expectations of those it serves" (Vazquez et al 2017). Viewed from this perspective, social infrastructure serves as the backbone for communities and societies and holds the key to unlocking economic growth and competitiveness (Aberdeen, 2018).

Social infrastructure is approached in the existing literature from two different perspectives, the *hard social infrastructure* perspective (which views social infrastructure as a physical asset) and the *soft social infrastructure* perspective (which views social infrastructure as ethos that form the core for social interactions and the overall prosperity of society) (Danchev, 2015).

What are examples of social infrastructure?

Primarily, social infrastructure projects can be classified as hard and soft infrastructure facilities:

Hard social infrastructure projects can be broadly defined as construction and maintenance of assets and facilities that accommodate / support social services and improve quality of social life. These include buildings which support social and spiritual relationships, health and well-being, education, employment and leisure.

The Australian Office of Urban Management categorises three groups of social infrastructure as follows: a) "community facilities, which refer to buildings that house a range of services, such as community centres, places of worship, hospitals and health centres," b) "community services, which refer to programmes that benefit the community, such as schools and day care facilities, library services, skills development, recreation and sporting programmes", and c) supporting physical infrastructure, "which includes urban elements that promote the well-being, lifestyles and enjoyment of the community, such as pedestrian and cycling networks and facilities, special needs facilities, sports and recreation facilities, and shopping facilities" (Teriman et al 2011 p24). Hard social infrastructure projects can be carried out at local level (such as a local park, child care centre, or primary school), at district level (such as a community health centre, secondary school, or emergency services) or at regional level (such as a hospital, convention centre, indoor sports stadium).

The 'soft' aspects of social infrastructure are primarily associated with relationships such as: a) participation in groups and networks, b) promotion of the degree of trust within networks, among strangers, and in civic institutions, and c) enhancement of the level of social inclusion, including access to opportunities. Soft social infrastructure projects also focus on 'institutional' aspects that promote effectiveness of government institutions through a) "constitutional conventions, such as the doctrine of ministerial responsibility, that represent an important check on the potential abuse of power by the executive", b) "effective legal framework establishing property rights and supporting the functioning of markets facilitates voluntary economic exchanges, thereby contributing to the development of social norms such as fair dealing and trust", and c) "enabling environment for civil society" (e.g., a well-functioning and independent judicial system and transparent government – see Box 5 for a case-in-focus in this context) "that creates the space for social bonds to be created in the non-government sector" (New Zealand Government Treasury, 2013). In turn, as Petrie (2002) notes, these mechanisms (such as an effective civil society including an active media and well-informed civil society organisations) can generate pressure for governments to function more effectively and in an accountable manner.

Box: 5

Case in focus

Russian Judicial System Support Project

Project aimed at improving the efficiency, effectiveness and transparency of the judicial system, through infrastructure and improved Information Communication Technology (ICT) systems.

The Russian Judicial System Support project is a USD 601 million project by New Development Bank to the Government of Russian Federation (GoRF). The project intends to upgrade existing conditions of the four main elements of the judiciary: a) improvement of conditions for the delivery of justice, b) upgrade to electronic case management and automated processes, c) integration of ICT across various levels and sub sectors of the judiciary, and d) institutional development and capacity building.

Photo Credit: NDB Annual Report 2017

The project could be classified as a social infrastructure project considering the important purposes served by judicial systems in up-holding social values and determining economic performance. Well-functioning judiciaries guarantee security of rights and enforcement of contracts. Security of rights strengthens incentives to save and invest by protecting returns from these activities. A good enforcement of contracts stimulates agents to enter into economic relationships, by dissuading opportunistic behaviour and reducing transaction costs. This in turn fosters domestic and foreign investment, the creation of jobs, and the reduction of poverty leading to sustainable development.

The project contributes to sustainable development through by having comprehensive structural long-term effects on development of the country and its basic institutions, which are a vital part of the country's business enabling infrastructure.

Source: http://www.ndb.int

How can social infrastructure contribute to sustainable development?

Classification of social infrastructure projects as sustainable development projects stems from their contribution to the SDGs relating to gender equality (**SDG-5**), reduced inequalities (**SDG-10**), and promotion of just, peaceful and inclusive societies.

A brief description of the goal, relevance of infrastructure projects to promote these goals and further context of sustainable infrastructure is provided below:

SDG-5: Gender equality

Achieve gender equality and empower all women and girls

SDG-10: Reduced inequalities

Reduce inequality within and among countries

SDG-16: Peace, justice and strong institutions

Promote just, peaceful and inclusive societies

Social infrastructure is provided in response to the basic needs of communities and to enhance the quality of life, equity, stability and social well-being. “Successful communities normally treasure their social infrastructure because these are places and programmes that citizens and associations collectively use to build healthy communities” (Teriman 2011 p3). Social infrastructure, thus deals with both the relationships between people and the effectiveness of institutional structures by bonding between people and communities, bridging gaps that could exist between groups; and linking across the boundaries of power (New Zealand Government Treasury, 2013). Social infrastructure also acts as the building block for the enhancement of human and social capital.

Hard social infrastructure facilities contribute to sustainable development by providing one or more of the following softer or intangible benefits: a) enabling people to be "hired, housed, healthy and happy", b) promoting social cohesion, which strengthens the economy because it makes "social disorder less likely", c) ensuring reduction in transaction costs by promoting "cooperative behaviour as well as facilitating and diffusing knowledge and innovation" - allowing society to function efficiently, and d) "boosting community resilience and regeneration in times of adversity" (New Zealand Government Treasury, 2013 p2).

Soft social infrastructure facilities contribute to SDGs in many forms. For instance, in the context of **SDG-5** (gender equality), legal and institutional infrastructure that enable women and girls with equal access to education, health care, decent work, and representation in political and economic decision-making processes will fuel sustainable economies and benefit societies and humanity at large. While the world has achieved progress towards gender equality and women's empowerment under the Millennium Development Goals (including equal access to primary education between girls and boys), women and girls continue to suffer discrimination and violence in every part of the world. Social infrastructure enables promotion of gender equality not only as a fundamental human right, but as a necessary foundation for a peaceful, prosperous and sustainable world.

Similarly, in the context of **SDG-10** (reduced inequalities), the international community has made significant strides towards lifting people out of poverty. The most vulnerable nations – the least developed countries, the landlocked developing countries and the small island developing states as defined by the UN (UNOHRLLS 2019) – continue to make inroads into poverty reduction. However, inequality still persists and large disparities remain, in regards to access to health and education services and other assets. Social infrastructure enables the reduction of inequality, by ensuring adequate infrastructure support for implementation of policies that pay attention to the needs of disadvantaged and marginalised populations.

Social infrastructure further supports **SDG-10,** dedicated to the promotion of peaceful and inclusive societies for sustainable development, the provision of access to justice for all, and building effective, accountable institutions at all levels.

How to assess the contribution of social infrastructure to sustainable development?

Social infrastructure delivers sustainable development through a range of benefits from community maintenance to economic growth. The economic benefit of social infrastructure projects can be generally assessed in terms of: a) lower transaction costs to make doing business in the region easier, b) decreased uptake of other government programs (e.g. policing, health support, special education classes), c) increased productivity (output per worker) and hard social infrastructure output (such as health and education services or facilities) in the region, d) stimulation of investment from outside to create new jobs, skills and opportunities, and e) facilitation of innovation and new ideas in the region.

Assessment of social infrastructure contribution therefore usually follows a three-step process. The first step is understanding the baseline, or what would happen in the economy if the project did not go ahead. The second is listing all the benefits from the project and seeing which ones can be measured in terms of new jobs, dollars spent, health, employment outcomes etc. and over which time frame. Finally, the third step is to compare having the social infrastructure project to not having the project - the difference is the economic benefit of the project.

When is social infrastructure not classifiable as sustainable infrastructure?

At a very basic level, it should be understood that while hard physical infrastructure (such as a school building or a prison) could constitute social infrastructure, it does not include provision of social services supplementary to the hard infrastructure, such as the provision of teachers at a school or custodial services at a prison (NZSIF, 2018).

Further, in the context of social infrastructure from a sustainable development perspective, it should be noted that most social infrastructure supports early action. It helps to build the individual and social resourcefulness that helps avoid problems in the first place and also provides the social networks, facilities and services that can help address any arising problems.

For instance, some of the reactive, rather than preventive, infrastructure designs that would limit the classification of social infrastructure facilities as sustainable infrastructure include (Slocock 2018):

- Initiatives that involve only public services, disregarding the fact that many voluntary, community and private sector organisations and services in an area, as well as buildings and facilities, can make a difference. A public health initiative, for example, will be less successful if it ignores the fact that access to healthy food is restricted by lack of shops or the presence of multiple fast food outlets.

- Economic regeneration initiatives often carried out only with buildings, facilities and the built environment in mind without focus on social norms relevant for the context. For instance, physical investment in 'slum clearance' schemes may destroy or displace communities, if people lack a say about how to improve their community. Similarly, if buildings are refurbished but the services run in them remain poorly designed, targeted or even non-existent, little will actually change. In such situations, there is a danger that areas will become gentrified and that the people who originally lived in them will simply be displaced.

- Community based approaches to bring about social change are based on the belief that if communities are strengthened and empowered, they will become more resourceful and resilient. However, if social infrastructure facilities such as community halls are built, and if meeting spaces are not welcoming and inclusive, it will be hard to build relationships, and, then cohesion will not exist. If public services are cut back in the hope that communities will substitute for them, communities will end up impoverished rather than empowered.

Conclusions

Economic development is traditionally associated with political, institutional, social and cultural aspects of societal change. However, the academic discipline of large-scale infrastructure development, until recently, placed high-level political and social systems at the forefront of the development discussion, with an expectation that economic development would emerge 'naturally' as a result of political stability and social development. Consequently, many of the international development initiatives tend to have a rather narrow focus towards transportation, water and sanitation (including access to clean drinking water and toilet facilities), and, increasingly, access to clean energy.

The United Nations Sustainable Development Goals (SDG) and the Paris Agreement, however, have put forward a new and ambitious global development agenda since 2015. This comprehensive agenda has shifted the focus of the discussion from economic development to sustainable development. In this context, the term 'sustainable' refers to social, economic and environmental issues. This creates an expectation that development will not only need to take into account immediate economic well-being of the communities, but should also ensure that it remains environmentally and socially sustainable.

The sustainability debate also focusses strongly on large-scale infrastructure projects which play a significantly greater role in recent development bank strategies for poverty reduction and economic development than they do in a more traditional development studies approach. Existing stakeholders have approached the subject of sustainable infrastructure through various principles, criteria and approaches that enable assessment of infrastructure in terms of economic, environmental and social sustainability criteria.

This paper has defined *sustainable infrastructure project* in a graduated manner taking into account the following three dimensions: a) Commitment to achievement of one or more of the SDGs at the project design stage; b) Assessment and monitoring against clear social, environmental, and economic objectives through a triple bottom line approach; c) Consideration of financial sustainability and affordability.

The paper has outlined various Sustainable Infrastructure project terms using their potential contribution to the achievement of relevant SDGs, the criteria for measuring the development impact of such projects and other additional circumstances, under which such projects may not be classifiable as sustainable infrastructure projects. The paper, thus, focused on the definitional aspects of sustainable infrastructure. Aspects relating to financial sustainability and the institutional mechanisms that are often essential components of sustainable infrastructure, such as the regulatory and policy frameworks prevalent in various countries - require further research and analysis in terms of how they impact the overall financing and execution of sustainable infrastructure projects. These aspects therefore form the scope of a further research.

Bibliography

1. Aberdeen Asset Management (2018). "*What is Social Infrastructure?*" Retrieved on May 2, 2018 from http://www.aberdeen-asset.fr/en/thinkingaloud/investment-clarity/what-is-social-infrastructure.

2. ADB (2009). "*Investing in Sustainable Infrastructure – Improving Lives in Asia and the Pacific*". Asian Development Bank. Manila.

3. AIIB (2018). "*Transport Sector Strategy: Sustainable and Integrated Transport for Trade and Economic Growth in Asia*". Asian Infrastructure Investment Bank.

4. Ardila-Gomez, A. and A. Ortegon-Sanchez (2016). "*Sustainable Urban Transport Financing from the Sidewalk to the Subway: Capital, Operations, and Maintenance Financing*". Washington, DC: World Bank.

5. Bhattacharya, A., Oppenheim J., & Stern, N. (2015). "*Driving sustainable development through better infrastructure: key elements of a transformational program*". Brookings Global Working Paper Series No: 91. Retrieved on July 22, 2019 from https://www.brookings.edu/wp-content/uploads/2016/07/07-sustainable-development-infrastructure-v2.pdf

6. Christiansen, L., Martinez, G. and Naswa, P. (2018). "*Adaptation metrics: perspectives on measuring, aggregating and comparing adaptation results*". UNEP DTU Partnership, Copenhagen. Danchev, A. (2015). "*Evolution of the Idea of Soft Social Infrastructure: The latest achievements*". Management and Sustainable Development (2/2015 – 51). Faith University, Istanbul, Turkey.

7. Devi, S. (2016). "*Urban Heat Islands and Environmental Impact*". Retrieved on May 2, 2018 from https://www.coolrooftoolkit.org/wp-content/uploads/2012/04/SSDevi.pdf.

8. EU (2013). "*Building a Green Infrastructure for Europe*". Retrieved on May 2, 2018 from http://ec.europa.eu/environment/nature/ecosystems/docs/green_infrastructure_broc.pdf.

9. Fukayama F (1995). “*Trust: The Social Virtues and the Creation of Prosperity*”. New York: Free Press.

10. Gabrielsen, P., and Bosch, P., (2003). “*Internal Working Paper Environmental Indicators: Typology and Use in Reporting*”. European Environment Agency, Copenhagen. 20 pp.

11. Gartner, T. and Difrancesco, K. (2015). “*From Gray to Green, Investing in Natural Infrastructure to address Water, Food, and Energy Nexus & Challenges*” Blog post retrieved on 16th July 2019 from https://www.iucn.org/lo/node/18358

12. GIZ (2019). “*Sustainable Urban Transport: Avoid-Shift-Improve (ASI)*”. Fact sheet available on the website of Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. https://www.giz.de/en/worldwide/62687.html. Retrieved on October 18, 2019.

13. Hallegatte, S., Shah, A., Brown, C., Lempert, R., and Gill, S. (2012). *Investment decision making under deep uncertainty--application to climate change*. Policy Research Working Paper 6193, World Bank, Washington DC.

14. Hammer, J. & Pivo, G. (2016). “*The Triple Bottom Line and Sustainable Economic Development Theory and Practice*”. Economic Development Quarterly (1-12). Sage Publications.

15. IDB (Inter-American Development Bank) & IDB Invest. (2018). “What Is Sustainable Infrastructure? A Framework to Guide Sustainability Across the Project Cycle”. Technical Note No. IDB-TN-1388. Retrieved on July 19, 2019 from: https://publications.iadb.org/publications/english/document/What_is_Sustainable_Infrastructure__A_Framework_to_Guide_Sustainability_Across_the_Project_Cycle.pdf

16. IPCC (2014). “*Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report*”. Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

17. ISO (2018). "*Greenhouse gases Part 1: Specification with guidance at the organisation level for quantification and reporting of greenhouse gas emissions and removals*". Retrieved on July 22, 2019 from https://www.iso.org/standard/66453.html

18. Joint Report (2016). "*On Multilateral Development Bank's Climate Finance*". Retrieved on May 2, 2018 from https://www.ebrd.com/2016-joint-report-on-mdbs-climate-finance.pdf

19. Klausing, Roscoe (2016). "*What is Green Infrastructure? A Definition and 5 Examples of how it can work on your commercial Kentucky Property*". Online article retrieved on October 18, 2019 from https://www.ebrd.com/2016-joint-report-on-mdbs-climate-finance.pdf.

20. Kristensen Peter (2004). "*The DPSIR Framework*". Paper presented at the Workshop on a comprehensive / detailed assessment of the vulnerability of water resources to environmental change in Africa using river basin approach. UNEP Headquarters, Nairobi, Kenya. September.

21. Lagos, R. & Wirth T. (2009). "*Facilitating an International Agreement on Climate Change – Adaptation to Climate Change*". A proposal of the Global Leadership for Climate Action. Retrieved on July 22, 2019 from https://www.preventionweb.net/publications/view/10267

22. Levin K., Morgan J. and Jiawei S. (2015, December 15). "*Insider: Understanding the Paris Agreement's Long-term Goal to Limit Global Warming*". Retrieved on July 22, 2019 from https://www.wri.org/blog/2015/12/insider-understanding-paris-agreement-s-long-term-goal-limit-global-warming

23. Li, J., Mullan, M. and Helgeson, J., (2014). "*Improving the practice of economic analysis of climate change adaptation*". *Journal of Benefit-Cost Analysis*, 5(3), 445-467.

24. Meltzer, J. (2016). "*Financing Low Carbon, Climate Resilient Infrastructure: The Role of Climate Finance and Green Financial Systems*". Brookings Global Working Paper Series No: 96. September.

25. Montgomery, R (2015). "How can we promote Sustainable Infrastructure?" World Economic Forum. Retrieved on July 19, 2019 from https://www.weforum.org/agenda/2015/11/how-can-we-promote-sustainable-infrastructure/.

26. NCE (2016). "*The Sustainable Infrastructure Imperative*". Report of the New Climate Economy. Retrieved on May 2, 2018 from https://newclimateeconomy.report/2016/.

27. New Zealand Government Treasury (2013). "*Living Standards: A Short Guide to Social Infrastructure*". Retrieved on May 2, 2018 from http://www.treasury.govt.nz/abouttreasury/higherlivingstandards

28. Nilsson, M., Griggs, D. and Visbeck, M. (2016). "*Policy: Map the interactions between Sustainable Development Goals*". Retrieved on July 22, 2019 from https://www.nature.com/news/policy-map-the-interactions-between-sustainable-development-goals-1.20075

29. NZSIF (2018). Retrieved on May 2, 2018 from New Zealand Social Infrastructure Fund website. http://www.nzsif.co.nz/Social-Infrastructure/What-is-Social-Infrastructure/.

30. OECD (2001). "*The Well-Being of Nations: The Role of Human and Social Capital*". Organisation for Economic Co-operation & Development. Paris. Retrieved on July 22, 2019 from https://treasury.govt.nz/publications/wp/institutions-social-norms-and-well-being-wp-02-12-html#section-7

31. Ollivier, G. and Wei, W. (2015). "*Hong Kong Rail plus Property Program*". In Lawrence, Martha and Ollivier, Gerald. (2015). "*Attracting Capital for Railway Development in China*". World Bank, Washington, DC.

32. Putnam, R., Leonardi, R. & Nanetti, R. (1993). "*Making Democracy Work: Civic Traditions in Modern Italy*". Princeton: Princeton University Press.

33. Ranger, N., A. Millner, S. Dietz, S. Fankhauser, A. Lopez and G. Ruta (2010). *Adaptation in the UK: A Decision Making Process*. Grantham Research Institute on Climate Change and Centre for Climate Change Economics and Policy, London School of Economics.

34. Schmidt-Thomé, P., (2017). "*Towards applying climate change adaptation - Investigaciones Geográficas (Esp)*". No. 67, 2017. Universidad de Alicante. Available at http://www.redalyc.org/jatsRepo/176/17651756003/html/index.html accessed 14th July 2019.

35. Shaheen S, Finson R, Bhattacharyya A, Jaffee M, TSRC, UC Berkeley (2016). "*Moving Towards a More Sustainable California: Exploring Livability, Accessibility, and Prosperity*". University of California Center for Economic Competitiveness in Transportation White Paper.

36. Slocock, C. (2018). "Valuing Social Infrastructure, London: Community Links Early Action Task Force". Retrieved on October 18, 2019 from www.civilexchange.org.uk/wp-content/uploads/2018/06/ Valuing-Social-Infrastructure-final.pdf.

37. Smyth, E., Steyn, M., Esteves, A.M., Franks, D.M. and Vaz, K., (2015). "*Five 'big' issues for land access, resettlement and livelihood restoration practice*". Findings of an international symposium. *Impact Assessment and Project Appraisal*, *33*(3), pp.220-225.

38. SSSA (2018). Retrieved on February 26, 2018, from Soil Science Society of America (SSSA) website. https://www.soils.org/discover-soils/soils-in-the-city/green-infrastructure/important-terms/grey-infrastructure.

39. Talberth, J. & Hansen, C. (2012). "*Green vs. Gray – When Nature Better Concrete*". World Resources Institute Weblog Post. Retrieved on July 22, 2019 from http://www.wri.org/blog/2012/06/green-vs-gray-infrastructure-when-nature-better-concrete

40. Teriman, S., Yigitcanlar, T. and Mayere, S., (2011). "*Social infrastructure planning and sustainable community: example from south east Queensland, Australia*". In "*Proceedings of the Business and Social Science Research Conference*". 2011 (pp. 1-12). World Business Institute Australia.

41. UN (2016a) retrieved on July 15, 2019 from UN academic impact page on SDG 13 http://academicimpact.un.org/content/climate-action

42. UN (2016b) retrieved on July 15, 2019 from UN "*Transforming our world*" available at https://sustainabledevelopment.un.org/post2015/transformingourworld

43. UN (2019) retrieved on July 16, 2019 from UN Sustainable Development Goals – Climate Action available at https://www.un.org/sustainabledevelopment/climate-action/

44. United Nations (2015). "*Mobilizing for Development*". Analysis and Policy Recommendations from the United Nations Secretary-General's High-Level Advisory Group on Sustainable Transport.

45. UNDESA (2017) retrieved on July 15, 2019 from UN Department of Economic and Social Affairs web page https://www.un.org/development/desa/en/news/sustainable/ocean-conference-commitments.html

46. UNDP (2015) retrieved on January 20, 2020 from UN Development Programme Web page https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-14-life-below-water.html

47. UNOHRLLS United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and the Small Island Developing States (2019) retrieved on July 16, 2018 from http://unohrlls.org/

48. United Nations General Assembly (1987). "*Report of the world commission on environment and development: Our common future*". Oslo, Norway: United Nations General Assembly, Development and International Co-operation: Environment.

49. USEPA (2018). Retrieved on May 2, 2018 from US Environmental Protection Agency website. https://ofmpub.epa.gov/sor_internet/registry/termreg/searchandretrieve/glossariesandkeywordlists/search.do?details=&glossaryName=Green%20Infrastructure%20Glossary. Retrieved on October 18, 2019.

50. Valerio Micale, Bella Tonkonogy & Federico Mazza (2018). "*Understanding and increasing finance for climate adaptation in developing countries*". A Climate Policy Initiative Report. Available online at https://climatepolicyinitiative.org/.

51. Vazquez, K. Roychoudhury S. & Borges C. (2017). "*Building Infrastructure for 21st Century Sustainable Development: Lessons and Opportunities for the BRICS-led New Development Bank*".

Jindal School of International Affairs, Center for African, Latin American and Caribbean Studies at O.P. Jindal Global University Delhi NCR, India.

52. Watkiss, P. and A. Hunt. 2016. "*Assessing Climate-Resilient Development Options*", in: S. Fankhauser and T. McDermott, eds. *The Economics of Climate-Resilient Development*. Cheltenham: Edward Elgar.

53. WBCSD & WRI (2004). "*The Greenhouse Gas Protocol – A corporate reporting and accounting standard"*. World Business Council for Sustainable Development & World Resources Institute Washington D.C., 2004.

54. World Bank (2008). "*Sustainable Infrastructure Action Plan 2009-11*". World Bank Group. Washington DC.

55. World Bank - (2010). "*Cost-benefit analysis in World Bank Project: An Overview*". World Bank Group. Washington DC.

56. Yee SH, Bradley P, Fisher WS, Perreault SD, Quackenboss J, Johnson ED, Bousquin J, and Murphy PA. (2012). "*Integrating human health and environmental health into the DPSIR framework: A tool to identify research opportunities for sustainable and healthy communities*". EcoHealth 9:411–426.