NATURE-BASED INFRASTRUCTURE
GLOBAL RESOURCE CENTRE

How Can Investment in Nature Close the Infrastructure Gap?

An estimate of how much nature-based infrastructure can save costs and create value relative to traditional grey infrastructure

NBI REPORT

Supported by

Led by

October 2021

Published by the International Institute for Sustainable Development

The **NBI Global Resource Centre** aims to bring together key partners to establish a business case for nature-based infrastructure. We provide data, training, and sector-specific valuations based on the latest innovations in systems thinking and financial modelling.

The complexity of NBI requires us to take a systemic approach when we plan, value, and implement infrastructure projects. It is also essential to exchange knowledge and collaborate with partners in the field.

The NBI Global Resource Centre is funded by the Global Environment Facility (GEF) and the MAVA Foundation and led by the International Institute for Sustainable Development (IISD), in partnership with the United Nations Industrial Development Organization (UNIDO).

IISD
nbi.iisd.org
@iisd_sustinfra

UNIDO
unido.org
@unido

GEF
thegef.org
@theGEF

MAVA
mava-foundation.org
@MavaFdn

How Can Investment in Nature Close the Infrastructure Gap?

August 2021

Written by Andrea M. Bassi, Ronja Bechauf, Liesbeth Casier, and Emma Cutler

Photo: iStock/wmaster890

NATURE-BASED INFRASTRUCTURE
GLOBAL RESOURCE CENTRE

Supported by

Led by

Executive Summary

New research shows that nature-based infrastructure (NBI) is up to 50% cheaper than traditional "grey" infrastructure to provide the same infrastructure service. In addition, NBI provides 28% better value for money than grey infrastructure. These numbers are based on the International Institute for Sustainable Development's Sustainable Asset Valuation assessments of various NBI projects.

To put these figures into context, we undertook a literature review on the global infrastructure gap and the extent to which a portion of this could be filled by using NBI. This allows us to estimate a global range of cost savings and value creation that NBI brings in comparison to "grey" alternatives. We found that if we met our current global infrastructure needs but swapped just over 11% of this with NBI—rather than traditional or "grey" infrastructure—we would save USD 248 billion each year, out of the USD 4.29 trillion needed annually. These savings could relieve some of the hefty strain already placed on public budgets by the ongoing health crisis and go to other urgent investment needs.

Our research shows that this infrastructure swap could create additional benefits worth up to USD 489 billion every year—a figure that rivals the annual GDP of countries such as Austria, Ireland, or Nigeria.

Governments and infrastructure investors normally default to grey infrastructure to meet infrastructure needs for coastal protection, water supply, energy, and transport, as well as to increase the resilience of existing infrastructure. This happens because the cost savings and added benefits of NBI options are neither well understood nor integrated into traditional assessments of infrastructure projects.

This means that grey infrastructure often appears as the more attractive option on paper, though it is less so on the ground. The result is a missed opportunity to tackle our climate and biodiversity crises, which places both our natural environment and societal health at risk.

The Nature-Based Infrastructure Global Resource Centre was created to address this evidence gap. Over the next few years, we will develop more than 40 assessments comparing NBI with built infrastructure for a variety of assets. A database will collect and share data on the economic performance of NBI for use by policy-makers, investors, and infrastructure planners. Stakeholders will be able to better collaborate and share knowledge about what is (and is not) working. And we will be making efforts to boost education about NBI through communications initiatives, videos, events, and outreach.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

The world is facing a series of environmental and social challenges, many of them compounded by the COVID-19 pandemic. Currently, 770 million people do not have access to electricity (International Energy Agency [IEA], 2020), and 2 billion people lack safe, nutritious, and sufficient food (Food and Agriculture Organization of the United Nations et al., 2020). At the same time, more than 2 billion people do not have access to safe drinking water, while 4.2 billion people live without safely managed sanitation (World Health Organization & United Nations Children's Fund, 2019).

The climate crisis has grown worse, and the current national strategies for slashing greenhouse gas emissions are nowhere near the ambition needed to limit the global average temperature rise to 1.5°C and avert irreversible damage (United Nations Framework Convention on Climate Change, 2021). Countries are already having to adapt to the impact of a warming planet as extreme weather events become commonplace. The biodiversity crisis, which is linked to the climate crisis, has also become direr, amid the continued loss of crucial biodiversity that helps support ecosystem health and local livelihoods.

The ongoing pandemic has created new challenges and greater infrastructure needs. Supply chain disruptions and overwhelmed health systems are just two of the many examples that have shown us how the infrastructure we have is far from the infrastructure we need. Responding to these challenges so that people and the planet can thrive requires massive investments over the coming years and decades. It also requires us to rethink whether our past approach to infrastructure investments will be enough.

Historically, governments and private investors tend to support traditionally engineered infrastructure, also known as grey infrastructure. Common examples include wastewater treatment plants, dikes, and seawalls. In recent years, evidence has clearly shown that we should instead rely on nature for solving some of these infrastructure needs, given that nature-based infrastructure (NBI) saves money and provides greater benefits (Bassi et al., 2018, 2019; Cardinali et al., 2021; Cohen-Shacham et al., 2016; Cross et al., 2021; Somarakis et al., 2019; Temmerman et al., 2013). NBI—such as sand dunes, wetlands, and forests—delivers key services such as flood protection and water filtration while also providing additional benefits to communities and the environment.

Making this case to governments and investors, however, means showing them the numbers. Traditional valuations of infrastructure projects often fail to account for the added benefits to health and the environment that NBI can provide. We need to better understand, quantify, and value the role of NBI in meeting infrastructure needs and the contribution NBI can make to reaching the Sustainable Development Goals (SDGs).

The questions we pose to ourselves are simple: How does NBI perform compared to grey infrastructure? How can NBI help to bridge the infrastructure gap? And what outcomes would emerge from shifting investments from built infrastructure to nature?

Building on this overarching question, this working paper aims to shed light on the following, more detailed research questions:

- What is the infrastructure investment required to meet development goals across sectors?
- How much of this need can be filled by NBI?
- What would it cost if we chose to build with nature instead of using traditional methods?
- How much additional value does NBI create for our economy, society, and the environment?

We answer these questions by bringing together two elements of research: a literature review on infrastructure investment needs and the results from IISD's Sustainable Asset Valuations (SAVi) of NBI projects. We describe our methodology in Section 2 and the results in Section 3. We then place these results in context in Section 4, looking at what they mean for our research questions. Annex A to this paper contains the overview of the literature review, and Annex B contains the details from the SAVi valuations in which we compare the performance of NBI with grey infrastructure.[1]

This working paper was developed by the Nature-Based Infrastructure Global Resource Centre.[2] At the centre, we aim to establish a business case for NBI by providing data, training, and customized valuations of NBI projects. These valuations are co-created using a multistakeholder approach, customized to the project and local context, conceived using systems thinking, and created using system dynamics, spatial, and financial modelling.

Over the next few years, we will analyze more than 40 NBI projects around the world. We will study and assess their performance against comparable built infrastructure options, looking at their capacity to deliver infrastructure services, their climate resilience, and their support to climate adaptation efforts. This research effort will help to strengthen the track record of NBI in comparison to grey infrastructure and will help to refine the findings of this working paper.

[1] Annexes A and B can be accessed here.

[2] The Nature-Based Infrastructure Global Resource Centre is a new initiative established by the International Institute for Sustainable Development (IISD), together with the Global Environment Facility (GEF), the MAVA Foundation, and the United Nations Industrial Development Organization (UNIDO).

2.0 Methodology

We use two main methods to answer the research questions above:

1. A literature review on the investment required to fill the infrastructure gap and to reach stated development targets.
2. An assessment, based on several SAVi applications, of how much money can be saved by investing in nature rather than built infrastructure.

In the first step, we reviewed the available literature to understand how much infrastructure investment is needed for fulfilling national development plans and the SDGs. Based on this review, where we also describe which sectors are already covered in existing estimates of the global infrastructure investment gap, we calculated an average investment need per year in different sectors.

Second, we reviewed the literature to assess how much NBI can contribute to fulfilling each sector's infrastructure needs. To do this, we matched the infrastructure services required to meet development goals (e.g., water purification) with those services that NBI can provide (e.g., wetland rehabilitation, natural water filtration). We complement this analysis with the findings from our previous research on NBI, along with over 20 assessments where we looked at how sustainable infrastructure performed against conventional infrastructure.[3]

Third, we looked at the total infrastructure investment required and examine how much of that can be satisfied by NBI. There are certain ecosystem services that are directly comparable with built infrastructure services (e.g., coastal resilience with mangroves or a seawall). Building on the literature review, we estimated what portion of the total investment (and hence service required) could be delivered by NBI.

Fourth, we have reviewed all past SAVi assessments that focus on NBI, and we have determined whether (i) the investment required for the NBI option is larger or smaller than the corresponding built infrastructure option and (ii) whether the value generated by NBI, considering all ecosystem services provided and not only those desired in the first place, is larger or smaller than the corresponding built infrastructure option. Data for this part of the assessment were obtained from 10 SAVi assessments in Canada, Ethiopia, India, Indonesia, Italy, Senegal, and South Africa.

Using the results of these 10 SAVi assessments, we compared the costs and benefits of NBI and built alternatives. For each asset, we considered the undiscounted lifetime cost (construction plus operations and maintenance) and value (direct benefits plus avoided costs) (Table B1). From these numbers, we calculated the percent decrease in cost and percent increase in value of NBI compared to grey infrastructure. We also calculated the benefit-to-cost ratio for each asset. We then averaged these percent changes and ratios across the 10 assessments (Table B1).

[3] For the technical background of these analyses, refer to https://www.iisd.org/publications/sustainable-asset-valuation-tool-natural-infrastructure and https://www.iisd.org/publications/integration-climate-data-savi-model

We did not include all assessments in each of the averages shown in Table B1. We did not have information on grey infrastructure for the forest restoration in Indonesia or the tree planting in Tshwane—we could include only the NBI benefit-to-cost ratio from these assessments. We also could not calculate the benefit-to-cost ratio for the Saloum Delta because there was no cost estimate for keeping the ecosystem in its current state. The benefit-to-cost ratios for Pelly's Lake and the Stephenfield Reservoir are much greater than for the other NBI assets. Similarly, the grey infrastructure benefit-to-cost ratio from the Stephenfield Reservoir assessment is an outlier because the benefits of the NBI are disproportionally high compared to the other assessments. We excluded these values from the averages.

Finally, knowing the total investment that could be supported by NBI and having information on the comparative performance of NBI versus built infrastructure, we estimated:

a) The financial savings that could be accrued (if NBI requires less investment to deliver the same services that built infrastructure would be designed and implemented for).

b) The societal costs that could be avoided by using NBI (e.g., the additional carbon sequestration that an NBI project could provide and how much economic value that would be worth, given that this project would make it possible to reduce climate mitigation investments in other areas).

c) The added benefits it provides (e.g., if the NBI option is more labour intensive and creates more jobs and income or makes more water available for productive and recreational uses).

This assessment allows us to estimate the material (or tangible) cost savings from NBI, as well as additional benefits. Some of these benefits may be intangible but nevertheless contribute to human well-being. On the other hand, such intangible benefits are important for economic analysis because, with policy action, they may become material and affect infrastructure-related cash flows in the future.

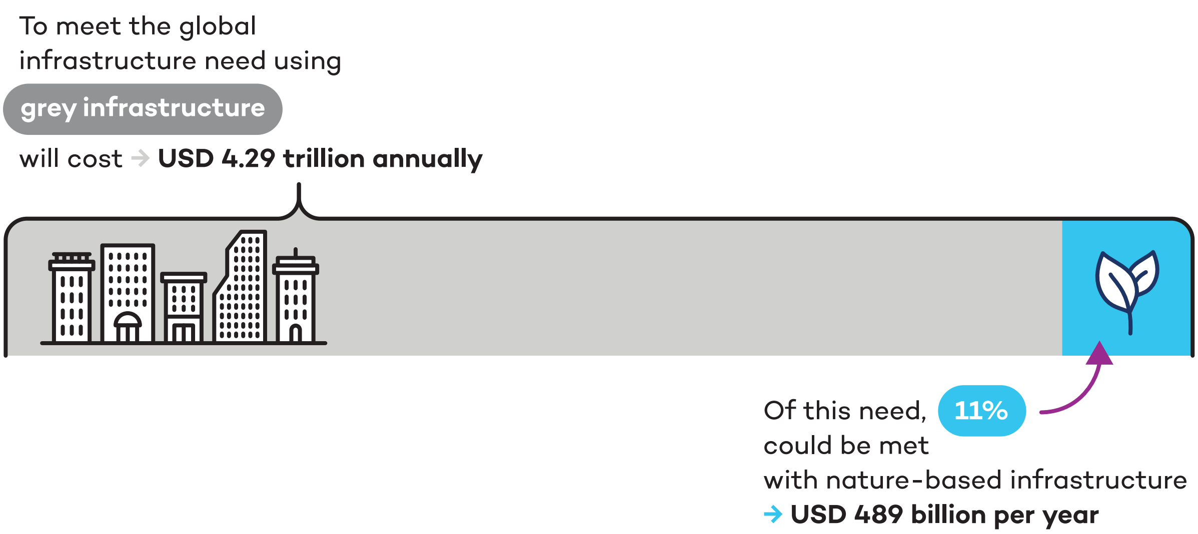
3.0 Results

Our research shows that NBI can be a game-changer in meeting some of the world's infrastructure needs and that it can do so while saving money and generating additional benefits. We made the following projections.

Over the next 20 years, the level of infrastructure needed to support development needs would **cost USD 4.29 trillion annually** if only grey infrastructure is used. The grand total would be USD 85.791 trillion.

In practice, some of this infrastructure can instead be built using nature. We found that **11.4% of this infrastructure need could be met effectively using NBI**.

Figure 1. Possible share of NBI investment in the global infrastructure need

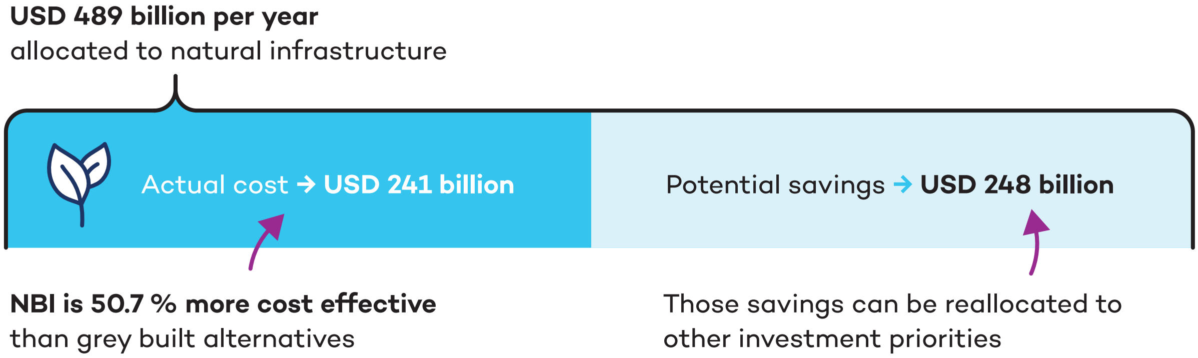


If policy-makers and infrastructure investors decided to use grey infrastructure instead, they would need to invest USD 489 billion. If they made the switch to NBI, they could save over half of that investment—50.7%, to be exact, or USD 248 billion. Those savings could then be reallocated to other investment priorities.

The argument in favour of NBI gets even stronger when looking at what other benefits come from using nature instead of a built solution. We found that NBI's added value is 28% greater than grey infrastructure, which in dollar terms translates to **USD 489 billion annually**. This corresponds to the annual GDP of countries such as Austria, Ireland, or Nigeria (International Monetary Fund, 2021).

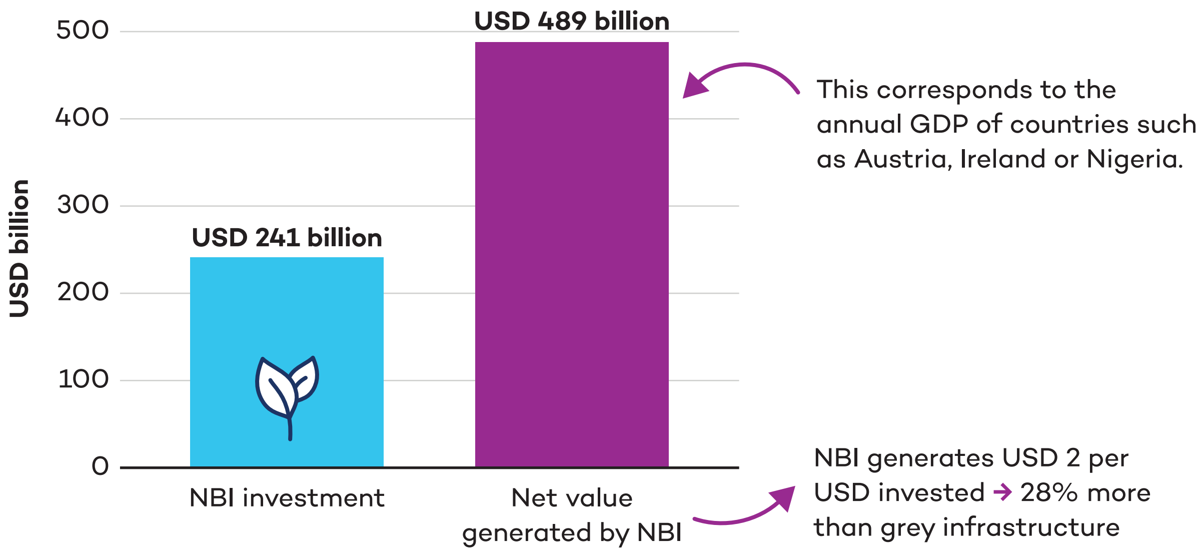
This additional USD 489 billion comes from the other ecosystem services that NBI provides, beyond the primary demands that the infrastructure project is designed to tackle. Traditional valuations do not factor into these ecosystem services and other benefits but instead focus only on a narrow set of financial indicators that have not been adjusted to integrate the value of nature or the value of its loss. The result is that those estimates paint a rosier picture in favour of grey infrastructure than what the actual results show.

Figure 2. The cost saving of NBI compared to grey infrastructure



Continuing to use traditional valuations means that investments will flow disproportionately to grey infrastructure. The result is a missed opportunity to tackle the twin crises of biodiversity loss and climate change, which will lead to far greater environmental, societal, and economic costs down the line.

Figure 3. Net additional value generated by NBI



3.1 Infrastructure Investment Needs and the Potential Role of NBI

Table 1 summarizes our calculations of the average annual investment need for different infrastructure sectors and the share of this need that can be performed by NBI. The details of these calculations can be found in Tables A1 to A5 (in Annex A).

We estimate that across different sectors, there is an average annual investment need of USD 4.29 trillion. We estimate that around 11.4% of this need (USD 489 billion) can be covered through investment in NBI.

Table 1. Annual infrastructure need and share of NBI

Sector	Average investment per year (USD billion)	NBI share	Corresponding potential NBI investment per year (USD billion)	Comments
Water and sanitation	448.43	25%	112.11	There is restricted space for NBI in urban areas, a high volume of required services, and a need for built infrastructure and maintenance.
Energy supply	1,382.18	5%	69.11	We assume 70% of the investment need is for energy supply. NBI can be used for micro-scale hydropower and bioenergy.
Energy efficiency	592.36	10%	59.24	We assume 30% of the investment need is for energy efficiency and demand-side measures. Green roofs and walls reduce energy demand.
Transport	1,709.46	10%	170.95	NBI can be part of coherent planning for resilient transport infrastructure.
Agriculture	125.16	50%	62.58	Agricultural production will embrace NBI, but grey infrastructure is needed for machinery and supply chains.
Irrigation	3.33	20%	0.67	NBI can improve water supply, but there is a need for built irrigation infrastructure.
Climate resilience	28.62	50%	14.31	NBI can address coastal, river, and urban flood risks by regulating water volume and speed.
All sectors	4,289.54	11.40%	488.95	While we work with the 11.4% estimate for the calculations of the total cost savings and added benefits of NBI globally, we acknowledge the uncertainty and estimate a range between 9% and 14%, or a corresponding USD 400 billion to 600 billion of investment that can be fulfilled through NBI.

Sources: Authors' elaborations based on Bassi et al., 2020; Berghage et al., 2009; Bowler et al., 2010; Cross et al., 2021; DiMuro et al., 2014; Grant et al., 2012; Griscom et al., 2017; IEA, 2020a, 2020b, 2020c; Kabisch et al., 2017; Lesbarrères & Fahrig, 2012; Narain et al., 2011; Rossi, 2019; Roth, 2013; Rozenberg & Fay, 2019; Storey et al., 2009; Talberth et al., 2016; Tavakol-Davani et al., 2016; Temmerman et al., 2013; United Nations Educational, Scientific and Cultural Organization, 2018; United Nations Environment Programme, 2021; United Nations Environment Programme et al., 2014; U.S. Environmental Protection Agency, 2003; Vineyard et al., 2015; Zhou et al., 2006.

There is a wide range in the estimates of how much infrastructure is needed at a global scale. These numbers can run from as low as USD 150 billion to as high as USD 7.9 trillion per year. How these estimates are calculated also varies, depending on what infrastructure services they cover, whether and how they account for the SDGs and climate action, and which countries and regions they include. We found that, based on average annual investment needs for infrastructure sectors, a total average investment of **USD 4.29 trillion** is required every year. To put this into perspective, low- and middle-income countries are estimated to currently spend between USD 820 billion and USD 1.21 trillion on infrastructure every year (Fay et al., 2019).

Until now, there has been no global estimate on how much of this global infrastructure need can be met using NBI. The research conducted to date has, however, already shown that various types of NBI can provide the same services that governments and infrastructure investments also seek to obtain from built infrastructure (Bassi et al., 2019; Cross et al., 2021; Somarakis et al., 2019; Temmerman et al., 2013; United Nations Environment Programme et al., 2014).

For example, coastal ecosystems such as mangroves, reefs, and sand dunes protect people from floods, a service that would otherwise require building dikes or conventional infrastructure. A variety of NBI systems, such as human-made wetlands and reed beds, can treat wastewater and are an alternative to wastewater treatment plants. In urban areas, street trees, parks, and green roofs regulate temperatures and reduce heat stress for residents, thus decreasing demand for energy-intensive air conditioning.

A detailed overview of the infrastructure functions NBI can provide for each sector is provided in Annex A (Tables A4 and A5).

Based on the reviewed studies (see Annex A, Table A1), the largest infrastructure investments are required in the energy and transportation sectors. **Energy infrastructure** will require investments of about USD 1.975 trillion per year for both energy supply and energy-efficiency measures. Investment needs for transportation go up to about USD 1.709 trillion per year.

Rising temperatures, more intense heat waves, and the resulting urban heat island effect are driving demand for cooling, and thus more energy. Trees and green spaces can naturally cool down their surroundings and prevent the need for investments in energy-intensive air conditioning. NBI can also improve building insulation and thus improve energy efficiency. Bioenergy and micro-scale hydrop85ower are two examples of how NBI can provide renewable energy and contribute to energy supply.

Based on our literature review, the average annual investment need for energy is USD 1.975 trillion. We break down those results to consider how much of that investment goes into energy supply and how much goes into improving energy efficiency or managing the demand for energy. In both cases, we find that NBI can be a promising solution for the energy sector.

We assume that 70% of these investments (USD 1.382 trillion) goes into energy supply, with the remaining 30% (USD 592.36 billion) going to demand management/energy efficiency.

First, NBI can help lower energy demand. We estimate that 10% of the investments that are normally given to grey infrastructure to manage energy-related demand can instead go to green roofs, trees, and other types of NBI. In dollar terms, that means that the global demand for energy will actually drop by USD 59.24 billion annually.

Second, we found similarly promising results when looking at how NBI can help supply energy. We assume that 5% of the investments could be used to fund micro-scale hydropower and bioenergy (USD 69.11 billion annually) (see also Annex A, Tables A4 and A5).

Flooding of transportation infrastructure such as roads and railway tracks—which will only increase in frequency and severity as the climate crisis worsens—demands greater spending on maintenance and replacement. Grey infrastructure like sewage upgrades and water retention basins can reduce the extent of damage caused by floods, but there is also great potential for using NBI instead. For example, stormwater infrastructure such as swales and wetlands can retain and slow the pace of water, reducing the amount of damage from road washouts. We estimate that 10% of the investments into transportation, totalling USD 170.95 billion every year, could be better spent on climate-resilient infrastructure that incorporates NBI (see also Annex A, Tables A4 and A5).

In the **water and sanitation sector**, the average investment need is USD 448.43 billion per year, with estimates from the literature ranging from USD 18 billion to USD 900 billion depending on the spending efficiency, targets, and country coverage.

Around the world, better wastewater treatment is required to provide access to safe water and protect natural ecosystems. Wastewater treatment plants have traditionally performed this function, but there is also a range of NBI options available to do just that. Wetlands, reed beds, or soil infiltration systems, for example, can efficiently clean water. Riparian buffers, forests, and bioswales can trap sediments, remove toxins, and regulate nutrient levels, thus avoiding investments in water filtration.

NBI is also crucial for water retention and supply. Freshwater ecosystems such as wetlands, forests, and green spaces can sustain water supplies through soil infiltration and storage. Built infrastructure such as water reservoirs and dams are otherwise needed to provide these services.

Given this potential of NBI to supply and treat water (see also Annex A, Tables A4 and A5), we estimate that 25% of the investment need for water and sanitation infrastructure can be performed through NBI instead of grey infrastructure. This means an annual investment of USD 112.11 billion. This estimate takes into account that space for NBI in urban areas is limited, huge volumes of water are needed around the world, and built elements are a core part of water and sanitation systems.

In the **agriculture sector**, we calculated an investment need of USD 125.16 billion per year. Estimates from the literature range from USD 2.54 billion for helping the agriculture sector adapt to the impacts of climate change to investing USD 265 billion into infrastructure to improve food security and end hunger. Agricultural practices like agroforestry, composting, and grazing management can improve water availability, increase yields, protect crops from extreme weather, protect and improve soil health, and provide fodder for livestock. They can also increase carbon storage and help to stabilize biodiversity. Given this potential of NBI in the agriculture sector, we estimate that 50% of the total investments could flow toward NBI (USD 62.58 billion per year) (see also Annex A, Tables A4 and A5).

In relation to **irrigation** infrastructure, we found that an additional USD 3.33 billion is needed to extend irrigation systems. We estimate that 20% of the estimate for irrigation, or USD 670 million, could be invested into NBI that improves water supply every year (e.g., through agroforestry practices) (see also Annex A, Tables A4 and A5).

Under **climate resilience**, we grouped investments required for flood protection, for making existing infrastructure such as roads more climate resilient, and for strengthening coastal zones. According to the literature review, estimates range from USD 7.5 billion to USD 70.36 billion per year, with an average of USD 28.62 billion. In addition, NBI can prevent floods from rivers and extreme rainfall by retaining water and slowing down water flows. Based on this high potential of NBI to offer flood protection along coasts, inland water bodies, and in urban areas, we estimate that 50% of the investment gap in this sector could be filled with NBI. This means investments of USD 14.31 billion every year (see also Annex A, Tables A4 and A5).

3.2 Avoided Costs and Added Benefits of NBI Investments Compared to Grey Infrastructure

Early evidence points to significant cost savings when choosing NBI over built infrastructure. In our work with SAVi, we find that, in most instances, NBI costs about 50% less than built infrastructure alternatives while delivering the same—or better—outcomes. This is primarily due to lower capital investment for NBI, in particular when nature is already present and does not have to be "rebuilt." As well, NBI often proves more climate resilient than built infrastructure and costs less over time because it actively avoids costs in relation to extreme weather events.

We also find that, in addition to cost savings, NBI generates about 28% added value because it provides for a healthier environment, job creation, and opportunity for growth in other economic sectors such as tourism and agriculture. As explained in detail under the Methodology section, data for this part of the analysis is derived from 10 SAVi assessments, captured in Tables B1 and B2 (in Annex B).

As shown in Table B2, grey infrastructure generates, on average, USD 3.57 per dollar invested. Thus, we expect that investing USD 489 billion in grey infrastructure will generate USD 1.744 trillion in value. However, NBI generates 28% additional value compared to grey infrastructure, resulting in USD 2.233 trillion in value.

We also found that NBI costs on average 50.7% less than built alternatives (Table B2), meaning that policy-makers and infrastructure investors can save USD 248 billion if they use NBI to meet 11.4% of the global infrastructure gap, relative to the USD 489 billion that they would have to invest otherwise.

Combining the extra value created from NBI (USD 489 billion) with the cost savings (USD 248 billion), we find that using NBI would result in an additional USD 737 billion available every year. When weighing this figure against a world population of 7.8 billion, this corresponds to USD 94 per person per year—crucial gains that could be used to address other needs.

Table 2. Lifetime, undiscounted costs and value generated by NBI and grey alternatives from 10 SAVi assessments

SAVi assessment	Type of infrastructure	Total cost (thousand USD)		Value generated (thousand USD)	
		NBI	Grey	NBI	Grey
Pelly's Lake	Water reservoir	783	38,260	93,596	93,596
Stephenfield Reservoir	Water reservoir	6,511	4,716	481,244	480,172
Lake Dal	Water treatment	229,914	211,716	5,107,480	3,221,043
Saloum Delta	Wetland	0	674,920	2,374,135	87,166
S'Ena Arrubia Wetland	Wetland	17,354	29,996	96,516	85,232
Corru S'Ittiri Wetland	Wetland	17,354	77,782	261,215	231,171
Stormwater in Johannesburg	Water treatment	3,050	5,772	9,491	0.679
Indonesia Forest Restoration	Tree planting and water retention wells	9,600	N/A	113,930	N/A
Addis Ababa Tree Planting	Tree planting	58,163	457,178	472,015	625,214
Rainbow Junction Tswhane	Green roofs and tree planting	185	N/A	223,655	N/A

Table 3. Cost savings, value increase, and benefit-to-cost ratios for NBI and grey infrastructure

Project name	Type of infrastructure	NBI cost savings	NBI value increase	NBI benefit-to-cost ratio	Grey benefit-to-cost ratio
Pelly's Lake	Water reservoir	783	38,260	93,596	93,596
Stephenfield Reservoir	Water reservoir	6,511	4,716	481,244	480,172
Lake Dal	Water treatment	229,914	211,716	5,107,480	3,221,043
Saloum Delta	Wetland	0	674,920	2,374,135	87,166
S'Ena Arrubia Wetland	Wetland	17,354	29,996	96,516	85,232
Corru S'Ittiri Wetland	Wetland	17,354	77,782	261,215	231,171
Stormwater in Johannesburg	Water treatment	3,050	5,772	9,491	0.679
Indonesia Forest Restoration	Tree planting and water retention wells	9,600	N/A	113,930	N/A
Addis Ababa Tree Planting	Tree planting	58,163	457,178	472,015	625,214
Rainbow Junction Tswhane	Green roofs and tree planting	185	N/A	223,655	N/A

Note: Crossed-out numbers are outliers that are excluded from the average. On average, NBI costs 50.6% less and generates 29.1% more value. NBI generates USD 10 for every dollar invested, while grey infrastructure generates USD 3.6 per dollar invested.

4.0 Conclusion

This paper points to clear benefits from investing in NBI compared to grey infrastructure. By combining two strands of research—a review of the global investments required to fill the infrastructure gap and reach stated development targets coupled with the avoided costs and added benefits of investing in nature rather than in built infrastructure—we can provide tentative, yet evidence-based, answers to the following research questions.

What is the global infrastructure need?

Meeting the global infrastructure need using grey infrastructure will cost USD 4.29 trillion annually over 20 years for a total of USD 85.791 trillion. This includes investments in water and sanitation, energy, transportation, agriculture, irrigation, and climate resilience. The literature review of these infrastructure investment needs revealed great differences between the studies and considerable uncertainty about what it will cost to fill the infrastructure gap and reach sustainable development objectives.

How much of this need can be filled by NBI?

For the calculations in this working paper, we estimate that 11.4% of our infrastructure needs can be met with NBI. Without NBI, this 11.4% corresponds to USD 489 billion.

For each category, such as water and sanitation or agriculture, we studied the literature to estimate the share of investments that could be met with NBI. This revealed that, until now, there had been little consideration for the potential of NBI, which highlights the need for a better evidence base.

How much do we save if we choose to build with nature?

Our assessments of NBI projects indicate that NBI costs 50.7% less than built alternatives. This implies that, instead of investing USD 489 billion every year to meet 11.4% of the global infrastructure need, we could—through investments in NBI—spend only USD 241 billion, resulting in annual savings of USD 248 billion, which can be invested in other development priorities. To put this into perspective, ending hunger by 2030 requires about USD 330 billion (Ahmed, 2020).

How much additional value does NBI create for our economies, society, and the environment?

NBI not only delivers key infrastructure services, but it also provides additional benefits, such as improved health and nutrition, increased revenues, and benefits for biodiversity. Based on our valuations of 10 NBI projects, we expect that using NBI to fulfill infrastructure needs generates 28% more value than choosing grey infrastructure.

Therefore, using NBI instead of a grey alternative would increase the value created by USD 489 billion every year. This additional value corresponds to the annual GDP of countries like Austria, Ireland, or Nigeria.

Why has the case in favour of NBI not been made sooner?

The additional value creation of NBI comes primarily from the (intangible) value of other ecosystem services beyond the infrastructure need for which the NBI is designed. Traditional assessments of infrastructure projects overlook these benefits, as well as the cost savings. This means that there is no well-established track record on the performance of NBI in particular in comparison with grey infrastructure.

These inaccurate and incomplete valuations skew decisions in favour of grey infrastructure as the default option to meet infrastructure needs. This leads to disproportionately higher investment into grey infrastructure, which means that policy-makers and infrastructure investors are missing the opportunity to tackle biodiversity loss and climate change, as well as the opportunity to spend money more efficiently. A more comprehensive valuation, such as those undertaken using SAVi, makes it clear that using NBI has better outcomes for society while also being better for the investors' bottom lines.

We acknowledge that these results emerge from a preliminary assessment and encourage future research in this area. We found that (i) the literature on the global infrastructure investment need is fragmented, with a variety of estimates that are grouped in different clusters of infrastructure and cannot be easily compared; (ii) the few existing NBI assessments focus on water services, ignoring the wide variety of NBI and the range of services this type of infrastructure can provide; and (iii) there are few studies that consider the cost and performance of NBI against built infrastructure, meaning that there are few other models to draw inspiration from and compare our work to at this stage.

What will the NBI Global Resource Centre do?

The NBI Global Resource Centre aims to address this latter gap. We will undertake more than 40 comprehensive assessments to improve the understanding of NBI performance. This evidence base will be recorded in a database.

We will regularly integrate findings from this work into our working paper. This will allow us to refine the estimates of the cost savings and value creation of NBI compared to grey infrastructure.

The NBI Global Resource Centre will also undertake the development of capacity-building materials for sustainable asset valuation, which will be published on our website. We will also pair this capacity-building work with communication and outreach efforts, allowing us to clearly show the business case in favour of NBI and the lessons we are learning along the way.

Investing in NBI that helps to achieve multiple goals at once will be key to successfully confronting the overlapping global challenges facing the world today. Together with our current and future partners, we hope to support policy-makers and investors in understanding the true value of investing in infrastructure that helps both people and the planet thrive.

References

Ahmed, K. (2020, October 13). Ending world hunger by 2020 would cost $330bn, study finds. *The Guardian*. https://www.theguardian.com/global-development/2020/oct/13/ending-world-hunger-by-2030-would-cost-330bn-study-finds

Bassi, A., Bechauf, R., Casier, L., Lago, S., Pallaske, G., Parette, M., Uzsoki, D., & Wuennenberg, L. (2020). *The integration of climate data into the SAVi Model. C3S_428h_IISD-EU: Sustainable Asset Valuation (SAVi): Demonstrating the business case for climate-resilient and sustainable infrastructure*. Copernicus Climate Change & International Institute for Sustainable Development. https://www.iisd.org/publications/integration-climate-data-savi-model

Bassi, A., Pallaske, G., Wuennenberg, L., Graces, L., & Silber, L. (2019). *Sustainable Asset Valuation tool: Natural infrastructure*. International Institute for Sustainable Development. https://www.iisd.org/system/files/publications/sustainable-asset-valuation-tool-natural-infrastructure.pdf

Bassi, A., Perera, O., Wuennenberg, L., & Pallaske, G. (2018). *Lake Dal in Srinagar, India: Application of the Sustainable Asset Valuation (SAVi) methodology for the analysis of conservation options*. International Institute for Sustainable Development. https://www.iisd.org/publications/lake-dal-srinagar-india-application-sustainable-asset-valuation-savi-methodology

Berghage, R., Beattie, D., Jarrett, A., Thurig, C., Razaei, F., & OConnor, T. (2009). *Green roofs for stormwater runoff control*. Environmental Protection Agency. https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NRMRL&dirEntryId=205444

Bhattacharya, A., Gallagher, K. P., Muñoz Cabré, M., Jeong, M., & Ma, X. (2019). *Aligning G20 infrastructure investment with climate goals and the 2030 Agenda. Foundations 20 Platform: A report to the G20*. https://www.foundations-20.org/wp-content/uploads/2019/06/F20-report-to-the-G20-2019_Infrastrucutre-Investment.pdf

Bhattacharya, A., Meltzer, J. P., Oppenheim, J., Qureshi, Z., & Stern, N. (2016). *Delivering on sustainable infrastructure for better development and better climate*. https://www.greengrowthknowledge.org/research/delivering-sustainable-infrastructure-better-development-and-better-climate

Bowler, D. E., Buyung-Ali, L., Knight, T. M., & Pullin, A. S. (2010). Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning, 97*(3), 147–155. https://doi.org/10.1016/j.landurbplan.2010.05.006

Brown, S., Jenkins, K., Goodwin, P., Lincke, D., Vafeidis, A. T., Tol, R. S. J., Jenkins, R., Warren, R., Nicholls, R. J., Jevrejeva, S., Arcilla, A. S., & Haigh, I. D. (2021). Global costs of protecting against sea-level rise at 1.5 to 4.0 °C. *Climatic Change, 167*(1–2), 4. https://doi.org/10.1007/s10584-021-03130-z

Cardinali, M., Dumitru, A., Vadewoestijne, S., & Wendling, L. (2021). *Evaluating the impact of nature-based solutions: A summary for policy makers*. Publications Office of the European Union. https://data.europa.eu/doi/10.2777/521937

Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (2016). *Nature-based solutions to address global societal challenges*. IUCN International Union for Conservation of Nature.

Cross, K., Tondera, K., Rizzo, A., Andrews, L., Pucher, B., Istenič, D., Karres, N., & McDonald, R. (Eds.). (2021). *Nature-based solutions for wastewater treatment: A series of factsheets and case studies*. IWA Publishing. https://doi.org/10.2166/9781789062267

Cunnif, S., & Schwartz, A. (2015). *Performance of natural infrastructure and nature-based measures as coastal risk reduction features*. Environmental Defense Fund. https://www.edf.org/sites/default/files/summary_ni_literature_compilation_0.pdf

DiMuro, J. L., Guertin, F. M., Helling, R. K., Perkins, J. L., & Romer, S. (2014). *A financial and environmental analysis of constructed wetlands for industrial wastewater treatment* (SSRN Scholarly Paper ID 2512025). Social Science Research Network. https://doi.org/10.1111/jiec.12129

Food and Agriculture Organization of the United Nations, International Fund for Agricultural Development, United Nations Children's Fund, World Food Programme, & World Health Organization. (2020). *The state of food security and nutrition in the world 2020: Transforming food systems for affordable healthy diets*. https://doi.org/10.4060/ca9699en

Fay, M., Lee, H., Mastruzzi, M., Han, S., & Cho, M. (2019). *Hitting the trillion mark: A look at how much countries are spending on infrastructure* (Policy Research Working Paper 8730). World Bank. https://documents1.worldbank.org/curated/en/970571549037261080/pdf/WPS8730.pdf

Food and Agriculture Organization of the United Nations, World Food Programme, & International Fund for Agricultural Development. (2015). *Achieving zero hunger: The critical role of investments in social protection and agriculture*. http://www.fao.org/3/i4951e/i4951e.pdf

Foster, J., Lowe, A., & Winkelman, S. (2011). *The value of green infrastructure for urban climate adaptation*. Center for Clean Air Policy. https://wrrc.arizona.edu/publications/water-harvesting/value-green-infrastructure-urban-climate-adaptation

Gaspar, V., Amaglobeli, D., Garcia-Escribano, M., Prady, D., & Soto, M. (2019). *Fiscal policy and development: Human, social, and physical investment for the SDGs*. International Monetary Fund. https://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=2015049

Global Infrastructure Hub. (2018). *Global infrastructure outlook*. https://outlook.gihub.org/

Grant, S. B., Saphores, J.-D., Feldman, D. L., Hamilton, A. J., Fletcher, T. D., Cook, P. L. M., Stewardson, M., Sanders, B. F., Levin, L. A., Ambrose, R. F., Deletic, A., Brown, R., Jiang, S. C., Rosso, D., Cooper, W. J., & Marusic, I. (2012). Taking the "waste" out of "wastewater" for human water security and ecosystem sustainability. *Science, 337*(6095), 681–686. https://doi.org/10.1126/science.1216852

Griscom, B. W., Adams, J., Ellis, P. W., Houghton, R. A., Lomax, G., Miteva, D. A., Schlesinger, W. H., Shoch, D., Siikamäki, J. V., Smith, P., Woodbury, P., Zganjar, C., Blackman, A., Campari, J., Conant, R. T., Delgado, C., Elias, P., Gopalakrishna, T., Hamsik, M. R., … Fargione, J. (2017). Natural climate solutions. *Proceedings of the National Academy of Sciences, 114*(44), 11645–11650. https://doi.org/10.1073/pnas.1710 465114

Hutton, G., & Varughese, M. (2016). *The costs of meeting the 2030 Sustainable Development Goal targets on drinking water, sanitation, and hygiene*. World Bank. https://openknowledge.worldbank.org/handle/10986/23681

International Energy Agency (IEA). (2020a). *Bioenergy*. https://www.iea.org/fuels-and-technologies/bioenergy

International Energy Agency. (2020b). *Cooling*. https://www.iea.org/reports/cooling

International Energy Agency. (2020c). *Renewables 2020: Analysis and forecast to 2025*. https://www.iea.org/reports/renewables-2020

International Monetary Fund. (2021). *GDP, current prices*. https://www.imf.org/external/datamapper/NGDPD@WEO/OEMDC/ADVEC/WEOWORLD

Kabisch, N., Korn, H., Stadler, J., & Bonn, A. (Eds.). (2017). *Nature-based solutions to climate change adaptation in urban areas: Linkages between science, policy and practice*. Springer International Publishing. https://doi.org/10.1007/978-3-319-56091-5

Lesbarrères, D., & Fahrig, L. (2012). Measures to reduce population fragmentation by roads: What has worked and how do we know? *Trends in Ecology & Evolution, 27*(7), 374–380. https://doi.org/10.1016/j.tree.2012.01.015

Narain, U., Margulis, S., & Essam, T. (2011). Estimating costs of adaptation to climate change. *Climate Policy, 11*(3), 1001–1019. https://doi.org/10.1080/14693062.2011.582387

Organisation for Economic Co-operation and Development. (2017). *Investing in climate, investing in growth*. https://doi.org/10.1787/9789264273528-en

Rao, N. S., Carruthers, T. J. B., & Anderson, S. (2012). *A comparative analysis of ecosystem-based adaptation and engineering options for Lami Town, Fiji: Synthesis report*. SPREP PROE. https://ian.umces.edu/site/assets/files/11017/a-comparative-analysis-of-ecosystem-based-adaptation-and-engineering-options-for-lami-town-fiji.pdf

Rossi, R. (2019). Irrigation in EU agriculture. *European Parliamentary Research Service*. https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/644216/EPRS_BRI%282019%29644216_EN.pdf

Roth, R. (2013). *Natural infrastructure: A climate-smart solution*. Northwest Biocarbon Initiative. https://www.climatesolutions.org/resources/reports/natural-infrastructure

Rozenberg, J., & Fay, M. (Eds.). (2019). *Beyond the gap: How countries can afford the infrastructure they need while protecting the planet*. World Bank. https://openknowledge.worldbank.org/handle/10986/31291

Saghir, J., Schaeffer, M., Chen, A., Ijjasz-Vasquez, E. J., So, J., & Carrasco, M. (2020). *State and trends in adaptation report 2020*. Global Center on Adaptation. https://gca.org/reports/state-and-trends-in-adaptation-report-2020/

Somarakis, G., Stagakis, S., & Chrysoulakis, S. (2019). *ThinkNature nature-based solutions handbook*. ThinkNature project. https://www.researchgate.net/publication/339983272_ThinkNature_Nature-Based_Solutions_Handbook/link/5e7257cfa6fdcc37caf61a18/download

Storey, B., Li, M.-H., McFalls, J., & Yi, Y.-J. (2009). *Stormwater treatment with vegetated buffers*. Association of State Highway and Transportation Officials. https://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP25-25(53)_FR.pdf

Sutton-Grier, A., Gittman, R., Arkema, K., Bennett, R., Benoit, J., Blitch, S., Burks-Copes, K., Colden, A., Dausman, A., DeAngelis, B., Hughes, A., Scyphers, S., & Grabowski, J. (2018). Investing in natural and nature-based infrastructure: Building better along our coasts. *Sustainability, 10*(2), 523. https://doi.org/10.3390/su10020523

Talberth, J., Gray, E., Yonavjak, L., & Gartner, T. (2016, February 21). *Green versus gray: Nature's solutions to infrastructure demands*. Solutions. https://thesolutionsjournal.com/2016/02/22/green-versus-gray-natures-solutions-to-infrastructure-demands/

Tavakol-Davani, H., Burian, S. J., Devkota, J., & Apul, D. (2016). Performance and cost-based comparison of green and gray infrastructure to control combined sewer overflows. *Journal of Sustainable Water in the Built Environment, 2*(2), 04015009. https://doi.org/10.1061/JSWBAY.0000805

Temmerman, S., Meire, P., Bouma, T. J., Herman, P. M. J., Ysebaert, T., & De Vriend, H. J. (2013). Ecosystem-based coastal defence in the face of global change. *Nature, 504*(7478), 79–83. https://doi.org/10.1038/nature12859

United Nations Conference on Trade and Development. (2014). *World investment report 2014. Investing in the SGDs: An action plan*. https://worldinvestmentreport.unctad.org/wir2014/

United Nations Framework Convention on Climate Change. (2021). *Nationally Determined Contributions under the Paris Agreement*. https://unfccc.int/sites/default/files/resource/cma2021_08_adv_1.pdf

United Nations Educational, Scientific and Cultural Organization (Ed.). (2018). *Nature-based solutions for water*. http://www.unesco.org/new/en/natural-sciences/environment/water/wwap/wwdr/2018-nature-based-solutions/

United Nations Environment Programme, World Economic Forum, The Economics of Land Degradation Initiative and Vivid Economics. (2021). *State of finance for nature 2021*. https://www.unep.org/resources/state-finance-nature

United Nations Environment Programme (UNEP), UNEP-DHI Partnership Centre on Water and Environment, International Union for Conservation of Nature, & The Nature Conservancy. (2014). *Green infrastructure guide for water management: Ecosystem-based management approaches for water-related infrastructure projects*. https://www.greengrowthknowledge.org/sites/default/files/downloads/resource/Green_Infrastructure_Guide_For_Water_Management_UNEP.pdf

U.S. Environmental Protection Agency. (2003). *Cooling summertime temperatures: Strategies to reduce heat islands*. https://www.epa.gov/sites/default/files/2014-06/documents/hiribrochure.pdf

Vineyard, D., Ingwersen, W. W., Hawkins, T. R., Xue, X., Demeke, B., & Shuster, W. (2015). Comparing green and grey infrastructure using life cycle cost and environmental impact: A rain garden case study in Cincinnati, OH. *JAWRA Journal of the American Water Resources Association*, *51*(5), 1342–1360. https://doi.org/10.1111/1752-1688.12320

Vorisek, D., & Yu, S. (2020). *Understanding the cost of achieving the Sustainable Development Goals* (Policy Research Working Paper No. 9164). World Bank. https://openknowledge.worldbank.org/handle/10986/33407

World Health Organization & United Nations Children's Fund. (2019). *1 in 3 people globally do not have access to safe drinking water – UNICEF, WHO* [News release]. https://www.who.int/news/item/18-06-2019-1-in-3-people-globally-do-not-have-access-to-safe-drinking-water-unicef-who

Zhou, Z. C., Shangguan, Z. P., & Zhao, D. (2006). Modeling vegetation coverage and soil erosion in the Loess Plateau Area of China. *Ecological Modelling, 198*(1–2), 263–268. https://doi.org/10.1016/j.ecolmodel.2006.04.019

Annexes

Annex A. Literature review

Annex B. Comparisons of NBI Cost Savings and NBI Value Creation With Built Infrastructure Based on SAVi Assessments

Can can be found here.

NATURE-BASED INFRASTRUCTURE
GLOBAL RESOURCE CENTRE