NATURE-BASED INFRASTRUCTURE
GLOBAL RESOURCE CENTRE

ANNEXES

How Can Investment in Nature Close the Infrastructure Gap?

NBI Report

You can view the full report here.

Annex A. Literature review

Table A1 provides the overview of the literature review on infrastructure investment needs. We reviewed academic publications and reports from international organizations, such as the World Bank, United Nations Environment Programme (UNEP), and the Organisation for Economic Co-operation and Development (OECD). We used the information from these sources to calculate an average annual investment need for each entry (second column, Table A1).

In Table A1, we indicate the geographical and sectoral coverage, as well as the time frame for the estimate provided in the different reports. We note that the assumptions behind these estimates differ depending on the author and scope.

Table A1. Infrastructure investment needs

Name	Average investment need per year (USD billion)	Total investment (USD billion)	Annual/cumulative	From	To	Sectors	Countries	Reference	Comment
Total infrastructure investment needs	**4,041.67**	**97,000**	**cumulative**	**2016**	**2040**	Seven sectors: energy, telecommunication, different transport sectors, and water	50 countries, 85% of global GDP	Global Infrastructure Hub, 2018	Considers SDGs for water and electricity
Water investment needs	304.17	7,300	cumulative	2016	2040	Water sector, including universal access to drinking water, sanitation	50 countries, 85% of global GDP	Global Infrastructure Hub, 2018	Additional investments for reaching water SDG in 2016–2030
Energy investment needs	1,291.67	31,000	cumulative	2016	2040	Energy sector, including universal access to electricity	50 countries, 85% of global GDP	Global Infrastructure Hub, 2018	Additional investments for reaching energy SDG in 2016–2030
Road investment needs	1,416.67	34,000	cumulative	2016	2040	Roads (included in total transport investment need)	50 countries, 85% of global GDP	Global Infrastructure Hub, 2018	
Transportation investment needs	2,079.17	49,900	cumulative	2016	2040	Airports, ports, rail, roads	50 countries, 85% of global GDP	Global Infrastructure Hub, 2018	

Name	Average investment need per year (USD billion)	Total investment (USD billion)	Annual/cumulative	From	To	Sectors	Countries	Reference	Comment
SDG investment needs	414.29	5,800	cumulative	2016	2030	For universal access to drinking water, sanitation, and electricity. Not included in total investment needs	50 countries, 85% of global GDP	Global Infrastructure Hub, 2018	Additional investments for reaching SDGs in 2016–2030
Total infrastructure capital needs	**100.00**	**1500**	**cumulative**	**2015**	**2030**	Water and sanitation, transportation, electricity, irrigation, and flood protection	Low- and middle-income countries	Rozenberg & Fay, 2019	Preferred scenario with high ambitions and high spending efficiency (in 2015 USD)
Total infra maintenance needs	**50.67**	**760**	**cumulative**	**2015**	**2030**	Water and sanitation, transportation, electricity, irrigation, and flood protection	Low- and middle-income countries	Rozenberg & Fay, 2019	Preferred scenario with high ambitions and high spending efficiency (in 2015 USD)
Transport capital needs	28.00	420	cumulative	2015	2030	Transportation, with a shift toward public transport and rail, accompanying policies	Low- and middle-income countries	Rozenberg & Fay, 2019	Preferred scenario with high ambitions and high spending efficiency (in 2015 USD)

Name	Average investment need per year (USD billion)	Total investment (USD billion)	Annual/cumulative	From	To	Sectors	Countries	Reference	Comment
Transport maintenance needs	30.67	460	cumulative	2015	2030	Transportation, with a shift toward public transport and rail, accompanying policies	Low- and middle-income countries	Rozenberg & Fay, 2019	Preferred scenario with high ambitions and high spending efficiency (in 2015 USD)
Water and sanitation capital needs	13.33	200	cumulative	2015	2030	Water, sanitation, and hygiene–safe, not just basic water access	Low- and middle-income countries	Rozenberg & Fay, 2019	Preferred scenario with high ambitions and high spending efficiency (in 2015 USD)
Water and sanitation maintenance needs	4.67	70	cumulative	2015	2030	Water, sanitation, and hygiene–safe, not just basic water access	Low- and middle-income countries	Rozenberg & Fay, 2019	Preferred scenario with high ambitions and high spending efficiency (in 2015 USD)
Flood protection capital needs	6.67	100	cumulative	2015	2030	Coastal and river floods	Low- and middle-income countries	Rozenberg & Fay, 2019	Dutch flood protection standards for cities, higher accepted risks for river floods

Name	Average investment need per year (USD billion)	Total investment (USD billion)	Annual/cumulative	From	To	Sectors	Countries	Reference	Comment
Flood protection maintenance needs	1.33	20	cumulative	2015	2030	Coastal and river floods	Low- and middle-income countries	Rozenberg & Fay, 2019	Dutch flood protection standards for cities, higher accepted risks for river floods
Irrigation capital and maintenance needs	3.33	50	cumulative	2015	2030	Irrigation	Low- and middle-income countries	Rozenberg & Fay, 2019	Costs for extending irrigation to the full extent of available water (after satisfying human and industrial consumption)
Electricity investment and maintenance needs	6.50	97.5	cumulative	2015	2030	Universal access to electricity, including low-carbon technologies and demand management	Sub-Saharan countries and 6 low- and middle-income countries	Rozenberg & Fay, 2019	For middle range service. About half of the total costs are for maintenance. Estimate between USD 92 billion and USD 103 billion.

Name	Average investment need per year (USD billion)	Total investment (USD billion)	Annual/cumulative	From	To	Sectors	Countries	Reference	Comment
Infra investment needs for climate and basic SDGs	**6,900**	**6900**	**annual**	**2015**	**2030**	Energy, transport, water, and telecoms, considering climate	Global	Bhattacharya et al., 2019 based on OECD, 2017	Low-emission, climate-resilient pathway for limiting climate change to 2°C (in 2015 USD)
Energy investment needs	2,700	2700	annual	2015	2030	Energy	Global	Bhattacharya et al., 2019 based on OECD, 2017	Low-emission, climate-resilient pathway for limiting climate change to 2°C (in 2015 USD)
Transport investment needs	2,700	2700	annual	2015	2030	Transportation	Global	Bhattacharya et al., 2019 based on OECD, 2017	Low-emission, climate-resilient pathway for limiting climate change to 2°C (in 2015 USD)
Water and sanitation investment needs	900	900	annual	2015	2030	Water and sanitation	Global	Bhattacharya et al., 2019 based on OECD, 2017	Low-emission, climate-resilient pathway for limiting climate change to 2°C (in 2015 USD)

Name	Average investment need per year (USD billion)	Total investment (USD billion)	Annual/cumulative	From	To	Sectors	Countries	Reference	Comment
Infra investment needs for climate and basic SDGs	**7,900**	**7900**	**annual**	**2015**	**2030**	Energy, transport, water, and telecoms (considering climate)	Global	Bhattacharya et al., 2019 based on Bhattacharya et al., 2016	Low-carbon, climate-resilient pathway for limiting climate change to 2°C (in 2015 USD)
Energy investment needs	3,900	3900	annual	2015	2030	Energy	Global	Bhattacharya et al., 2019 based on Bhattacharya et al., 2016	Low-carbon, climate-resilient pathway for limiting climate change to 2°C (in 2015 USD)
Transport investment needs	2,000	2000	annual	2015	2030	Transportation	Global	Bhattacharya et al., 2019 based on Bhattacharya et al., 2016	Low-carbon, climate-resilient pathway for limiting climate change to 2°C (in 2015 USD)
Water and sanitation investment needs	900	900	annual	2015	2030	Water and sanitation	Global	Bhattacharya et al., 2019 based on Bhattacharya et al., 2016	Low-carbon, climate-resilient pathway for limiting climate change to 2°C (in 2015 USD)

Name	Average investment need per year (USD billion)	Total investment (USD billion)	Annual/cumulative	From	To	Sectors	Countries	Reference	Comment
Investment needs for NBS	**279.31**	**8100**	**cumulative**	**2021**	**2050**	Nature-based solutions (forests, mangroves, peatland, and silvopasture)	Global	UNEP, 2021	Scenario: Limit climate change to 2°C, stabilize biodiversity by 2050 at today's levels, and stop land degradation
Reforestation/ afforestation investment needs	161.52	4684	cumulative	2021	2050	Forests	Global	UNEP, 2021	Forest and agroforestry area increases by 300 million ha by 2050 compared to 2020
Mangrove restoration investment needs	0.52	15	cumulative	2021	2050	Mangroves	Global	UNEP, 2021	
Peatland restoration investment needs	10.38	301	cumulative	2021	2050	Peatland	Global	UNEP, 2021	

Name	Average investment need per year (USD billion)	Total investment (USD billion)	Annual/cumulative	From	To	Sectors	Countries	Reference	Comment
Silvopasture	107.93	3130	cumulative	2021	2050	Silvopasture	Global	UNEP, 2021	Forest and agroforestry area increases by 300 million ha by 2050 compared to 2020
SDG investment needs	6000	6000	annual	2015	2030	Basic infrastructure, food security, climate adaptation and mitigation, health, education	Global	Vorisek & Yu, 2020 based on United Nations Conference on Trade and Development (UNCTAD), 2014	Estimated between USD 5 trillion and 7 trillion
Food security investment needs	265	265	annual	2016	2030	Food/agriculture	Global	Vorisek & Yu, 2020, based on Food and Agriculture Organization of the United Nations (FAO) et al., 2015	Investment needed to sustainably end hunger

Name	Average investment need per year (USD billion)	Total investment (USD billion)	Annual/cumulative	From	To	Sectors	Countries	Reference	Comment
Water and sanitation investment needs	120	120	annual	2015	2030	Water, sanitation, and hygiene	Global	Vorisek & Yu, 2020, based on Hutton & Varughese, 2016	To meet targets 6.1 and 6.2 of SDG 6 on clean water and sanitation, the estimate ranges from USD 74 billion to USD 166 billion.
Climate adaptation costs	85	85	annual	2010	2050	Infrastructure, coastal zones, water supply, agriculture, fisheries, forests and ecosystems, human health, and extreme weather events	Developing countries	Narain et al., 2011	For adapting to 2°C global warming. Defines “adaptation costs” as those additional costs of development due to climate change (in USD 2005). Estimates between USD 70 billion and USD 100 billion.

Name	Average investment need per year (USD billion)	Total investment (USD billion)	Annual/cumulative	From	To	Sectors	Countries	Reference	Comment
Infrastructure adaptation costs	27.52	27.52	annual	2010	2050	Measures like design standards, climate-proofing maintenance	Developing countries	Narain et al., 2011	Costs for adapting to 2°C of warming. National Center for Academic Research (NCAR) climate scenario (in 2005 USD).
Coastal zones adaptation costs	28.48	28.48	annual	2010	2050	Measures like river and sea dikes, beach nourishment, port upgrades	Developing countries	Narain et al., 2011	Costs for adapting to 2°C of warming. NCAR climate scenario (in 2005 USD).
Water supply and flood protection adaptation costs	14.36	14.36	annual	2010	2050	Measures like reservoir storage, recycling, rainwater harvesting, desalination, flood protection dikes and polders	Developing countries	Narain et al., 2011	Costs for adapting to 2°C of warming. NCAR climate scenario (in 2005 USD).

Name	Average investment need per year (USD billion)	Total investment (USD billion)	Annual/cumulative	From	To	Sectors	Countries	Reference	Comment
Agriculture, forestry, fisheries adaptation costs	2.54	2.54	annual	2010	2050	Measures like rural roads, irrigation infrastructure expansion, efficiency improvements, livelihood diversification	Developing countries	Narain et al., 2011	Costs for adapting to 2°C of warming. NCAR climate scenario (in 2005 USD).
Human health adaptation costs	1.97	1.97	annual	2010	2050	Measures related to prevention and treatment of disease	Developing countries	Narain et al., 2011	Costs for adapting to 2°C of warming. NCAR climate scenario (in 2005 USD).
Costs of adapting to extreme weather events	6.68	6.68	annual	2010	2050	Investment in human resources	Developing countries	Narain et al., 2011	Costs for adapting to 2°C of warming. NCAR climate scenario (in 2005 USD).
Additional spending needs for SDGs		2,600	/	/	2030	Education, health, roads, electricity, and water and sanitation	121 emerging market economies and low-income countries	Gaspar et al., 2019	

Name	Average investment need per year (USD billion)	Total investment (USD billion)	Annual/cumulative	From	To	Sectors	Countries	Reference	Comment
Sea dike investment costs	7.5	7.5	annual			Sea dikes	Global	Brown et al., 2021	For 2°C global warming and shared socio-economic pathway (SSP) 5 at 1 m sea level rise. Number extracted from Figure 3 in Brown et al., 2021.

Table A2 provides an overview which infrastructure sectors are covered in the different studies.

Table A2. Sectoral investment need coverage

Study name	Water and sanitation	Energy	Transport	Agriculture	Irrigation	Climate resilience
Global Infrastructure Outlook (Global Infrastructure Hub, 2018)	x	x	x			
Beyond the Gap (Rozenberg & Fay, 2019)	x	x	x		x	x
Investing in Climate, Investing in Growth (OECD, 2017)	x	x	x			
Aligning G20 Infrastructure investment… (Bhattacharya et al., 2019)	x	x	x			
State of Finance for Nature 2021 (UNEP, 2021)				x		
Understanding the Cost of Achieving the SDGs (Vorisek & Yu, 2020)	x			x		
"Estimating Costs of Adaptation to Climate Change" (Narain et al., 2011)				x		x
"Global Costs of Protecting Against Sea Level Rise" (Brown et al., 2021)						x

Table A3 brings together the results of the average annual investment needs (Table A1) with the sectoral overview (Table A2) to provide an average annual investment need per sector (USD billion).

The numbers show great variation within the infrastructure sectors. This can partly be attributed to diverging country coverage and assumptions, such as climate mitigation efforts, levels of ambitions, and socio-economic assumptions.

Table A3. Average annual investment needs per sector (USD billion)

Study name	Water and sanitation	Energy	Transport	Agriculture	Irrigation	Climate resilience
Global Infrastructure Outlook (Global Infrastructure Hub, 2018)	304.17	1,291.67	2,079.17			
Beyond the Gap (Rozenberg & Fay, 2019)	18.00	6.50	58.67		3.33	8.00
Investing in Climate, Investing in Growth (OECD, 2017)	900.00	2,700.00	2,700.00			
Aligning G20 Infrastructure investment... (Bhattacharya et al., 2019)	900.00	3,900.00	2,000.00			
State of Finance for Nature 2021 (UNEP, 2021)				107.93		
Understanding the Cost of Achieving the SDGs (Vorisek & Yu, 2020)	120.00			265.00		
"Estimating Costs of Adaptation to Climate Change" (Narain et al., 2011)				2.54		70.36
"Global Costs of Protecting Against Sea Level Rise" (Brown et al., 2021)						7.50
Average investment need per year (USD billion)	**448.43**	**1,974.54**	**1,709.46**	**125.16**	**3.33**	**28.62**

Table A4 provides an overview of the infrastructure services that nature can provide. We used this table to further determine how NBI can replace or complement grey infrastructure.

Table A4. Overview of infrastructure services of nature

Sector	Available infrastructure
Water and sanitation, irrigation	**Water retention and supply** **Built:** Water reservoirs, dams **NBI:** Freshwater ecosystems like wetlands, as well as forests, sustainable urban drainage systems, and green spaces can increase or sustain water supplies by increasing soil infiltration, storage, and aquifer recharge. They provide water, contribute to drought mitigation, and support biodiversity, nutrition, and recreation.
Water and sanitation	**Water filtration and quality regulation, stormwater treatment** **Built:** Water treatment plants **NBI:** NBI like vertical and horizontal flow treatment wetlands, willow systems, treatment reed beds, treatment ponds, natural wetlands, and soil infiltration systems can effectively treat wastewater. They can be applied at different treatment stages and demonstrate high treatment efficiency. For example, vertical-flow treatment wetlands can reduce chemical oxygen demand, total suspended solids, and ammonium by up to 90%. Natural wetlands, riparian buffers, bioswales, vegetated roadsides, and forests can purify polluted water, protect groundwater from future contamination, and enhance pre-existing water treatment facilities. These NBI trap sediments, remove toxins, and regulate nutrient levels while also supporting natural water cycles. For example, New York conserves forests in the Catskill Mountains to source clean drinking water and avoid investments in filtration plants.

Sector	Available infrastructure
Energy	**Energy demand** **Built:** Air conditioning, building retrofits **NBI:** Trees and green spaces can regulate temperatures and reduce energy needs. For example, Houston's 663 million trees are providing cooling that reduces the need for air conditioning valued at USD 131 million annually, while San Francisco's urban forest canopy saves an estimated USD 27 million in natural gas costs and USD 305 million in electricity. In addition, the trees store carbon, improve property values, and support biodiversity. Space cooling was responsible for emissions of about 1 $GtCO_2$ and nearly 8.5% of total final electricity consumption in 2019.
Energy	**Renewable energy** **Built:** Wind, geothermal **NBI:** Small-scale hydropower and biomass are renewable sources of energy. About half the costs for universal access to electricity is for operations and maintenance in countries with a lack of electricity access.
Agriculture	**Agricultural productivity** **Built:** Water reservoirs, drainage and irrigation systems, protective features such as rain covers **NBI:** Agricultural practices like agroforestry can improve water availability, increase yields, protect crops from extreme weather, improve soil quality, and provide fodder for livestock. They also increase carbon storage and help to stabilize biodiversity.

Sector	Available infrastructure
Climate mitigation	**Carbon storage** **Built:** Carbon capture **NBI:** Conservation, restoration, and improved land management actions such as reforestation, forest management, agroforestry, and peat restoration can contribute to climate mitigation. The maximum carbon storage and emissions reduction potential of such natural climate solutions is 23.8 petagrams of CO_2 equivalent ($PgCO_2e$) y^{-1} (95% CI 20.3–37.4). Natural climate solutions can provide up to 37% of global cost-effective solutions needed until 2030. Cost-effectiveness in this case assumes that the social cost of CO_2 pollution is ≥100 USD $MgCO_2e^{-1}$ by 2030.
Transport	**Flood protection** **Built:** Sewage upgrades, road design, retention basins **NBI:** Nature-based stormwater infrastructure such as wetlands and swales can reduce flood risks. The inclusion of stormwater management in road design supports natural water cycles and reduces the chance of flooding and road washouts. About half the total costs for transportation are needed for maintenance (see Table 1).
Transport	**Wildlife and biodiversity** **Built:** Conventional infrastructure design **NBI:** Ecopassages allow for wildlife to safely bypass roads and other linear infrastructure, which facilitates access to otherwise fragmented habitats and supports biodiversity.

Sector	Available infrastructure
Climate resilience	**Coastal flood protection** **Built:** Seawalls, dikes, storm surge barriers **NBI:** Mangroves, reefs, dunes, and coastal marshes reduce storm waves and surges. They can also accumulate sediments, avoid erosion, and are a habitat for diverse species. Other co-benefits include carbon sequestration and possible increases in recreation and fishing opportunities.
Climate resilience	**Urban stormwater management, flood risks reduction** **Built:** Sewerage systems, water retention basins, dikes, flood gates **NBI:** Green spaces, urban wetlands, rain gardens, and green roofs can retain and infiltrate water, as well as reduce runoff speed. This can reduce flood damage, sewage overflows, and contamination. In addition, NBI helps to regulate temperatures and provides space for nature and recreation. Forest management, riparian buffers, wetlands, reconnecting rivers to floodplains, and re-naturalizing rivers and streams reduce flood risks at the watershed scale. These NBI systems increase river discharge capacity, reduce flow velocity, and lower peak discharges. They can also regulate water quality and natural water cycles and benefit nature and recreation.

Sources: Cross et al., 2021; DiMuro et al., 2014; Griscom et al. 2017; International Energy Agency (IEA), 2020b; Kabisch et al., 2017; Lesbarres & Fahrig, 2012; Roth, 2013; Rozenberg & Fay, 2019; Storey et al., 2009; Talberth et al., 2016; Temmerman et al., 2013; UNEP et al., 2014; United Nations Educational, Scientific and Cultural Organization, 2018.

Table A5 brings together the information we gathered in the previous steps to ultimately calculate the share of the global investment need per sector that can be filled through NBI. The information on the NBI contribution (third column, Table A5) is based on evidence from the referenced literature. We found a wide range of qualitative and, to a lesser extent, quantitative information available on how nature can provide infrastructure services, but the evidence is scattered and there is no consolidated knowledge on the exact extent to which NBI can provide infrastructure services.

Table A5. Share of infrastructure needs that can be filled by NBI

Sector	Average investment need per year (USD billion)	NBI contribution	Share of investment that could be NBI	Potential NBI investment per year (USD billion)
Water and sanitation	448.43	**Yes, for water filtration and quality regulation, water retention and supply.** • Investment needs of USD 14.4 billion annually for adapting water supply and flood protection to climate change through reservoir storage, recycling, rainwater harvesting, desalination, dikes; just for developing countries and additional adaptation (Narain et al., 2011). • NBI like treatment wetlands, willow systems, and soil infiltration systems have a high wastewater treatment efficiency (Cross et al., 2021). For example, French vertical-flow treatment wetlands reduce chemical oxygen demand, a key indicator for water quality, by more than 90% and can be used for untreated wastewater. NBI alone can fulfill wastewater treatment requirements, but they can also be combined with grey infrastructure. • A single rain garden can offset 34% of the yearly eutrophication impact of an average U.S. citizen (Vineyard et al., 2015). • A study in Ohio (United States) indicates that implementing rainwater harvesting could reduce combined sewer overflows and improve life-cycle cost-effectiveness by 48%. The collected rainwater could also cover the water demand for flushing toilets (Tavakol-Davani et al., 2016). • Improved local water supply can reduce the need to pump water from distant sources, which is costly and often inefficient. “Drinking water is lost after it leaves treatment plants because of physical leaks in urban water distribution systems and poor accounting. ... Pipeline losses range from over 50% in much of the developing world to less than 10% in well run utilities. The World Bank estimates that if just half of the losses in developing countries were eliminated, $1.6 billion would be saved	25% Reason: Restricted space for NBI in urban areas, and a high volume of required services, need for built infrastructure and maintenance.	112.11

Sector	Average investment need per year (USD billion)	NBI contribution	Share of investment that could be NBI	Potential NBI investment per year (USD billion)
		annually in production and pumping costs, and drinking water could be extended to an additional 90 million people without the need for new treatment facilities" (Grant et al., 2012). • Operation and maintenance costs account for more than half of the financing needs for water and sanitation (Rozenberg & Fay, 2019).		
Energy supply	1,382.18	**Yes, increased renewable energy supply** • Modern bioenergy for electricity, transport, and heating makes up about one tenth of global primary energy supply today (IEA, 2020a). • Hydropower supplies about half of global renewable electricity. By 2015, renewable sources of electricity are expected to provide about 30% of global electricity supply (IEA, 2020c).	5% Reason: We assume 70% of the investment need in the energy sector is for energy supply. NBI can be used for microhydropower and bioenergy.	69.11
Energy efficiency	592.36	**Yes, reduced energy needs for cooling.** • Space cooling was responsible for nearly 8.5% of total final electricity consumption in 2019 (IEA, 2020b). • Implementing green roofs can reduce the building's energy consumption by 15%–45% per year (UNEP et al., 2014). • In comparison to built-up areas in the same town or city, urban green spaces are on average 1°C cooler (Bowler et al., 2010). • Areas with trees are cooler by 2.15˚C (0.7°C–3.6 ˚C range in the literature review depending on location and method) (Bassi et al., 2020). • A 0.6˚C increase in air temperature can increase peak utility load by 2% (U.S. Environmental Protection Agency, 2003).	10% Reason: We assume 30% of the investment need is for energy efficiency and demand-side measures. Green roofs and walls reduce energy demand.	59.24

Sector	Average investment need per year (USD billion)	NBI contribution	Share of investment that could be NBI	Potential NBI investment per year (USD billion)
		• Bhattacharya et al. (2016) assume that USD 8.8 trillion is required for improving the energy efficiency of buildings, industry, and transportation (USD 586 billion per year).		
Transport	1,709.46	**Yes, reduced flood risks and damages, and reduced maintenance costs** • Operation and maintenance costs represent approximately 50% of the costs for transportation infrastructure. Good maintenance can reduce the life-cycle cost of transport infrastructure by 50% (Rozenberg & Fay, 2019). • Permeable pavements can contribute to flood mitigation by reducing stormwater runoff by 70%–90% (Foster et al., 2011; UNEP et al., 2014). • Green roofs retain about 53% of precipitation compared to 14% for flat asphalt roofs (Berghage et al., 2009).	10% of the investments Reason: NBI can be part of coherent planning for resilient transport infrastructure.	170.95
Agriculture	125.16	**Yes, increased productivity and climate resilience, avoided land degradation** • Silvoforestry investment needs amount to USD 104.3 billion annually (UNEP, 2021). • Vegetation prevents soil erosion. A study in China found that for a 1% annual increase in vegetation cover, soil erosion could be reduced by 456 $t/km^2/a^{-1}$ (Zhou et al., 2006).	50% of the investments Reason: Agricultural production will embrace NBI, but grey infrastructure is needed for machinery and supply chains.	62.58
Irrigation	3.33	**Yes, reduced need and cost for irrigation through improved water supply** (wetland/soil infiltration and storage, groundwater recharge) • Over 40% of total water use in the European Union goes to agriculture (80% in some regions). 20% of cultivated land worldwide is irrigated.	20% of the investments Reason: NBI can improve water	0.67

Sector	Average investment need per year (USD billion)	NBI contribution	Share of investment that could be NBI	Potential NBI investment per year (USD billion)
		Farming uses about 70% of global water withdrawals and up to 95% in some developing countries (Rossi, 2019).	supply, but there is a need for built irrigation infrastructure.	
Climate resilience	28.62	**Yes, for coastal and inland flood mitigation** • Mangrove restoration investment needs USD 0.5 billion annually; peatland restoration investment needs USD 10 billion annually (UNEP, 2021). • "Lami Town, a coastal town in Fiji, is very susceptible to storm surges, flooding and erosion, as it is predominantly built over shallow soils on sloped hills. A cost-benefit assessment of Lami Town compared engineered options to NI-based alternatives for storm protection, such as mangrove conservation. Benefits were estimated to range from FJD 8 to FJD 19.50 for every dollar spent on NI-based coastal adaptation, with an assumed damage avoidance of 10–25 per cent. These values include avoided health costs, damage to businesses and households, and damage to ecosystem services. Engineered options (grey infrastructure) only reaped benefits of FJD 9 but have an assumed damage avoidance of 25–50 per cent. Therefore, the best plan based on cost-to-benefit and assumed level of avoided damage was established to be a combination of engineered and NI-based alternatives, using the more efficient, engineered measures in areas of particular economic importance" (Bassi et al., 2019, based on Rao et al., 2012). • "The cost of building, operating and maintaining a built infrastructure project is more expensive than allowing ecosystem services to carry out their natural functions. As seen in Figure 1, comparing a seawall with a natural/ living shoreline shows that the maximum capital cost for NNBI is just about as high as the lower end of capital costs for grey infrastructure	50% Reason: NBI can address coastal, river, and urban flood risks by regulating water volume and speed.	14.31

Sector	Average investment need per year (USD billion)	NBI contribution	Share of investment that could be NBI	Potential NBI investment per year (USD billion)
		(Cunnif & Schwartz, 2015). Capital costs for seawalls can be as high as USD 32,800 per metre, but typical costs range between USD 6,500 and USD 9,800 per metre, whereas typical costs for a natural/living shoreline ranges between USD 0 and USD 6,562 per metre. In addition to higher capital costs, O&M costs can be as much as six times higher for seawalls, and they generate no added benefits beyond their original purpose (Sutton-Grier et al., 2018)" (Bassi et al., 2019).		
All sectors	**4,289.54**	**Given uncertainty in the gap estimations in the literature, how to group investment categories, and how to determine the NBI share, we use a range of USD 400 billion to USD 600 billion or estimate that NBI can cover between 9% and 14% of the infrastructure gap.**	**11.40%**	**488.95**

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

Table B1. Lifetime, undiscounted costs and value generated by nature-based infrastructure (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	60,116	447,331	643,483	795,129
Rainbow Junction	Green roofs and tree planting	185	N/A	223,655	N/A

Table 1. 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	98%	0%	~~119.5~~	2.4
Stephenfield Reservoir	Water reservoir	-38%	0.2%	~~73.9~~	~~101.8~~
Lake Dal	Water treatment	-8.6%	36.9%	22.2	15.2
Saloum Delta	Wetland	100%	96.3%	N/A	0.1
S'Ena Arrubia Wetland	Wetland	42.1%	11.7%	5.6	2.8
Corru S'Ittiri Wetland	Wetland	77.7%	11.5%	15.1	3.0
Stormwater in Johannesburg	Water treatment	47.2%	100%	3.1	0.0
Indonesia Forest Restoration	Tree planting and water retention wells	N/A	N/A	11.9	N/A
Addis Ababa Tree Planting	Tree planting	86.6%	-23.6%	10.7	1.8
Rainbow Junction	Green roofs and tree planting	N/A	N/A	1.2	N/A
Average	50.6%	29.1%	10.0	3.6	

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.

Table B3. Summary

Total infra need (literature review)		
	4,290	Annual
	85,791	Cumulative (20 years)
NBI potential (literature review)		
	11.40%	% of the total gap
	489	Annual
	9,779	Cumulative
Actual investment and savings – NBI		
	50.7%	Cost saving for capital and O&M investment
Investment	241	Annual
Investment	4,821	Cumulative (20 years)
Saving	248	Annual
Saving	4,958	Cumulative (20 years)
Value creation from infrastructure		
Grey	**3.57**	USD of value per USD invested (weighted average)
	1,744	Annual
	34,884	Cumulative
NBI	**28%**	Percent increase in value created
	2,233	Annual
	44,661	Cumulative (20 years)
Additional value - NBI		
Extra value (from ES)	489	Annual
Extra value (from ES)	9,777	Cumulative
Total USD per USD invested in NBI	9.26	
Extra USD per USD invested	2.03	
Total value compared to built infrastructure	737	
Total value NBI per capita	94	

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