Policy Brief - November 2021

Scaling up Circular Economies through Sustainable Infrastructure

Background

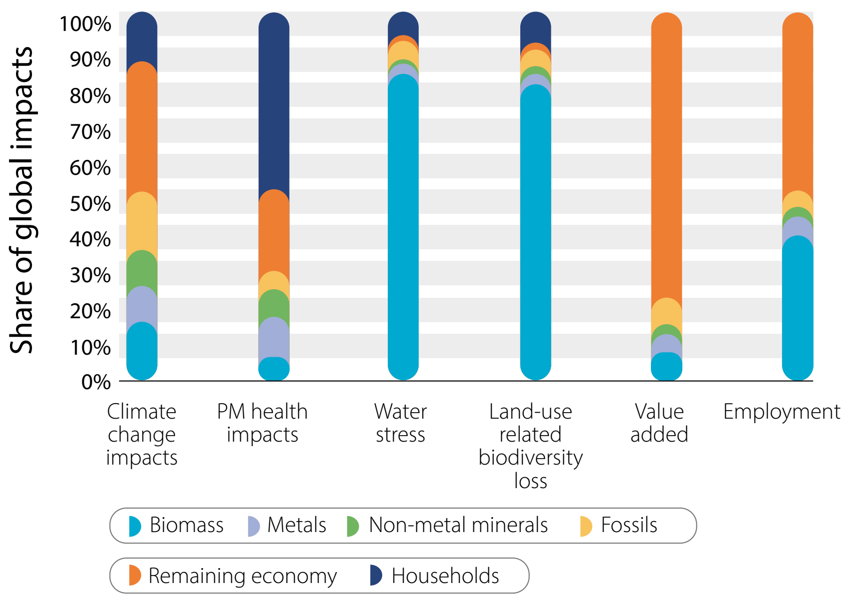
Traditionally, industrial economies have continually relied on a single model of resource consumption: a linear economic model that follows a "take-make-dispose" pattern. This has led to ever-increasing resource extraction and excessive waste generation, exerting significant pressure on the environment.[1]

The amount of natural resources used in buildings and transport infrastructure increased 23-fold between 1900 and 2010, and approximately 79%[2] of global greenhouse gas (GHG) emissions are associated with infrastructure.[3, 4, a] If we continue to follow linear economic models, both resource extraction and GHG emissions will continue to increase in the future as more infrastructure is built to meet the needs of a growing and increasingly urban population.

An estimated 75% of the infrastructure that will exist in 2050 remains to be built.[5] Excessive resource extraction leads to ecosystem degradation, sediment erosion, and biodiversity loss. It is estimated that resource extraction and processing are correlated with more than 90% of biodiversity loss and comprise approximately half of the global GHG emissions (see Figure 1).[6] These impacts also have serious consequences on water and food security and, therefore, on human well-being.[1]

In addition to damage caused by extractive processes and GHG emissions, infrastructure is also a major source of solid waste and other forms of pollution throughout its lifecycle. In developed countries, for example, 40% of solid waste comes from the construction, maintenance, and demolition of buildings.[7]

Figure 1: Share of the total global environmental impacts and socio-economic benefits between resource types (extraction and processing), the remaining economy (i.e., without the resource extraction and resource processing sectors), and households.



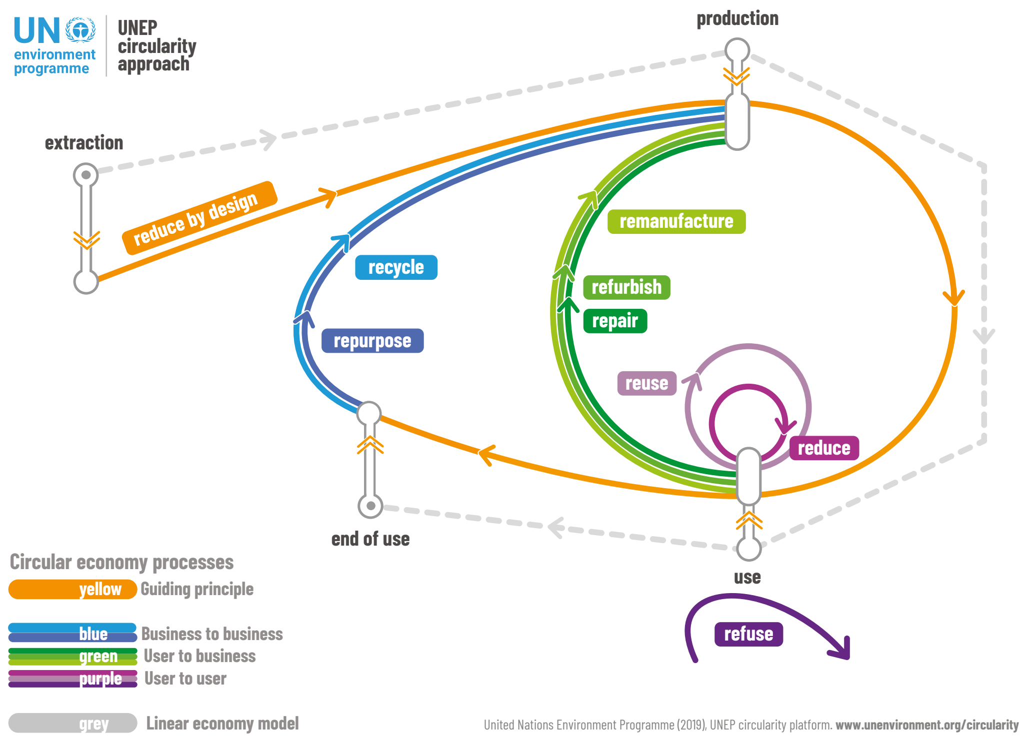
Source: International Resource Panel, Global Resources Outlook 2019 (2019)[8]

a. Food systems are expected to contribute to half of the world's GHG emissions by 2050, as per the International Monetary Fund (IMF) and Intergovernmental Panel on Climate Change (IPCC), https://blogs.imf.org/2020/07/14/why-sustainable-food-systems-are-needed-in-a-post-covid-world/.

Value is lost at every stage of the linear production process through waste and inefficiency. Therefore, systemic changes to this approach would be consequential for natural resource use and efficiency.[5] Reaching the 1.5°C target of the Paris Agreement and reducing stress on the environment can only be achieved through bold government leadership, scaling up efforts on energy efficiency and renewable energy, and with transformational shifts to a circular economy among all actors.[9]

A circular economy is one in which "the value of products, materials, and resources is maintained in the economy for as long as possible", and resource extraction and waste generation are minimized.[4] Circular economic models decouple economic growth from resource consumption by extending the useful life of the things we make, build, and use, and by closing material loops (see Figure 2). Thus, "waste" from certain products and processes serves to provide inputs for other products and processes (also known as "industrial symbiosis").[10]

Figure 2: Circular economy processes



Source: UNEP circularity platform[11]

Transitioning to circular economic models will require infrastructure that is fit for purpose. Infrastructure must be planned, built, and operated in a way that maximizes synergies between infrastructure systems to enable industrial symbiosis and closed loops. A shift towards sourcing materials locally, more shared ownership, and flexible models can also help reduce the resource intensity of infrastructure systems.[12] The successful implementation of these concepts requires strategic planning during the early phases of the infrastructure lifecycle, prior to the development of infrastructure projects.

COVID-19 economic recovery packages present a particularly favourable opportunity to introduce policies and economic incentives to promote this shift to a more sustainable, flexible, and circular infrastructure. Given that infrastructure systems have decades-long lifespans, it is critical that stimulus investment is targeted at sustainable infrastructure. The infrastructure we build today will help shape the economy of tomorrow; the magnitude of the resulting costs and benefits depends on the choices we make now.

The remainder of this policy brief outlines key opportunities and requirements for mainstreaming circular economy principles into sustainable infrastructure development and elaborates on how infrastructure development can support more circular economies.

KEY MESSAGES

1. 'Systems' thinking and integrated approaches to infrastructure planning accelerate transitions to a circular economy.

Infrastructure systems in different sectors are interlinked and interdependent. Integrated, systems-level approaches to infrastructure planning and development consider these connections, as well as the relationship of infrastructure with its economic, environmental, and social context. These approaches maximize synergies between different infrastructure systems and sectors, close resource and material loops, enable industrial symbiosis, and decouple consumption (and carbon) from growth. The density of infrastructure in cities and campuses (education, industrial, health care, etc.) presents an excellent opportunity to integrate spatial planning and circular infrastructure design through, for instance, waste-to-energy facilities or district energy systems. Eco-industrial parks – communities of businesses from diverse sectors located together on common property and cooperating with each other – further demonstrate the benefits of an integrated approach. For example, by developing systematic waste and by-product networks among companies, between 2005 and 2016 the Ulsan Mipo and Onsan Industrial Park in South Korea collectively reduced 279,000 tons of oil equivalent in energy use, resulting in a 665,000-ton reduction in CO_2 emissions. They also reused 79,000 tons of water and 40,000 tons of waste and by-products.[13,14] The companies involved invested USD 520 million in industrial symbiosis and saved USD 554 million, while reducing their collective carbon footprint.[15] Integrated approaches can and should be encouraged beyond the city level, as regions and national governments can play a significant role in creating transformational and necessary incentives that can mainstream such practices across territories and industries.

2. New business models and reuse practices improve the circularity of built infrastructure.

New business models, such as performance-based contracts and product-as-a-service concepts can encourage developers to efficiently produce or use sustainable, long-lasting building components, thereby reducing the need for new resources. Moreover, early in the infrastructure cycle, built infrastructure can be designed to facilitate the reuse (more recently known as "looping") of building components. This can be achieved by reusing materials from decommissioned infrastructure assets, thus allowing elements and materials to remain in the value chain for longer. The retrofit work of Brummen town hall in the Netherlands presents a good example, where architects designed the building for disassembly and each building component received a material passport to facilitate its reuse after disassembly.[16] Innovative techniques play a central role in the effective deconstruction of buildings. For instance, the Grand Prince Hotel Akasaka in Tokyo was dismantled using new techniques that preserve beams, concrete, and other key structural elements. The crane used to lower these materials to ground level is able to generate energy through this demolition process, too.[17] Even if buildings are not designed with disassembly and reuse in mind, recycling is still possible by recovering materials and waste for use as new building material. The United States of America encourages the practice of greening federal buildings through their design, construction, retrofit, and operations. Indeed, the United States Environmental Protection Agency buildings in Virginia demonstrated this practice by earning Leadership in Energy and Environmental Design (LEED) certifications and using 27% of its construction material from recycled compounds such as fly ash and gypsum wallboard.[18,19,20]

3. Sharing, multi-purposing, and repurposing can deliver quality services with less infrastructure.

Maximizing the utilization of existing assets can reduce the demand and need for new infrastructure. For instance, in the mobility sector there is an increasing trend away from ownership and towards sharing models. Car-share users worldwide are estimated to increase by more than 20% over the next four years, reaching 58.3 million users in 2025.[21] There is also great potential for sharing models in the building sector. Even before the outbreak of COVID-19, 40% of all office space was empty on any given workday.[22] During the COVID-19 pandemic, empty office space became even more common, and much space will likely remain under-utilized in the long-run due to remote working. This means that vast amounts of resources and waste can be reduced by increasing the utility of floor space through sharing, multi-purposing and repurposing existing assets. Many sharing platforms do exactly this by renting out unused offices and housing. Multi-purposing of buildings can also increase the efficiency of floor space by allowing different activities to take place in the same vicinity without the need for significant modifications. For example, events can be hosted in schools or libraries in the evening when the area is not being used. Repurposing of existing buildings also reduces the need for demolition, by converting free office space into residential housing or repurposing old industrial facilities and warehouses. A good example is the idle 93-year-old grain silo complex in Cape Town that was repurposed to become the Zeitz Museum of Contemporary Art Africa (MOCAA).[23]

4. Incorporating digital and other innovative technologies into infrastructure planning can unlock circular economy opportunities and enhance value.

Digital technologies and other new, innovative approaches could potentially play a key role in the transition towards more circularity-enabling infrastructure. For example, big data, analytics, artificial intelligence, and the Internet of things can provide information about the location, condition, and availability of assets, while also sharing and connecting relevant data and systems.[b] This could increase the utilization of infrastructure assets or resources and improve the looping of materials through additional use cycles.[24] Another exciting development is 3D printing, which can produce building modules and components. The benefits of this approach have already been demonstrated by building full-sized houses solely with materials and components made by 3D printers, realizing up to 60% material savings.[25] Innovative technologies can also accelerate circular economy practices across sectors. For example, RichWater, a project in Spain, developed a low-cost, energy-efficient membrane bioreactor that treats local community wastewater and releases nutrient rich water to irrigate crops.[26]

b. Innovative tools such as the Open Contracting for Infrastructure Data Standard (OCDS) help centralize data from across the entire infrastructure projects cycle, making it available in real time. The standard adopts a project unifier approach, bringing together data from project, contracts and procurement processes. This tool and others like it can be found at the Sustainable Infrastructure Tool Navigator website: https://sustainable-infrastructure-tools.org.

5. Strong policy frameworks and adjusted public procurement practices are decisive in order to mainstream circularity into infrastructure development.

Governments can and must lead by actively promoting a shift towards circular, sustainable infrastructure by establishing incentivizing policy frameworks, including robust regulations, standards, fiscal and financial measures, and implementing sustainable public procurement practices. Regulatory frameworks can be targeted at circular economy practices directly, through ambitious mandatory recycling rates, or indirectly, through resource efficiency, GHG emission targets, or national competitions promoting best practices, such as "smart city" challenges.[27] Fiscal reforms, such as shifting taxation from labour to extraction and consumption of natural resources or generation of waste, can also lead to increased investment in circular, resource-efficient infrastructure.[28] New Zealand, for instance, plans to introduce a waste disposal levy for construction and demolition landfills of NZD 30 per ton and will use the collected revenue for resource recovery and waste reduction.[29] Other financial incentives, such as retrofit and renovation subsidies and research grants could stimulate the private sector to reduce new construction and further invest in circular infrastructure research and development. Governments can also incentivize businesses and industries to adopt circular economy practices by adjusting current public procurement practices around circularity. This can be done by incorporating circularity and sustainability as essential criteria in the bidding process for infrastructure projects, as well as in final contracts. Adjusting public procurement practices and building additional staff capacity, in impact assessment and lifecycle thinking, are especially important as governments are the primary planners and financers of infrastructure projects and therefore hold considerable power to drive change at scale.[30] Over time, consistent application of sustainable public procurement will hopefully lead to companies aligning operations, aiding the mainstreaming of circularity practices.

6. Coordination and consultation can remove barriers and ensure enabling policy efficacy.

Many barriers remain to the full incorporation of circularity in infrastructure, including market failures, such as split incentives, and regulatory failures, such as the unintended consequence of obsolete building codes and regulatory frameworks.[21] Aligning incentives and removing regulations that hamper circular practices are critical to closing loops and inefficiencies in the value chain. Better enabling policies, stronger institutional arrangements, access to finance, and strong political will are additional key ingredients that must be recognized and embraced. In order to improve the enabling environment, government agencies must collaborate both horizontally (across departments) and vertically (across sub-national, national, international levels) to provide multi-disciplinary, well-aligned solutions that maximize system effectiveness. These top-down processes should be accompanied by bottom-up approaches like stakeholder consultation to ensure inclusiveness, transparency, and better local knowledge.

7. Active private sector involvement is crucial for scaling up a circular economy.

There are three main reasons for this. First, intense private sector involvement throughout the process can provide governments with insights that help identify the best circular economy opportunities and key barriers in each sector. Second, collaborating with businesses, through public-private partnerships, for example, leads to an early alignment of incentives and strategy – an important condition for achieving transformation in an efficient and timely manner. Third, including the private sector in planning efforts can further illuminate and demonstrate opportunities and benefits to businesses, which may encourage them to expand capacity.[21] For instance, research has shown that in the European Union (EU), a circular economy can potentially lead to net annual resource savings for EU companies of EUR 0.6 trillion through waste prevention, reuse, and eco-design, while also reducing annual GHG emissions.[19,31] Moreover, the estimated net increase in employment created through a circular economy in the EU amounts to 700,000 jobs by 2030.[32]

Call to Action

These seven key messages are a starting point for conversations, strategies, and initiatives to help accelerate circular economy transitions in infrastructure. The members of the Sustainable Infrastructure Partnership are committed to building the connections and supporting programmes working towards these ends. For further information on this topic and other key sustainable infrastructure principles, please refer to the International Good Practice Principles for Sustainable Infrastructure: https://www.greengrowthknowledge.org/research/international-good-practice-principles-sustainable-infrastructure.

Acknowledgements

UNEP would like to thank Motoko Aizawa (the Observatory for Sustainable Infrastructure), Charlotte Broyd (CoST Infrastructure Transparency Initiative), Andy Cole (World Food Programme), Cristina Contreras Casado (Sinfranova), Alexandra Gonzalez (World Food Programme), Jim Hall (University of Oxford), Oliver Hillel (Convention on Biological Diversity Secretariat), Mervyn Jones (the Ministry of Infrastructure and Water Management of the Netherlands), Bill Kelly (Asian Civil Engineering Coordinating Council Technical Committee 14 on Sustainable Infrastructure), Arend Kolhoff (Netherlands Commission for Environmental Assessment), Katrina Pielli (World Food Programme), Graham Pontin (International Federation of Consulting Engineers), Judith Rodriguez (Zofnass Program for Sustainable Infrastructure, Harvard University), Marie-Aimée Salopiata (UNEP), Scott Thacker (United Nations Office for Project Services), and Anna-Sophia Elm, Dominic MacCormack, Rowan Palmer, Joseph Price, Chengchen Qian, Fulai Sheng, and Ying Zhang (all UNEP) for their valuable contributions to this policy brief.

The Observatory

Convention on Biological Diversity

Sinfranova

CoST Infrastructure Transparency Initiative

ZOFNASS PROGRAM FOR SUSTAINABLE INFRASTRUCTURE

UNOPS

References

1. Oberle, B., Bringezu, S., Hatfield-Dodds, S., Hellweg, S., Schandl, H., Clement, J. et al. *Global Resources Outlook 2019 - Natural Resources for the Future We Want*. Nairobi, Kenya: International Resource Panel and United Nationals Environment Programme; 2019. Available from: https://www.resourcepanel.org/reports/global-resources-outlook.

2. Thacker S, Adshead D, Fantini C, Palmer R, Ghosal R, Adeoti T, Morgan G, Stratton-Short S. 2021. Infrastructure for climate action. UNOPS, Copenhagen, Denmark.

3. Torres, A., Brandt, J., Lear, K. and Liu, J. A looming tragedy of the sand commons. *Science*. 2017; 357(6355): 970-971.

4. Intergovernmental Panel on Climate Change, AR5 *Climate Change 2014: Mitigation of Climate Change,* p. 9, https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_summary-for-policymakers.pdf.

5. Dasgupta, A. *IPCC 1.5° Report: We Need to Build and Live Differently in Cities.* World Resources Institute blog; 2018. Available from: https://www.wri.org/blog/2018/10/ipcc-15-report-we-need-build-and-live-differently-cities [Accessed 26 February 2021].

6. Oberle, B., Bringezu, S., Hatfield-Dodds, S., Hellweg, S., Schandl, H., Clement, J. et al. *Global Resources Outlook 2019 - Natural Resources for the Future We Want.* Nairobi, Kenya: International Resource Panel and United Nationals Environment Programme; 2019. Available from: https://www.resourcepanel.org/reports/global-resources-outlook.

7. Bringezu, S., Ramaswami, A., Schandl, H., O'Brien, M., Pelton, R., Acquatella, J. et al. *Assessing global resource use: A systems approach to resource efficiency and pollution reduction.* Nairobi, Kenya: International Resource Panel and United Nations Environment Programme; 2017. Available from: https://www.resourcepanel.org/reports/assessing-global-resource-use.

8. IRP (2019). Global Resources Outlook 2019: Natural Resources for the Future We Want. Oberle, B., Bringezu, S., Hatfeld-Dodds, S., Hellweg, S., Schandl, H., Clement, J., and Cabernard, L., Che, N., Chen, D., Droz-Georget , H., Ekins, P., Fischer-Kowalski, M., Flörke, M., Frank, S., Froemelt , A., Geschke, A., Haupt , M., Havlik, P., Hüfner, R., Lenzen, M., Lieber, M., Liu, B., Lu, Y., Lutter, S., Mehr , J., Miatto, A., Newth, D., Oberschelp , C., Obersteiner, M., Pfster, S., Piccoli, E., Schaldach, R., Schüngel, J., Sonderegger, T., Sudheshwar, A., Tanikawa, H., van der Voet, E., Walker, C., West, J., Wang, Z., Zhu, B. A Report of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya.

9. Ellen MacArthur Foundation. *Completing the Picture. How the Circular Economy Tackles Climate Change.* 2019. Available from: https://www.ellenmacarthurfoundation.org/publications/completing-the-picture-climate-change.

10. UNEP Circularity Platform. *Understanding circularity.* Available from: https://buildingcircularity.org/ [Accessed 16 December 2020].

11. United Nations Environment Programme (2019), UNEP circularity platform. https://www.unep.org/circularity.

12. UNIDO. *Driving towards Circularity.* Report from the International Conference on Circular Economy in the Automotive Industries; 2017. Available from: https://www.t2ge.eu/sites/www.t2ge.eu/files/attachments/final_report_-_driving_towards_circularity.pdf.

13. Behera, S.K., Kim, J.H., Lee, S.Y., Suh, S. and Park, H.-S. Evolution of 'designed' industrial symbiosis networks in the Ulsan Eco-industrial Park: 'research and development into business' as the enabling framework. *Journal of Cleaner Production.* 2012; 29-30: 103-112.

14. UNIDO, The World Bank and GIZ. *An International Framework for Eco-Industrial Parks.* Washington, DC, USA: The World Bank Group; 2017. Available from: https://openknowledge.worldbank.org/bitstream/handle/10986/29110/122179-WP-PUBLIC-AnInternationalFrameworkforEcoIndustrialParks.pdf?sequence=1&isAllowed=y.

15. The World Bank. *Eco-Industrial Parks Emerge as an Effective Approach to Sustainable Growth.* World Bank News; 2018. Available from: https://www.worldbank.org/en/news/feature/2018/01/23/eco-industrial-parks-emerge-as-an-effective-approach-to-sustainable-growth [Accessed 14 January 2021].

16. Ellen MacArthur Foundation. *Circularity in the Built Environment: Case Studies.* 2016. Available from: https://www.ellenmacarthurfoundation.org/assets/downloads/Built-Env-Co.Project_Final-Public.pdf.

17. Boyer, M. *New Skyscraper-Deconstruction Technique Harvests Energy from Demolition Process.* Inhabitat; 2013. Available from: https://inhabitat.com/new-skyscraper-deconstruction-technique-harvests-energy-from-demolition-process/ [Accessed 28 January 2021].

18. U.S. General Services Administration, *Greening Federal Buildings,* https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/greening-federal-buildings [Accessed 27 May 2021].

19. U.S. Environmental Protection Agency. *Using Recycled Industrial Materials in Buildings.* Washington, DC, USA: US Environmental Protection Agency; 2008. Available from: https://nepis.epa.gov/Exe/ZyPDF.cgi/60000VEM.PDF?Dockey=60000VEM.PDF.

20. U.S. Environmental Protection Agency, *EPA Headquarters, Potomac Yard One*, https://www.epa.gov/greeningepa/epa-headquarters-potomac-yard-one [Accessed 27 May 2021].

21. Statista. *Car sharing worldwide.* 2020. Available from: https://www.statista.com/outlook/502/100/car-sharing/worldwide [Accessed 18 December 2020].

22. Density Blog. *We have a space problem: Benchmarks reveal $150 billion in office waste.* 2019. Available from: https://www.density.io/blog/space-utilization-benchmarks-150-billion-office-waste [Accessed 28 January 2021].

23. Tucker, E. *Look inside Heatherwick's Zeitz MOCAA – a museum in a giant Cape Town grain silo.* n.d. Available from: https://thespaces.com/look-inside-heatherwicks-zeitz-mocaa-a-museum-in-a-giant-cape-town-grain-silo/3/ [Accessed 28 January 2021].

24. Ellen MacArthur Foundation. *Intelligent Assets: Unlocking the Circular Economy Potential.* 2016. Available from: https://www.ellenmacarthurfoundation.org/publications/intelligent-assets.

25. Ellen MacArthur Foundation, SUN and McKinsey. *Growth Within: A Circular Economy Vision for a Competitive Europe.* 2015. Available from: https://www.ellenmacarthurfoundation.org/publications/growth-within-a-circular-economy-vision-for-a-competitive-europe.

26. European Circular Economy Stakeholder Platform. *From waste water to RichWater, an innovative technology for combining treatment and reuse in agriculture.* n.d. Available from: https://circulareconomy.europa.eu/platform/en/good-practices/waste-water-richwater-innovative-technology-combining-treatment-and-reuse-agriculture [Accessed 18 December 2020].

27. U.S. Department of Transportation, *Smart City Challenge,* https://www.transportation.gov/smartcity [Accessed 27 May 2021].

28. Ellen MacArthur Foundation. *Delivering the circular Economy: A Toolkit for Policymakers.* 2015. Available from: https://www.ellenmacarthurfoundation.org/publications/delivering-the-circular-economy-a-toolkit-for-policymakers.

29. Ministry for the Environment New Zealand. *Waste and Government.* February 2021. Available from: https://www.mfe.govt.nz/waste/waste-and-government [Accessed 26 February 2021].

30. Corfee-Morlot, J., Rydge, J., Gencsu, I. and Bhattacharya, A. *The Sustainable Infrastructure Imperative: Financing for Better Growth and Development.* Washington, DC, USA and London, UK: The New Climate Economy; 2016. Available from: https://www.greengrowthknowledge.org/sites/default/files/downloads/resource/Sustainable_infrastructure_imperative_NCE.pdf.

31. European Parliament. *Circular economy: definition, importance and benefits.* European Parliament News; 2020. Available from: https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits [Accessed 26 February 2021].

32. Cambridge Econometrics, Trinomics, and ICF. *Impacts of circular economy policies on the labour market.* Brussels, Belgium: European Commission; 2018. Available from: https://op.europa.eu/en/publication-detail/-/publication/fc373862-704d-11e8-9483-01aa75ed71a1.

UN environment programme

50 1972-2022

SUSTAINABLE INFRASTRUCTURE PARTNERSHIP