SUSTAINABLE DEVELOPMENT GOAL 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Teacher's Manual

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Contents

1 Introduction to the SDGs 6

2. Defining SDG 9 9

2.1 Significance of SDG 9 …….

2.2 Interdependencies of SDG 9 ……

2.3 Advantages of SDG 9 ……

2.4 Difficulties associated with achieving SDG 9 …..

3. Overview of various crises that have negatively affected the achievement of SDG 9 17

3.1. Climate change 17

3.1.1 Impact of climate change in Latin America 18

3.1.2 Impact of climate change in Africa 19

3.1.3 Impact of climate change in Europe 21

3.2. The COVID-19 pandemic 23

3.2.1 Impact of COVID-19 in Latin America 23

3.2.2 Impact of COVID-19 in Africa 24

3.2.3 Impact of COVID-19 in Europe 26

3.3 Conflict 28

3.3.1 Impact of conflict in Latin America 28

3.3.2 Impact of conflict in Africa 29

3.3.3 Impact of conflict in Europe 32

4. Regional contexts/progress towards the achievement of SDG 9 39

4.1 Regional progress in Latin America 39

4.2 Regional progress in Africa 43

4.3 Regional progress in Europe 52

5. Case studies 58

5.1 Latin America 59

5.1.1 Case 1: MDE: Medellin Smart City, Colombia 59

5.1.2 Case 2: Guadalajara, Mexico: Digital upskilling in a conflict zone 62

5.1.3 Case 3: Itaipu Binacional, BraziL 65

5.2. Africa 70

5.2.1 Gorou Banda Thermal Power Plant (Niger) 70

5.2.2 Dangote Refinery Project, Nigeria

5.2.3 Hawassa Industrial Park (HIP) 77

5.3 Europe 80

5.3.1 Case 1 80

5.3.2 Case 2 83

5.3.3 Case 3 87
6. Exercises and assessment 92
6.1 Exercises .....
6.2 Assessment 93
7. Concluding remarks 95
References 95

1 Introduction to the SDGs

Learners will be able to:

- explain the connection between the SDGs and the MDGs.
- explain the origin and overall aim of the SDGs.
- list and briefly discuss the five priority areas of the SDGs.
- position SDG 9 within the framework of Agenda 2030.

The Sustainable Development Goals (SDGs) are the central component of the 2030 Agenda for Sustainable Development, agreed by the United Nations (UN) in September 2015. The 2030 Agenda consists of a set of 17 interlinked goals (United Nations, 2015), with associated targets and indicators, which are to be achieved by 2030.

The 2030 Agenda was developed as an action plan with the purpose of boosting the development of humanity in five priority areas: People, Planet, Prosperity, Peace and Partnerships, as well as continuing the progress made with the Millennium Development Goals (MDGs), which were in force during the years 2000 and 2015. The MDGs consisted of eight international development goals and were supported by 21 individual targets. In comparison with the MDGs, the SDGs have a more comprehensive scope, rely more on collective action, and are more detailed, with the message very clear that success will depend on the active support and participation of every nation (Feeny, 2020).

The SDGs provide a framework within which global approaches can be planned and implemented to secure a fair, healthy, and prosperous future for the current generation and generations to come (Morton et al., 2017). A key feature is the closely connected nature of all the SDGs; failure to take this into account will undermine efforts to resolve the sustainability dilemma that the world is facing (Van Soest et al., 2019). According to Van Soest et al. (2016), there are key interactions across all areas of critical importance of the SDGs, but especially within the area of People, as well as between the areas of People and Prosperity, and between the areas of People and Planet. Figure 1 presents the set of 17 SDGs proposed by the 2030 Agenda.

The aim of this module is to provide an introduction to SDG 9, Industry, Innovation and Infrastructure. In it we will cover the definition of this SDG, the impact of global crises on the achievement of its targets, the regional contexts, and progress towards the achievement of SDG 9. The module will also include case studies illustrating good practices, and examples of exercises that can be completed with students.

SDG 9 is included in the Prosperity dimension of the 2030 Agenda, and concerns building resilient infrastructure, promoting inclusive and sustainable industrialisation and fostering innovation United Nations, n.d. Goal 9).

Figure 1. The 17 Sustainable Development Goals
Source: United Nations (n.d. Communications materials)

Supplementary resources

- Allen, C., Metternicht, G., & Wiedmann, T. (2018). Initial progress in implementing the Sustainable Development Goals (SDGs): A review of evidence from countries. *Sustainability Science*, 13(5), 1453–1467.
- United Nations, 2023. The Sustainable Development Goals report 2023: Special edition. Available at: https://unstats.un.org/sdgs/report/2023/ Last accessed 14 November, 2023.
- Díaz-López, C., Martín-Blanco, C., De la Torre Bayo, J.J., Rubio-Rivera, B., & Zamorano, M. (2021). Analyzing the scientific evolution of the Sustainable Development Goals. *Applied Sciences*, 11(18), 8286.
- UN Video: The SDG report 2023: Special edition 6min02s https://www.youtube.com/watch?v=zF361a019zA&ab_channel=UNStats

Assessment

1. Introduction to the SDGs

- List the five areas of critical importance to which the 17 SDGs are linked, and explain why these are referred to as the 5 Ps.
- Explain the link between the MDGs and the SDGs.
- Explain how the SDGs differ from the MDGs.

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Van Soest, H.L., Van Vuuren, D.P., Hilaire, J., Minx, J.C., Harmsen, M.J., Krey, V., Popp, A., Riahi, K., & Luderer, G. (2019). Analysing interactions among sustainable development goals with integrated assessment models. *Global Transitions*, 1, 210–225.

2. Defining SDG 9

Learners will be able to:

- define SDG 9 and list its targets and indicators.
- explain the significance of SDG 9 with reference to its three main thematic areas.
- list and explain five advantages of SDG 9.
- reflect on the interdependencies between SDG 9 and the other SDGs.
- comprehend the implications of the interdependencies between SDG 9 and the other SDGs.
- understand the difficulties associated with the achievement of SDG 9, and discuss examples of actions to overcome these difficulties.

SDG 9 calls for action to "to build resilient infrastructure, promote sustainable industrialization and foster innovation" (United Nations, n.d.). It has five suggested global outcome targets and three additional targets, referred to as means of implementation, each of which is accompanied by one or more indicators to monitor progress over time, as presented in Table 1. The targets cover topics such as resilient infrastructure, sustainable industrialisation, research and innovation, and technological capabilities.

Table 1. Targets and indicators of SDG 9

Targets	Indicators
9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	9.1.1 Proportion of the rural population who live within 2 km of an all-season road 9.1.2 Passenger and freight volumes, by mode of transport
9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries	9.2.1 Manufacturing value added as a proportion of GDP and per capita 9.2.2 Manufacturing employment as a proportion of total employment
9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets	9.3.1 Proportion of small-scale industries in total industry value added 9.3.2 Proportion of small-scale industries with a loan or line of credit
9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	9.4.1 CO2 emission per unit of value added

Targets	Indicators
9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	9.5.1 Research and development expenditure as a proportion of GDP 9.5.2 Researchers (in full-time equivalent) per million inhabitants
9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States	9.a.1 Total official international support (official development assistance plus other official flows) to infrastructure
9.b Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities	9.b.1 Proportion of medium and high-tech industry value added in total value added
9.c Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020	9.c.1 Proportion of population covered by a mobile network, by technology

2.1 Significance of SDG 9

SDG 9 deals with the essential elements needed for sustainable development, including resilient infrastructure, inclusive and sustainable industrialisation, and innovation. Achieving this goal can contribute to economic growth, job creation, and improved living standards while ensuring environmental sustainability. These are summarised in Table 2.

With over half the world population now living in cities (The World Bank, 2024) puts this figure at about 57%), mass transport and renewable energy are becoming increasingly important. This makes investments in infrastructure and innovation crucial drivers of economic growth and development, as is the growth of new industries and information and communication technologies. It is proposed in the *Sustainable Development Goals report 2023*: *Special edition* (United Nations, 2023) that if SDG 9 is to be reached by 2030, investments in advanced technologies, lower carbon emissions and increased mobile broadband access, mainly in least developed countries (LDCs), are necessary. According to the report:

- The recovery of the manufacturing industry from the COVID-19 pandemic remains incomplete and uneven, particularly in LDCs.
- By 2022, approximately 95% of the world's population had access to a mobile broadband network; however, certain regions still lack adequate coverage.

- Global carbon dioxide (CO2) emissions from energy combustion and industrial processes increased by 0.9%, reaching a new record high of 36.8 billion metric tons. This rise, while below global GDP growth, marks a return to the decade-long trend of emissions decoupling from economic growth.

Table 2. Significance of SDG 9

Industry	Innovation	Infrastructure
Inclusive industrialisation entails raising industry's share of employment and gross domestic product, in line with national circumstances, and with special attention to least developed countries. Sustainable industrialisation involves an increased resource-use efficiency and greater adoption of clean and environmentally friendly technologies and industrial processes. It is integral to the transition of all countries toward a Green Economy, characterised by low carbon emissions, resource efficiency, and social inclusivity.	Innovation involves research and development (R&D) and new technologies to find lasting solutions to both economic and environmental problems, such as providing new jobs and promoting energy efficiency.	High-quality, reliable, sustainable, and resilient infrastructure, ensuring affordable and equitable access for all. Sustainable infrastructure yields positive economic and social results. Resilient infrastructure is able to bend but not break, and/or adapt to changing conditions – that is, more adaptive systems that are able to weather the storms, literally and figuratively, of a changing climate.

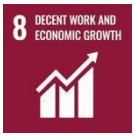
Source: Prepared by the authors based on UN Environment Program (2023), UN (2023), and Global Infrastructure Hub (2023)

2.2 Interdependencies of SDG 9

This section aims to set out the interrelationship among the 17 SDGs and the way in which the goals contained in the 2030 Agenda can be achieved, in that the targets of any one of the SDGs can contribute to the progress of the entire Agenda, or at least a significant part of it. Nonetheless, before we explore the interdependencies between the SDGs, it is important to highlight some aspects of the synergy between them. Breuer et al. (2019) emphasise that depending on the conditions of each context, achieving the SDG targets may be a lengthy process, and the result of the synergies between SDG targets may become evident only in the medium or long term rather than immediately.

As already stated, SDG 9 has direct or indirect influences on a series of other goals, in addition to there being a marked synergy among its own targets. The main connections are presented in the summary below (Table 3). There are particularly close connections between some SDGs; according to Mantlana and Maoela (2020), those connections represent co-benefits, signifying harmonies between industry, infrastructure, and innovation within the food–water–climate–energy–land use nexus.

Table 3. Interdependencies between SDG 9 and the other SDGs

	Limited access to and low-quality infrastructure have significant implications for the poor, particularly regarding their health, productivity and educational outcomes. Access to resilient infrastructure and sustainable industrialisation can create job opportunities and stimulate economic growth, thereby contributing to poverty eradication.
	Infrastructure capable of ensuring access by all people, and sufficient food all year round; providing rural infrastructure, agricultural research, technology and gene banks; and promoting sustainable food production.
	Infrastructure that ensures reliable, affordable and equitable access to all involves access to water and sanitation facilities, and thus less risk of disease. Access to healthcare facilities relies on robust infrastructure and transportation networks, which SDG 9 aims to provide. Additionally, industrialisation can lead to advancements in medical technology and healthcare services.
	Infrastructure development is crucial for providing access to education, including the building of schools, access to electricity, and ensuring internet connectivity for remote learning. Industrialisation also fosters innovation in educational tools and techniques.
	Access to sustainable industrialisation can create job opportunities for women, promoting gender equality. Furthermore, gender-responsive infrastructure planning can ensure the safety and accessibility of public spaces for women and girls.
	Sustainable and inclusive infrastructure ensures water availability and sanitation facilities for all. It may consider the efficient use of water resources and proper waste management so as to minimise pollution and ensure access to clean water.
	Sustainable infrastructure ensures universal access to affordable, reliable and modern energy services. Innovation is the way to find new and better ways to produce and consume energy.
	Reliable transportation access ensures job opportunities, reduces production costs, and provides access to markets for selling goods. R&D supports economic development and new technologies.
	While inclusive, sustainable industrialisation, supported by innovation and infrastructure, can stimulate dynamic, competitive economic forces that generate employment and income, the unequal levels of development in different countries make this impossible.
	Building resilient infrastructure and promoting sustainable industrialisation are essential for creating inclusive, safe, resilient, and sustainable cities and communities.

	Sustainable industrialisation involves promoting responsible consumption and production patterns, reducing waste generation, and minimising environmental impacts.
	Sustainable industrialisation aims to mitigate greenhouse gas emissions and build resilience to climate change by promoting clean and renewable energy sources and adopting eco-friendly technologies. Sustainable, resilient and sustainable infrastructure is vital in overcoming the negative results of climate change.
	Sustainable industrial practices and infrastructure development should aim to minimise negative impacts on marine ecosystems, and preserve biodiversity and ecosystem services.
	Sustainable industrial practices and infrastructure development should aim to minimise negative impacts on terrestrial ecosystems, and preserve biodiversity and ecosystem services.
	Infrastructure development is essential for establishing strong and resilient institutions, ensuring access to justice, and promoting peaceful and inclusive societies.
	Achieving SDG 9 requires collaboration between governments, businesses, civil society, and other stakeholders to mobilise resources, share knowledge, and build capacity for sustainable infrastructure development and industrialisation.

2.3 Advantages of SDG 9

The advantages of SDG 9 are listed below.

1. **Improved infrastructure:** Meeting the targets of SDG 9 leads to the development of robust infrastructure, including transportation, energy, and information and communication technology (ICT). This enhances connectivity and accessibility, facilitating economic growth and social development.
2. **Economic growth:** Sustainable industrialisation promoted by SDG 9 fosters economic growth by creating employment opportunities, stimulating innovation, and attracting investment. This leads to increased productivity and competitiveness, driving overall prosperity.
3. **Innovation and technological advancement:** Embracing SDG 9 encourages innovation and the adoption of new technologies. This can lead to breakthroughs in various sectors, such as renewable energy, clean technology, and digitalisation, contributing to sustainable development and solving global problems.

4. **Inclusive development:** SDG 9 emphasises inclusivity, ensuring that advancements in infrastructure and industrialisation benefit all segments of society, including marginalised and vulnerable groups. This promotes social equity and reduces disparities, fostering more inclusive growth and development.
5. **Resilience to climate change and disasters:** Building resilient infrastructure, as advocated by SDG 9, helps communities better withstand the impacts of climate change and natural disasters. This includes constructing infrastructure that can withstand extreme weather events and implementing measures to adapt to changing environmental conditions.
6. **Global partnerships:** Achieving SDG 9 requires collaboration and partnerships among governments, businesses, civil society, and other stakeholders. These partnerships facilitate knowledge-sharing, technology transfer, and capacity-building, accelerating progress towards sustainable development goals.

Overall, SDG 9 offers numerous advantages, ranging from economic growth and innovation to inclusive development and resilience, making it a crucial component of the broader sustainable development agenda.

2.4 Difficulties associated with achieving SDG 9

Obstacles encountered in the implementation of SDG 9 relate to securing sufficient funding and private investment, developing coherent policies and regulatory frameworks, bridging technological and innovation gaps, and building necessary skills and institutional capacities. Furthermore, ensuring environmental sustainability, social inclusion, and political and economic stability is critical. Effective implementation also requires reliable data for planning and monitoring, coordinated efforts across various sectors and levels of governance, and resilience against climate impacts, alongside the maintenance of infrastructure.

According to Leal Filho et al. (2023), two barriers hinder the achievement of SDG 9: the lack of innovation, particularly in the expansion of technology, which adversely affects industry, innovation, and infrastructure; and the traditional dominance of large corporations in the technology sector, which prioritizes consumption over sustainability.

Added to that, investments in R&D are insufficient and inequitable. Although overall spending on research and development has increased, especially since the pandemic, it is still too low in least developed countries. To leverage innovation for post-pandemic recovery and sustainable development, robust policies are crucial to stimulate investment in R&D and increase the number of researchers in a more globally balanced way (United Nations, 2023).

Persistent digital divides both among and within countries stand in the way of widespread progress in achieving the SDGs, and hamper the use of new data sources.

Policy and regulatory barriers constitute a further obstacle. Developing and implementing coherent policies aligned with SDG 9 can be a complex task, especially when balancing economic growth with sustainability. Furthermore, policies and regulations should promote long-term planning, incorporate externalities pricing, and eliminate detrimental subsidies to facilitate sustainable decision-making. The difficulties are presented in Table 4.

Table 4. Examples of specific difficulties involved in achieving the targets of SDG 9

Specific difficulty	Actions to overcome the difficulties
Lack of innovation	Increase funding for research and innovation and build capacity in all regions to contribute to and benefit from this research
Technology is traditionally dominated by giant companies	Establish more control, restrictions and regulations applicable to giant companies
Lack of and unbalanced R&D investments	Increase funding for R&D, increase the number of researchers in a globally balanced way
Digital divides among and within countries	Adopt a holistic approach, encompassing not only the entirety of government but also the broader system as a whole.
Revolutionise science, technology and innovation capacities and exchanges	Reinforce the science–policy–society interface, build trust in scientific knowledge, establish more efficient and effective technology transfer mechanisms and strengthen existing mechanisms
Policy and regulatory barriers	Coordinate policies across sectors such as transportation, energy, and industrial development and modernise regulations that align economic growth with sustainability goals

Source: UN Report, (2023); Leal Filho et al (2023); World Resource Institute (2020).

Supplementary resources

- Leal Filho, W, et al. (2023). When the alarm bells ring: Why the UN Sustainable Development Goals may not be achieved by 2030. *Journal of Cleaner Production*, 407, 2023, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2023.137108.

Assessment

2. Defining SDG 9

- What are the main areas covered by SDG 9?
- What is the focus of the first five targets of SDG 9?
- What is the focus of the last three targets of SDG 9?

2.1 Significance of SDG 9

- What progress has been made towards achieving SDG 9 by 2030?
- Discuss the main characteristics of the key aspects of SDG 9: Innovation, Industrialization and Infrastructure.

2.2 Interdependencies of SDG 9

- How is SDG 9 interconnected with the other SDGs? Which other SDGs will be most affected if SDG 9 is not achieved? Give reasons for your answer.
- Select any three SDGs and briefly explain how they interact with SDG 9. Use examples from your region to illustrate your explanation.

2.3 Advantages of SDG 9

- What would the main advantages be for the world if SDG 9 is achieved?
- Select any two of the targets of SDG 9 and explain the specific benefits that will be achieved if these targets were attained. State what the advantages would be for your specific region.

2.4 Obstacles to the achievement of SDG 9

- What are the difficulties standing in the way of achieving SDG 9 in your country? What are the main barriers? How can they be overcome?

References

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World Resource Institute (2020). Available at: https://www.wri.org/. Accessed 2 October 2024.

3. Overview of various crises that have negatively affected the achievement of SDG 9

Learners will be able to:

- identify the major crises that have had a negative impact on the achievement of SDG 9.
- explain how these major crises have prevented the achievement of SDG 9.
- describe how the impact of current crises on the achievement of SDG 9 differs regionally.

Historically, crises have been the catalysts that have initiated significant social, political, and economic change in society. A global or regional crisis also demonstrates exactly how interdependent and interlinked all the components of sustainable development are; this extends to the achievement of all the SDGs by 2030. Further, as the impact of most global and regional crises transcends national and international borders, it is important that the international community in collaboration with governments work together to develop common solutions that will mitigate the impact of the crisis. This collaboration could include the facilitation of structural transformation that will make possible and encourage success in pursuit of the achievement of the SDGs targets by 2030 (United Nations, 2022).

The most dominant global crises to exert a negative effect on the process of building resilient infrastructure, promoting inclusive and sustainable industrialisation and fostering innovation (SDG 9) by the year 2030 include climate change, the COVID-19 pandemic, and conflicts.

3.1. Climate change

Climate change has a severe impact on communities throughout the world, causing infrastructure damage, industrial activity disruption, instability of energy systems, financial risks, and reduced attention to innovation practices and R&D, among other things. Rising sea levels, increased temperatures, extreme weather events and unpredictable patterns are among the climate-related aspects that disrupt economies and hinder development, particularly in vulnerable areas. With regard to economic activities, industrial processes are affected by heatwaves and storms, which can disrupt water and power supply, reducing efficiency and productivity and potentially increasing production costs.

As industries must rapidly develop cleaner technologies and climate-resilient infrastructure so as to both adapt to climate change and mitigate damage, innovation is

both an opportunity and a challenge, since the need for resources in order to adapt existing infrastructure and rebuild it after extreme weather events tends to result in the diverting of investments away from innovative and sustainable solutions. Achieving a balance is an additional challenge for the sustainability agenda, especially for poorer nations.

The delicate relationship between building resilience and fostering innovation is further complicated by the potential for climate change to displace people and disrupt supply chains. Extreme weather events can devastate communities, forcing them to relocate and straining resources. Disruptions in weather patterns can also lead to unpredictable harvests and resource shortages, negatively affecting supply chains and industrial production. This can stifle economic activity and hinder progress towards inclusive and sustainable industrialisation. In conclusion, climate change acts as a multifaceted barrier to achieving SDG 9, and its targets also depend on efforts to mitigate and adapt to climate change. The goal demands innovative solutions, increased international cooperation, and a renewed focus on building a more resilient and sustainable future.

3.1.1 Impact of climate change in Latin America

Rising temperatures and extreme weather events threaten all aspects related to SDG 9 in the region. Trends presented in the WMO (2023) report “State of the Climate in Latin America and the Caribbean 2022” indicate that the period from 1991 to 2022 saw an average warming trend of about 0.2 °C/decade, which was the strongest on record since the start of the 30-year climatologies in 1900. Sea levels continued to rise at a higher rate around the region in comparison with the global mean threatening the continental coastal areas of several countries and small island developing states. Tropical storms and floods and landslides triggered by heavy rainfall caused hundreds of fatalities and enormous economic losses. Prolonged drought conditions contributed to negative impacts on several economic sectors in the region, including agriculture, energy, transportation and water supply.

A notable effect of climate change is its impact on the infrastructure of the region. Extreme weather events such as hurricanes, floods, and storms pose significant threats to infrastructure such as roads, bridges, ports, and airports, leading to disruptions in transportation and commerce. Data from the World Risk Index show that over 60% of the region’s countries present medium to very high levels of risk in the face of disasters **(**ECLAC, 2018). Among water, energy and other infrastructure services, transport is generally the most severely affected by extreme weather events in the region (Weikert Bicalho, 2020). This vulnerability underscores the importance of investing in climate-resilient infrastructure able to withstand such events.

Moreover, the industrial sector in Latin America and the Caribbean faces disruptions due to climate change. Almost 90% of the water extracted in the region is

used for agriculture and industry services, and water availability is changing due to changes in patterns of precipitation. While projections point to drier climates around the Caribbean, Andean cities will suffer water stress and South America will be more exposed to floods (ECLAC, 2019).

In addition to the infrastructure gap prevailing in the LAC region, it is well known that many of the region's infrastructure services do not operate adequately, thereby causing bottlenecks that hamper sustainable growth. Examples include flooding as a result of a lack of investment in new facilities or a failure to maintain and upgrade aging water infrastructure, and adverse environmental impacts due to the use of inefficient or obsolete technologies in the infrastructure sector.

Demographic projections indicate that by 2030, the population of the region is expected to be 58 million larger than in 2019 (ECLAC, 2019). The infrastructure quality and quantity gap raises persistent obstacles to greater resilience (Cerra et al., 2016; BNamericas, 2018). This not only affects the infrastructure itself, but also has impacts on the response capacities and investments needed for innovation. Aside from the maintenance of vital societal functions, the existence of adequate channels for the supply and distribution of basic services and products is crucial for minimising disaster impacts and recovery times. Moreover, non-resilient critical infrastructure can serve as a hazard multiplier, heightening the severity of a shock through cascading effects across different sectors (Fisher and Gamper, 2017).

Supplementary resources

- WWFCA (2022). Climate change impacts in Latin America, https://www.wwfca.org/en/our_work/climate_change_and_energy/climate_change_impacts_la/
- UNFCCC (2022). New report details dire climate impacts in Latin America and the Caribbean, https://unfccc.int/news/new-report-details-dire-climate-impacts-in-latin-america-and-the-caribbean
- COVID-19 and the world of work – UN Chief Policy Brief (19 June 2020) https://youtu.be/VjB2fcPhN3Q, 3min12s

3.1.2 Impact of climate change in Africa

SDG 9 focuses on building resilient infrastructure, promoting inclusive and sustainable industrialisation, and fostering innovation. In Africa, the impacts of climate change significantly hamper the achievement of these objectives. Africa is highly vulnerable to the impact of climate change, including extreme weather events such as cyclones, floods, heatwaves, wildfires, and droughts, all of which cause serious infrastructural damage (Masipa, 2017). The worst-case projected climate change scenario for Africa is a drop in crop yields, with a mean yield reduction of 13% in West

and Central Africa, 11% in North Africa, and 8% in East and Southern Africa by 2050 predicted (UNFCC, 2020). While this trend will directly affect food security (SDG 2), it will also negatively influence economic growth, which is an essential component of sustainable industrialisation, and will both directly and indirectly lead to higher repair and maintenance costs. This trend will also divert resources away from new projects and sustainable industrialisation efforts (Ugulu & Wohlmuth, 2022), which are crucial for the attainment of SDG 9 (UNFCC, 2020).

The need to allocate financial resources to immediate climate adaptation and mitigation efforts in Africa significantly limits investment in research and development and innovative technologies (Baarsch et al., 2020). This in turn will slow down the pace of technological advancement critical for sustainable industrialisation. The heightened chance of climate-induced disasters in Africa makes investments in certain regions or industries riskier, potentially leading to higher insurance and borrowing costs. This could deter investment in infrastructure projects and industrial development. Baarsch et al. (2020) report that research on the impact of climate change on income in Africa has revealed three important things. First, the estimated historical mean climate-induced losses can be calculated at between 10 and 15% of GDP per capita growth, as most African economies are poorly adapted to their current climatic conditions. Second, the countries located in the geographical areas of Western and Eastern Africa will be the worst affected. Third, the heightened impact of climate change on several countries in areas where warming is higher has increased the inequalities between countries in the region, while the opposite trend can be expected in those countries where the impact of climate change is lower.

Africa is probably the continent most vulnerable to climate change because of its limited adaptive capacity, and reliance on climate-sensitive sectors such as rain-fed agriculture. Additionally, extreme weather events disrupt energy infrastructure and supply, especially hydropower production, thus affecting industrial activities and economic growth (Zhao & Liu, 2023). Moyo et al. (2023) estimate that African countries have experienced over 1,500 recorded weather-related disasters over the past four decades, which have adversely affected the road infrastructure, and thus hindered industrial development due to reduced accessibility. This is particularly true of extreme weather events attributable to climate change, such as increased precipitation and flooding, which are projected to further disrupt and damage roads in countries such as Malawi, Mozambique, and Zambia (Moyo et al., 2023). Climate change has impeded technological innovations in Africa by creating a mismatch between mining and access to technologies (Ugulu & Wohlmuth, 2022), narrowing the scope of research and development efforts in African countries (Overland et al., 2022). Furthermore, the agricultural sector in Africa encounters obstacles in practising climate-smart agriculture due to limited access to up-to-date weather and climate information as well as the absence of technologically advanced infrastructure. In conclusion, climate change in

Africa is a growing concern that threatens the achievement of SDG 9 by undermining the stability and efficiency of infrastructure and industries, which are the backbone of innovation and sustainable development.

Supplementary resources

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3.1.3 Impact of climate change in Europe

Climate change is exerting a significant negative impact on Europe, particularly in terms of its ability to achieve SDG 9, which calls for building resilient infrastructure, promoting inclusive and sustainable industrialisation, and fostering innovation. The intrinsic relationship between climate change and these sustainable development targets is critical, as increasing temperatures, extreme weather events, and shifting climate patterns pose substantial direct and indirect threats to infrastructure and industrial systems throughout the Continent (D'Adamo et al., 2022).

Both the resilience and sustainability of infrastructure are severely tested by climate change (Target 9.1). Rising sea levels and increased flooding threaten coastal and low-lying areas, putting a strain on existing water management systems. For instance, in the Netherlands, a country renowned for its advanced water management infrastructure, sea-level rise presents a continuous risk, necessitating further innovation in dike construction and water routing to protect its population and economy. Similarly, in Italy, the increased frequency of severe weather events has prompted the need for more resilient transportation and urban infrastructure to prevent disruptions and ensure continuity in services (Mimmi, 2024).

These environmental challenges extend into the industrial sectors, affecting their sustainability and inclusivity (Target 9.2) (Hales & Birdthistle, 2022). In Spain, prolonged droughts have placed a strain on water resources, creating difficulties for industries such

as agriculture and manufacturing, which are heavily dependent on water. This affects not only industrial output, but also the livelihoods of communities dependent on these industries. The push towards sustainability has led to increased investment in renewable energy technologies, particularly in countries such as Germany, where the industrial base is transitioning towards more sustainable practices, at a significant financial and social cost.

Moreover, climate change indirectly affects financial services by influencing the economic environments within which they operate (Target 9.3). In agricultural regions in France, unpredictable weather patterns and increased incidence of pests and diseases have made farming riskier, which in turn affects the willingness of financial institutions to extend loans to farmers. This restricts access to the capital necessary for adopting innovative and more sustainable practices, thereby hindering the overall move towards sustainable agricultural industrialisation (Caubel et al., 2017).

Transitioning to cleaner energy sources is necessary, but difficult (Target 9.4), as seen in Eastern European countries such as Poland, where coal is an important source of industrial energy. Extreme weather events also put existing infrastructure at risk, underscoring the need for substantial investments in infrastructure upgrades to withstand new climate realities. Advancements in research and technology are crucial for mitigating the impacts of climate change on industrialisation and infrastructure (Target 9.5). Countries such as Sweden and Finland have invested heavily in research and development, particularly in technology to improve energy efficiency and reduce greenhouse gas emissions in industrial processes (Lipiäinen et al., 2022).

However, climate change itself poses a risk to these investments through the disruption of supply chains and manufacturing processes, thereby affecting the pace and applicability of technological innovations (Dasaklis & Pappis, 2013). While Europe strives to meet the ambitious goals set under SDG 9, climate change remains an opponent. Each target under SDG 9 is affected by climate-related threats that require a multifaceted approach involving policy changes, technological innovation, and international cooperation. Examples from various European countries highlight both the challenges and the efforts being made to adapt to these new realities. The path forward must integrate robust climate action with sustainable development to ensure that industrial and infrastructural advancements contribute positively to both economic growth and environmental sustainability.

Supplementary resources

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3.2. The COVID-19 pandemic

The COVID-19 pandemic has affected numerous aspects beyond the immediate health emergency, and has had a negative impact on all 17 SDGs (United Nations, 2020). In terms of SDG 9, there were supply chain disruptions, industries experienced decreased demand and revenue, and infrastructure projects were delayed. Once lockdowns were instituted, a huge part of the economy came to a complete standstill, which resulted in stagnation and declining investment, and in some cases even a reversal of economic growth. On the other hand, the pandemic accelerated the adoption of digital technologies and remote working practices across various industries. While this shift towards digitalisation has the potential to improve efficiency and innovation, it also highlights existing disparities in access to technology and digital infrastructure, particularly in rural and underserved areas.

In order to build resilient infrastructure, promote inclusive and sustainable industrialisation, and foster innovation as proposed by SDG 9, it is necessary to build back better, focus on resilience strategies for dealing with unexpected shocks and disruptions, and promote sustainable practices across sectors and industrial practices.

3.2.1 Impact of COVID-19 in Latin America

The COVID-19 pandemic has had a significant impact on the economic development of Latin America, with many countries in the region experiencing sharp declines in economic growth, employment and income. The region experienced an estimated 7.7% contraction in GDP in 2020 (ECLAC, 2020), driven by declines in key sectors such as tourism, manufacturing and services. Disruptions in industrial production,

such as lockdowns, supply chain interruptions, and decreased demand, have significantly affected sectors such as manufacturing and construction, hindering progress toward a number of the targets of SDG 9.

Lockdown measures and economic slowdowns have delayed infrastructure projects, hindering the development and upgrade of sustainable and resilient infrastructure (Targets 9.1 and 9.4). The pandemic disrupted construction activities, delaying infrastructure projects and affecting their quality and sustainability. Governments in Latin America were compelled to limit their investment in infrastructure due to the need to reallocate funds to other priority areas during the most critical periods of the pandemic, particularly in remote and marginalised areas. However, as things started to improve, the development agenda began to include infrastructure, as this is a key component of economic recovery (KPMG, 2020). However, limited attention has been paid to clean infrastructure (López-Calva & Meléndez, 2020).

Economic contractions and supply chain disruptions have impeded progress towards inclusive and sustainable industrialisation (Target 9.2). The decline in economic activity has led to job losses and reduced investments in industrial sectors, hindering efforts to promote inclusive industrialisation. Furthermore, the informal sector, which plays a significant role in many Latin American economies, has been particularly vulnerable to the economic downturn (Acevedo et al., 2021). The same applies to the economic uncertainties and reduced access to credit that have constrained the ability of small-scale enterprises to access financial services and integrate into value chains (Target 9.3). SMEs in the region were particularly limited in terms of support to sustain operations and invest in sustainable growth. On the other hand, the situation could also lead to increased innovation in some contexts (Restrepo-Morales et al., 2024).

The pandemic also underscored the importance of digital literacy and investments made for the purpose of improving access to and quality of information and communications technology (Target 9.8), which was already a weak development area in the context of the region (Cadena-Vela et al., 2021).

3.2.2 Impact of COVID-19 in Africa

The effects of COVID-19 have been destabilising to the point of halting and reversing progress towards the achievement of SDG 9 and other goals. The most significant impact of the pandemic has been in the area of the economy, leading to a sharp deterioration in livelihoods, with an estimated additional 30 million people pushed into extreme poverty in the region (United Nations, 2023). Although this has a direct impact on the achievement of SDG 1, it has both direct and indirect consequences for the achievement of SDG 9.

The disruption of global supply chains and reduced demand for goods have negatively affected industrialisation on the continent, and thus increased the risk of not

meeting SDG 9 targets due to the reduction in the availability of raw materials and goods (Njomane & Telukdarie, 2022; Onyango, 2024), leading to a potentially lasting reshaping of continental value chains and trade (Banga et al., 2020). COVID-19 also worsened global income inequality, with low-income countries on the African continent in particular badly affected, limiting the achievement of inclusive industrialisation (United Nations, 2023). When COVID-19 reached Africa, guidance was inadequate to assist the region in responding to the pandemic, primarily because there was no prior experience as a basis for testing its trade regulations in a crisis of this magnitude. Governments on the continent therefore enforced measures such as social distancing, the closure of borders, travel bans, and countrywide lockdowns (Feindouno, Arcand, & Guillaumont, 2024). Trade provisions were not thoroughly considered at the onset of the crisis, which resulted in severe supply chain disruptions (Warasthe, 2024). The pandemic affected both local and regional supply chains, leading to shortages of materials, increased costs, and production delays, all of which severely affected the manufacturing sectors and overall industrial development in the continent (Bagwandeen, 2022). The pandemic has dealt a severe blow to manufacturing and transport industries, causing disruptions in inter-global value chains and the supply of products, as well as job losses and declining work hours in these sectors. Reduced revenues and the burden of loan repayments have handicapped African states with regard to the measures taken in response to COVID-19, limiting their ability to invest in infrastructure development. Service-based industries came under severe pressure during the pandemic. In many such industries, human interaction is an essential part of the job, and the lockdowns imposed in an effort to contain the spread of the virus meant that most of these service-based industries were unable to operate. As a result, while some closed down temporarily, others closed permanently, and yet others opted to reduce staff or hours worked. The repercussions of the pandemic for these businesses were exacerbated by the lack of financial support made available by African governments compared with that offered by the governments in developed countries (United Nations, 2023).

Oppong, Dadson and Ansah (2022) in their comprehensive literature review established that COVID-19 triggered a creative response to innovation in Africa. They found that in many African countries old tools and approaches were used in newer and more creative ways, making it possible to develop and adapt to newer and more creative technologies with very limited resources. In this way the pandemic provided the opportunity for unparalleled transformation in primary health care (Ray & Mash, 2021), agriculture (Fernando, 2020), distance education (Akindele et al., 2022) and the economy in general (Asare et al., 2023). While in general the response to the pandemic had positive repercussions for innovation in Africa, the much-needed investment into critical infrastructure was directed towards dealing with the management of the health crisis. This has meant that crucial investment in infrastructure, such as land connectivity (transportation networks) and digitisation infrastructure (Anyanwu & Salami, 2021), has

fallen behind, and this will negatively affect the achievement of most of the SDG 9 targets and indicators.

Supplementary resources

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3.2.3 Impact of COVID-19 in Europe

The COVID-19 pandemic has had a profound negative impact on Europe's progress towards achieving SDG 9, which focuses on building resilient infrastructure, promoting inclusive and sustainable industrialisation, and fostering innovation. The crisis not only disrupted economic activities but also exposed and exacerbated vulnerabilities in the infrastructure, industry, and technology sectors across the continent (Martín-Blanco et al., 2022).

The pandemic starkly highlighted the gaps in sustainable and resilient infrastructure (Target 9.1) across Europe. In countries such as Italy and Spain, healthcare systems struggled to cope with the surge in patient numbers, underscoring the need for more robust and adaptable healthcare infrastructure. The rapid spread of the virus in these regions demonstrated the critical need for infrastructure able to respond effectively to health emergencies. Furthermore, the lockdowns and restrictions disrupted public transport systems, which are vital for sustainable urban development, demonstrating the urgent need for more resilient transport networks capable of withstanding such crises (Lupu & Tiganasu, 2022).

The impact on industrialisation (Target 9.2) was also significant. Industries across Europe, especially those reliant on physical labour and global supply chains, faced severe disruptions. For example, the automotive industry in Germany experienced significant slowdowns due to dependency on global supply chains and decreased consumer demand. This industry's struggles reflected broader problems in maintaining industrial

productivity and sustainability during major disruptions. The pandemic also highlighted the need for industries to adopt more flexible and sustainable practices so as to withstand similar shocks in future (Gräf & Topuria, 2023).

In terms of financial services (Target 9.3), the pandemic caused economic downturns that strained financial markets and institutions, reducing their ability to support economic activities (Weiss et al., 2021). Countries such as Greece, which is already economically vulnerable, faced heightened obstacles in ensuring access to financial services, crucial for the economic recovery and resilience of the country. This crisis emphasised the need for stronger financial frameworks able to support economies in distress and ensure continuous access to financial services, especially small and medium enterprises (SMEs) and vulnerable populations.

Upgrading industries and infrastructures for sustainability (Target 9.4) became a more pronounced challenge during the pandemic. For instance, in the UK, the sudden need to shift to remote work and digital platforms put immense pressure on IT infrastructure and demanded rapid adaptation. This situation revealed the importance of having advanced, sustainable, and resilient infrastructure able to support such transitions and reduce environmental impacts, aligning with broader sustainability goals (Rockström et al., 2023).

Research and technology upgrades (Target 9.5) had a dual impact. On the one hand, the pandemic spurred rapid advancements and innovations, such as in the development of vaccines and the accelerated adoption of digital technologies across sectors, including telemedicine and remote working solutions. Countries such as Finland and Sweden, which already have strong technological and research capabilities, were able to leverage these assets to manage the crisis more effectively. On the other hand, the economic strain reduced funding and support for research in less prosperous areas, delaying crucial innovations needed for sustainable industrial development (Casimiro et al., 2023).

Overall, the COVID-19 pandemic revealed critical vulnerabilities in Europe's quest to achieve SDG 9, underscoring the interconnectedness of health, economic stability, and sustainable development. Examples from various European countries demonstrate both the setbacks caused by the pandemic and the urgent need for enhanced resilience, flexibility, and sustainability in infrastructure and industries to prepare for future global challenges. Europe must integrate lessons learnt from the pandemic into future planning and development strategies to better meet the ambitious goals of SDG 9 (Casimiro et al., 2023).

Supplementary resources

- Ali, I., Arslan, A., Chowdhury, M., Khan, Z., & Tarba, S.Y. (2022). Reimagining global food value chains through effective resilience to COVID-19 shocks and

similar future events: A dynamic capability perspective. *Journal of Business Research*, 141, 1–12. https://doi.org/10.1016/j.jbusres.2021.12.006

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3.3 Conflict

The outbreak of conflict in a country or region gives rise to severe crises and compromises the economy due to the instability that results. From the perspective of industry, infrastructure and innovation, conflicts cause interruptions in economic activities and therefore compromise the growth of a nation or region and investments dedicated to innovative and sustainable practices. In this context, it has an enormous impact on aspects such as infrastructure, industries, and services. Damage to and destruction of infrastructure requires further investment in order to rebuild the services, which means that funds are diverted from other areas needing attention. Both internal and external conflicts increase uncertainties and economic instability, leading to a reduction in investment.

Furthermore, the displacement of populations leads to refugee crises and lack of access to basic services and infrastructure, exacerbating poverty, food and water insecurity, and vulnerability. Businesses may cease operations or relocate, resulting in job losses and reduced investment in infrastructure and industrial development. In this context, the challenge of advancing technology and focusing on research and development grows even larger, and these regions lag further behind in terms of innovation and progress towards sustainability goals.

3.3.1 Impact of conflict in Latin America

The ECLAC's report entitled "Repercussions in Latin America and the Caribbean of the war in Ukraine: How should the region face this new crisis?" is dedicated to covering the main areas of impact of the conflict in Ukraine and how it affects Latin America (ECLAC, 2022).

The first point of consideration is the impact on the world's production structure and its growth. Following other international crises (such as the global economic crisis of 2008–2009 and the pandemic, more recently), the region has been suffering from feedback loops of changes that weakened globalisation. These events have undermined the region's economic structure, particularly in areas related to investment, labour productivity, and development of human and technological capabilities.

The war in Ukraine has added a new source of uncertainty to the global economy. The GDP trends of the region's key trading partners (the USA, China and the European Union) have worsened, leading to declines in external demand and consequent impact on the industrial development of the region. In addition, rising energy product prices (and the prices of commodities in general) have increased international transport costs, worsened supply problems and pushed up global inflation.

The economic damage in Latin America and the Caribbean is unevenly distributed: while the impact is severe in some countries and industries, others have been practically unaffected. The level of dependence of each country on oil, gas and other primary products has determined the impact of supply disruptions on industry and infrastructure services. On the other hand, shared impacts include increased uncertainty and its effects in the form of lack of investment in infrastructure and innovation, reduction in per capita GDP, and social inequalities.

With regard to regional crises in Latin America and the Caribbean, some countries are facing difficult situations. Social conflict continues to affect Colombia and Chile, while in Haiti, the rise of gang violence has become a significant concern in recent years. This surge in violence has led to a severe security crisis, undermining state authority and asserting control in an increasingly destructive way. In Venezuela the political crisis, violence, insecurity, threats and shortages of food, medicine and essential services have made over 6 million Venezuelans refugees and migrants worldwide, the vast majority in countries within Latin America and the Caribbean. This has become the second-largest external displacement crisis in the world (IOM, 2023). Recipient countries in the region offered the advantage of common language and culture, but difficulties in terms of legal and non-legal barriers have led to the absorption of workers largely in the informal sector (Alvarez et al., 2022). Despite the crisis in the migrants' country of origin, the migration flows within Latin America and the Caribbean seem to be leading to a growth in GDP in the recipient economies, and could also potentially lead to innovation growth in these nations.

Supplementary resources

- Acosta-Ormaechea et al. (2022). Latin America faces unusually high risks https://www.imf.org/en/Blogs/Articles/2022/04/26/blog-latin-america-faces-unusually-high-risks
- How does war affect the global economy? Analyze this! https://youtu.be/srgC6N5KZm0, 1min52s

3.3.2 Impact of conflict in Africa

The continent's history and present are marked by conflicts arising from political, ethnic, religious, and resource-based disputes which significantly undermine efforts to achieve SDG 9. Africa remains prone to conflicts, with roughly 30% of the countries on the continent being affected in 2019. In addition to causing immeasurable human suffering, conflicts have severe economic costs, resulting in the destruction of infrastructure, human capital and institutions, and potentially impeding global investment and partnerships essential for innovation, as well as industrial and infrastructural development (Fang et al., 2020). Conflicts have pushed the African economy into a recession by causing a severe reduction in and disruption of investment in industry, innovation, research and development, and infrastructure (UN, 2023). Conflict disrupts economic activities and can lead to a decline in industrial output and productivity by creating an unstable economic environment characterised by insecurity, reduced foreign direct investment, and the diversion of state resources to security and defence at the expense of industrial development.

There are many examples of the direct infrastructural damage caused by war and conflict in Africa:

- Shishaye et al. (2023) estimate that at least 15% of the water infrastructure was damaged during the ongoing conflict in the Tigray Region in Ethiopia.
- Wanda, Oya and Monreal (2023) report that the civil war in Angola left most of the country's road and rail infrastructure impassable.
- Besteman (2019) describes how conflict in Somalia has disrupted air transport, as airports have been targeted, and airlines struggle to operate safely. The lack of functional airports hampers humanitarian aid delivery and economic connectivity.
- Siebels (2020) explains that the maritime routes in Sierra Leone and Djibouti (near the Bab-el-Mandeb Straits) have been affected, as ports have been damaged, affecting international, regional, and domestic imports and exports.
- Mailey (2024) provides an account of a communications network blackout that occurred in Sudan in 2024, attributed to the paramilitary Rapid Support Forces (RSF). This blackout disrupted aid deliveries and left the war-weary population without reliable communication.

The infrastructural damage as described in the examples above stands in the way of sustainable economic development, trade, mobility, and access to essential services, all of which are required in order to achieve the various targets of SDG 9. During conflict, the resources that would normally be utilised for the maintenance of critical networks are rerouted to the conflict effort, and therefore critical systems required in order to meet the targets of SDG 9 in Africa are often neglected.

Conflict both reduces global cooperation and exerts a negative impact on individual countries, as investments are diverted away from domestic and foreign investments in the infrastructure and industry necessary for the achievement of SDG 9. Lack of access to long-term financing is a key constraint for firms, particularly those wishing to invest in innovation. In Africa the financial sector tends to have short-term incentives, but many investments that are critical to the growth of enterprises are long-term in nature, and require long-term financing. Figure 2 provides an indication of the large number of domestic and foreign investment treaties and laws that exist in Africa. Wheal et al. (2022) estimate that these treaties account for US$2.5tn in investments in infrastructure projects estimated to be completed in Africa by 2025. The instability caused by conflicts in many African countries jeopardises foreign, domestic, public and private sector investment in various projects, including those that will provide much-needed and critical research and development in the area of infrastructure and industry, and this in turn limits the innovation that is essential for sustainable industrialisation.

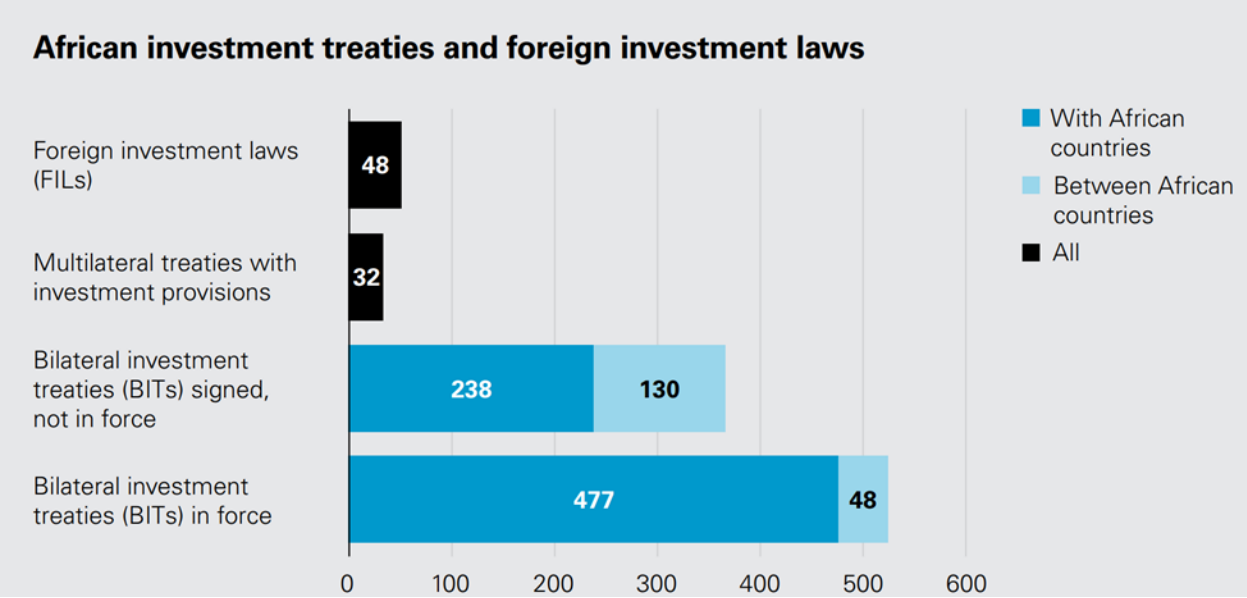

Figure 2. African investment treaties and foreign investment laws (Wheal et al., 2022)

Human resources are diverted during times of conflict. Political violence arising from civil wars and ethnic conflicts has resulted in millions of refugees and massive internal displacement in African countries such as Sudan, Chad, Somalia, Zimbabwe, the

Democratic Republic of the Congo, Mozambique, and Ethiopia. According to the 2023 Africa Center for Strategic Studies report, African conflicts have displaced over 40 million people (ACSS, 2023). The 2022 African Youth Survey established that 52% of young Africans are likely to consider emigrating for reasons that include economic hardship, the desire to seek economic opportunities elsewhere, and political situations that lead to conflict. This has dire consequences for the achievement of SDG 9 in Africa, because it results in the emigration of skilled professionals and academics, depleting countries in the continent of the human capital necessary for innovation and technological advancement.

Supplementary readings

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ACSS (Africa Center for Strategic Studies). (2023). African conflicts displace over 40 million people. https://africacenter.org/spotlight/african-conflicts-displace-over-40-million-people/ Accessed 16 February 2024.

3.3.3 Impact of conflict in Europe

Conflicts in Europe have placed significant obstacles in the way of achieving SDG 9, which aims to build resilient infrastructure, promote inclusive and sustainable industrialisation, and foster innovation. The impacts of conflicts are far-reaching, not only affecting the immediate area in which the conflict takes place, but also having broader implications for regional stability and development (Ayadi et al., 2023).

The development of sustainable, resilient, and inclusive infrastructure (Target 9.1) has been severely hindered in conflict zones. In Ukraine, for example, ongoing conflicts have resulted in the destruction of vital infrastructure, including roads, bridges, and public utilities, which disrupts daily life and hampers economic activity. The constant threat of conflict means that infrastructure must not only meet standard developmental goals, but also be resilient against the damage of war, a challenge that significantly increases the complexity and cost of development projects (Kosse, 2023).

Promoting inclusive and sustainable industrialisation (Target 9.2) has become exceptionally difficult in conflict-affected areas. In the Balkans, historical conflicts have left a legacy of economic disruption that continues to hinder industrial growth. This instability deters foreign investment, which is crucial for industrial development, and disrupts internal economic activities. Industries in these regions struggle to maintain operations and invest in sustainability under such volatile conditions, which often leads to economic stagnation or regression (Mitreva & Koleva, 2021).

Conflicts also hamper the ability to increase access to financial services and markets (Target 9.3). In regions such as Eastern Ukraine, ongoing instability makes it difficult for businesses to access the financial services needed to grow and compete in broader markets. Financial institutions are often reluctant to operate in high-risk areas, which leads to a scarcity of credit and insurance options (Nerlinger & Utz, 2022). Without adequate access to financial services, businesses cannot invest in new technologies or expand operations, as a result of which economic growth and innovation are stifled.

Upgrading industries and infrastructures for sustainability (Target 9.4) is particularly problematic in conflict-ridden areas (Allam et al., 2022). For example, countries affected by the Yugoslav Wars have had to prioritise reconstruction over sustainability upgrades. The need to rebuild basic infrastructure often diverts resources away from long-term sustainability projects, such as renewable energy installations or advanced manufacturing technologies, delaying progress in these critical areas.

Enhancing research and upgrading industrial technologies (Target 9.5) are crucial for sustainable development, but are often sidelined during conflicts. In Serbia, for instance, economic sanctions and the aftermath of conflicts have limited the country's ability to invest in research and development. This not only hampers immediate recovery efforts, but also reduces long-term industrial competitiveness and innovation capacity. The disruption of educational and research institutions further compounds the problem, leaving a lasting impact on the country's innovation ecosystem (Pidorycheva, 2022).

The negative results of conflicts for the achievement of SDG 9 are evident across many European regions that have experienced or are experiencing conflicts (Pereira et al., 2022). The destruction of infrastructure and industrial bases, the interruption of economic activities, and the displacement of populations create a cycle of instability and underdevelopment that is difficult to break. To move towards the goals set out in SDG 9 in such contexts, it is essential to integrate peacebuilding and conflict resolution as core components of development strategies (Nerlinger & Utz, 2022). Only through restoring stability can these regions begin to make meaningful progress toward sustainable industrialisation and resilient infrastructure development. This approach not only aids in immediate recovery, but also lays the groundwork for long-term sustainable growth, which is essential for the overall stability and prosperity of the continent.

Supplementary resources

- Allam, Z., Bibri, S.E., & Sharpe, S. A. (2022). The rising impacts of the COVID-19 pandemic and the Russia–Ukraine War: Energy transition, climate justice, global inequality, and supply chain disruption. *Resources*, 11(11), Article 11. https://doi.org/10.3390/resources11110099
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- Kosse, I. (2023). *Rebuilding Ukraine's infrastructure after the war* (Research report 72). Policy notes and reports. https://www.econstor.eu/handle/10419/278562
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- Leal Filho, W., Fedoruk, M., Paulino Pires Eustachio, J.H., Barbir, J., Lisovska, T., Lingos, A., & Baars, C. (2023). How the war in Ukraine affects food security. *Foods*, 12(21), Article 21. https://doi.org/10.3390/foods12213996

Assessment

3. Overview of global crises that have negatively affected the achievement of SDG 9

- Identify at least three (3) global crises that have negatively affected the achievement of the targets of SDG 9, and explain what the impact of each of these crises has been.

3.1 Climate change

- How has climate change exerted a negative impact on progress in the areas of innovation and industrialisation?
- How are these negative impacts perceived in your region?

3.2 COVID-19

- What effects has the COVID-19 pandemic had on the achievement of the targets of SDG 9?
- How are these effects perceived in your region?

3.3 Conflict

- Explain how conflicts exert a negative impact on efforts to achieve SDG 9.
- How are these impacts perceived in your region?

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4. Regional contexts/progress towards the achievement of SDG 9

Learners will be able to:

- develop an understanding of regional differences in achieving SDG 9.
- understand the various factors that have a negative impact on the achievement of the various targets for SDG 9.

The beginning of the Decade of Action – which was supposed to be dedicated to accelerating solutions for meeting the 2030 Agenda and achieving a more sustainable world from 2020 to 2030 – was marred by the outbreak of a global pandemic. Even before

the devastating impacts of the spread of COVID-19 across the world, the United Nations was reporting that global efforts were inadequate to bring about the change needed. Nevertheless, earlier reports were pointing out progress and positive trends in important areas.

Within the first five years of the implementation of the SDGs, some aspects had improved considerably.

4.1 Regional progress in Latin America

Based on the Industry Index scores for SDG 9, the average score for the Latin America and the Caribbean (LAC) region declined from 0.286 in 2000 to 0.237 in 2019. This suggests a reversal of progress in SDG 9 targets within LAC countries compared with global trends. Figure 3 illustrates that the overall performance of the LAC region lags behind that of North America and Europe (UNIDO, 2022).

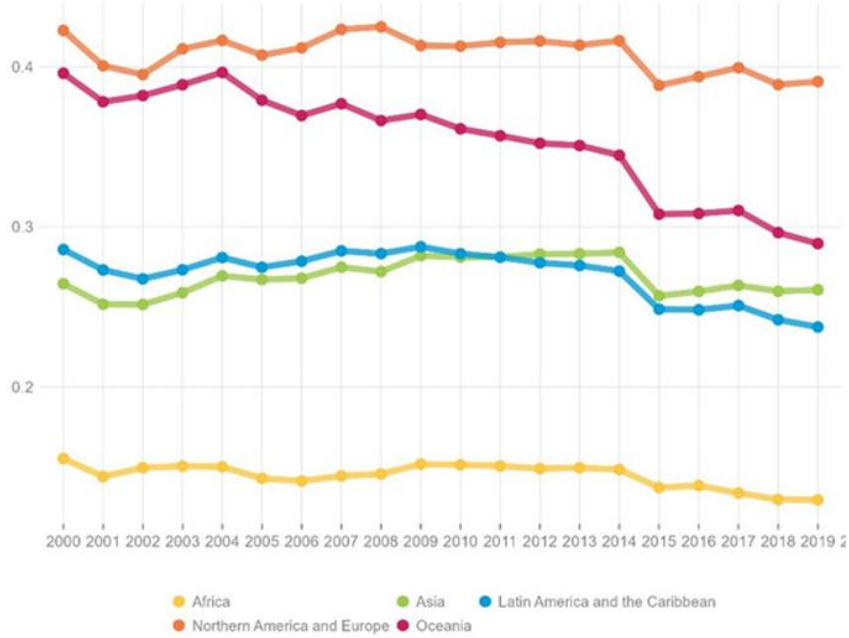

Figure 3. Source: UNIDO SDG 9 Industry Index 2022

In 2019, Mexico emerged as the top-performing country in the region, with a score of 0.399, and securing 30th position. Following Mexico, Trinidad and Tobago attained a score of 0.343, occupying 39th position. Argentina, with a score of 0.315, claimed 46th position, followed by Paraguay at a score of 0.298 (51st position), and Uruguay with a score of 0.278 (53rd position). Countries exhibiting the lowest performance included Venezuela (Bolivarian Republic of) in 100th position, Panama in 102nd position, and Haiti in 124th position. Generally, a deterioration in performance is evident across the region. Of the 21 countries assessed by the SDG 9 Industry Index, 17 experienced a decline in their ranking, while only four managed to improve their position (UNIDO, 2022).

The performance of the region in terms of its share of manufacturing value added (MVA) in GDP and manufacturing employment is significantly influenced by various dimensions. This underscores the crucial role played by the manufacturing sector in the region, distinguishing it from other areas. However, the sustainability and technological intensity of the manufacturing sector encounter numerous challenges (UNIDO, 2022).

In general, significant disparities persist between the LAC region and other global regions. The MVA per capita in the LAC region has reached a plateau, standing at USD 1,025 in 2021. Additionally, the region's MVA continues to be comparatively lower than that of North America and Europe. Furthermore, LAC countries trail behind other regions with regard to the share of MVA in GDP per capita and the proportion of medium- and high-tech industries in total MVA (UNIDO, 2022).

Globally, there has been a deceleration in manufacturing output across all regions and country groups since 2017, leading to an overall economic slowdown. Within the LAC region, the manufacturing sector has experienced stagnation since 2011, due primarily to a declining trend in South American countries. In contrast, Central America has shown a divergent trajectory, largely influenced by Mexico's performance. Mexico's manufacturing sector began to grow in 2009, following the global financial crisis, until the onset of the COVID-19 pandemic in 2020. While the Caribbean has the smallest contribution to regional manufacturing, its MVA has remained steady since 2009 (UNIDO, 2022).

MVA underwent a decline across all sub-regions of the LAC region in 2020 compared with 2019, with a decrease of 9.1% in Central America, 6.4% in South America, and 3.7% in the Caribbean. Although the LAC region's manufacturing sector showed a significant recovery in 2021, it has not yet fully returned to its pre-pandemic levels (UNIDO, 2022).

Despite diverse development patterns in respective LAC sub-regions, the share of manufacturing in GDP has decreased universally over the past two decades. Among the LAC sub-regions, South America witnessed the most substantial decline, by 3.5% from 2000 to 2021, followed by Central America (3.3%) and the Caribbean (2.3%) during the same period. Despite Central America's significant decrease in MVA share in GDP, it reported the highest share of MVA in GDP in the LAC region at 16.1% in 2021, driven primarily by Mexico's robust manufacturing sector (UNIDO, 2022).

After 2008, manufacturing jobs started to decline in South America, while Central America experienced significant growth in the aftermath of the global financial crisis. Similar patterns are evident in the share of manufacturing employment relative to total employment. Manufacturing employment in the LAC region decreased from 14.5% in 2000 to 11.7% in 2020. However, Central America, led by Mexico and El Salvador, has witnessed a gradual yet consistent increase since 2012.

It is important to approach the available data with caution, however, due to the high level of informality in Latin America. Additionally, a significant number of workers are employed in low-technology manufacturing industries.

As per the information provided by the ECLAC, micro and small to medium-sized enterprises (MSMEs) in the LAC region constitute approximately 25% of the total GDP (Dini & Stumpo, 2020). This implies that manufacturing activities contribute approximately 20 to 25% of the total GDP in the region (UNIDO, 2022).

In Peru, small enterprises secured the largest portion of loans and lines of credit, accounting for 72.2% in 2017, reflecting a 7% increase since 2010. Similarly, in Colombia, this share rose by 2 percentage points to reach 59.7%. Notable increases of approximately 20% compared with 2010 were observed in Guatemala (46.6%) and Uruguay (43.5%) (UNIDO, 2022). However, Ecuador (44.9%) and Argentina (42.2%) experienced a slight decrease in their respective shares of loans and lines of credit. In Paraguay, there was a significant decline from 70% to 35.7% (UNIDO, 2022).

Across the LAC region, 44.2% of SMEs accessed loans and lines of credit, with South America at 47.0%, the Caribbean at 44.0%, and Central America at 40.4% (UNIDO, 2022).

In 2019, the manufacturing sector exhibited the highest CO2 intensity per unit of MVA in the Caribbean, recording 0.41 kg/USD. South America followed with 0.35 kg/USD, and Central America with 0.25 kg/USD. Notably, it is important to acknowledge that the overall CO2 intensity in the Caribbean may be heavily influenced by Trinidad and Tobago (UNIDO, 2022). This country, being one of the largest oil and natural gas producers in the region, has CO2 emissions per capita that surpass the regional average (World Bank, 2018).

Nations exhibiting higher MVA per capita, indicative of advanced industrial capabilities, tend to have lower CO2 emission rates, signifying reduced manufacturing intensity, irrespective of their population size (UNIDO, 2022). The example of Paraguay is particularly noteworthy in this context. Paraguay boasts one of the world's cleanest electrical power production systems, with 99.7% of its electricity generated through hydropower, resulting in zero CO2 emissions (Pappis et al., 2021).

In 2019, low-technology industries continued to dominate manufacturing production in the LAC region, comprising 53.4% of the total, while medium-high and high-technology industries accounted for 30.9% (UNIDO, 2022).

Central America stood out with the highest share of medium-high and high-technology value added, making up 39.9% in 2019. This was driven primarily by the prevalence of high-tech industries in Mexico. In contrast, South America had a lower percentage, with medium-high and high-technology value added accounting for 26.8% of total manufacturing, while the Caribbean registered even less at 14.7% in 2019 (UNIDO, 2022).

During the second quarter of 2020, all industries experienced a sudden decline, irrespective of technological intensity, as the region was affected by the onset of the COVID-19 pandemic, leading to the implementation of containment measures. Generally, the manufacturing of essential consumer goods, such as food products, has maintained

a steady growth trajectory with limited losses since the beginning of the pandemic (UNIDO, 2022).

There is evidence suggesting that industries with higher technological intensity are playing a key role in the recovery, both in the LAC region and globally. However, the heavy reliance of the LAC region on the production of motor vehicles has posed significant challenges due to disruptions in the supply chain of resources and intermediate goods. This has resulted in a complex and unequal path to manufacturing recovery in the LAC region (UNIDO, 2022).

Supplementary readings

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4.2 Regional progress in Africa

At the 9th Africa Regional Forum on Sustainable Development held in Niger from 28 February to 2 March 2023, various African countries and organisations discussed progress, challenges and opportunities associated with the implementation of SDG 9, and

priority actions that would be needed to accelerate its achievement (ECA, 2023). A summary of the major discussions provides insight into the future actions that Africa should take to achieve SDG 9:

- More emphasis must be placed on the need to accelerate the evolution of science and technology education within universities to ensure that more practical components are infused into curricula, since this would better equip engineers and technicians to enter the labour market.
- Governments and the private sector should implement policies and strategies to support small and medium-sized enterprises, as this is essential for creating jobs and boosting productivity in Africa.
- Increased investment is needed in hard and soft infrastructure, including transport, and in the development of skills related to information and communications technology and science, technology, and innovation.
- Increased efforts must be made to increase exports, attract foreign direct investment, and facilitate technology transfer.
- It is necessary to build resilient regional value chains to develop productive and competitive economies that can take full advantage of the opportunities to implement the agreement establishing the African Continental Free Trade Area.
- An appeal should be made to the United Nations and regional development organisations to support countries in accessing blended financing instruments, including concessional capital, climate and green funds, and risk mitigation tools. This would encourage private investors who are interested in infrastructure development projects.

It is vital that countries and organisations in Africa move to a more constructive roadmap that will foster innovation, create jobs, and improve the quality of life of their citizens, ultimately contributing to the achievement of the 2030 Agenda for Sustainable Development and Agenda 2063: The Africa We Want (ECA, 2023). Given the lack of high-quality data relating to the Goal 9 indicators, however, it is difficult to report adequately on the progress achieved with regard to the Goal 9 targets by African countries and the likelihood that they will achieve Goal 9 by the 2030 deadline.

Figure 4 provides a schematic representation of the progress made towards reaching the various targets and associated indicators of the progress towards the successful achievement of SDG 9. Three targets appear to be losing any gains made and show negative progress towards reaching the targets by 2030. Efforts relating to a further six targets need to be accelerated if the target of 2030 is to be achieved. Only one target (9c.1) is on track for achievement by 2030 (African Union, 2024).

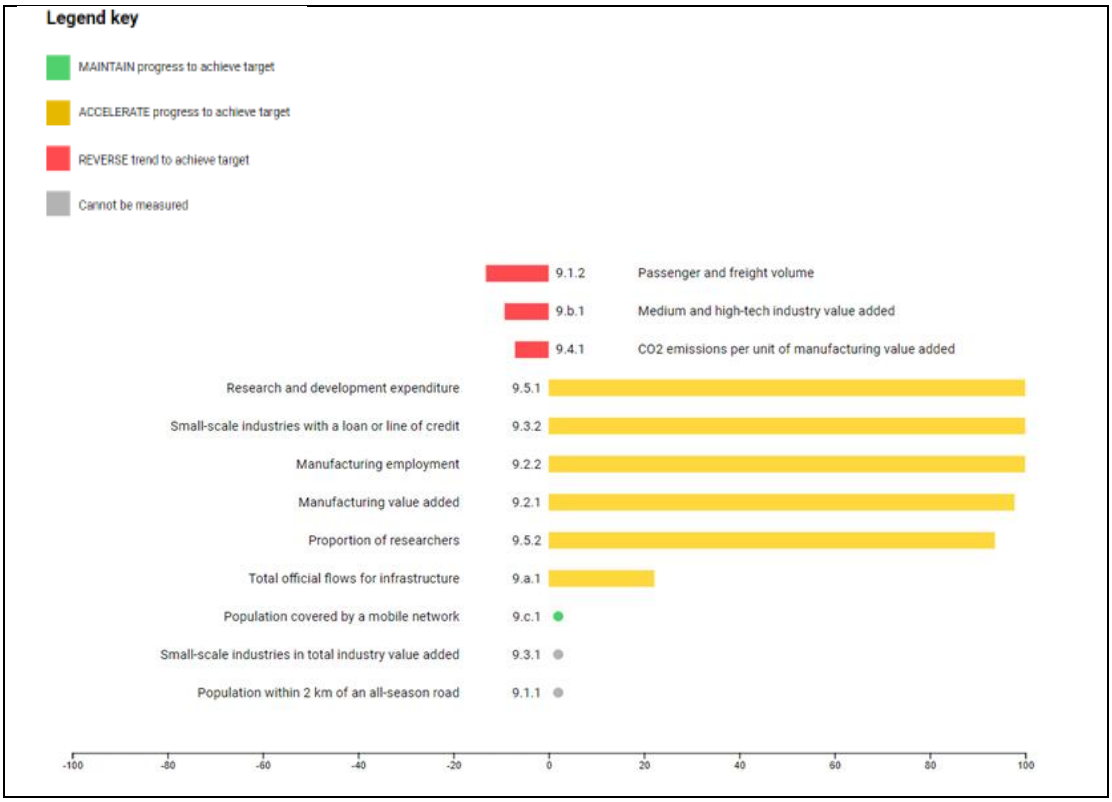

Figure 4. Africa progress towards achieving SDG 9 (African Union, 2024)

Targets that have shown a reverse trend

Indicator 9.1.2, Passenger, and freight volumes by mode of transport, has shown a reverse trend. Although Africa has a larger population than Europe and Latin America, the limited size of the African economies, low levels of trade and investment, and numerous infrastructure gaps mean that the volumes of passenger and freight transport are much lower than in Europe or Latin America. Passenger air transport volumes in Africa amounted to 71 billion kilometres, while in Latin America they amounted to 233 billion kilometres and in Europe 489 billion kilometres. Moreover, freight transport by air, measured at 34.0-billion-ton kilometres in Europe and 5.7-billion-ton kilometres in Latin America, far exceeds that of Africa, whose total air freight volume was measured at only 4.9-billion-ton kilometres in 2021 (United Nations, 2023). There is, however, a significant spatial distribution of the freight volume across the continent of Africa (Figure 5), ranging from higher volumes in East Africa (4 billion tkm) compared with other subregions, including West Africa (28 million tkm) and Central Africa (1 million tkm). This could be a consequence of the fact that several countries in East Africa, including Ethiopia, Kenya, and Rwanda, are home to successful national airlines (Samunderu, 2023), one of which, Ethiopian Airlines, is the continent's largest airline in terms of passengers carried, destinations served and fleet size (United Nations, 2023).

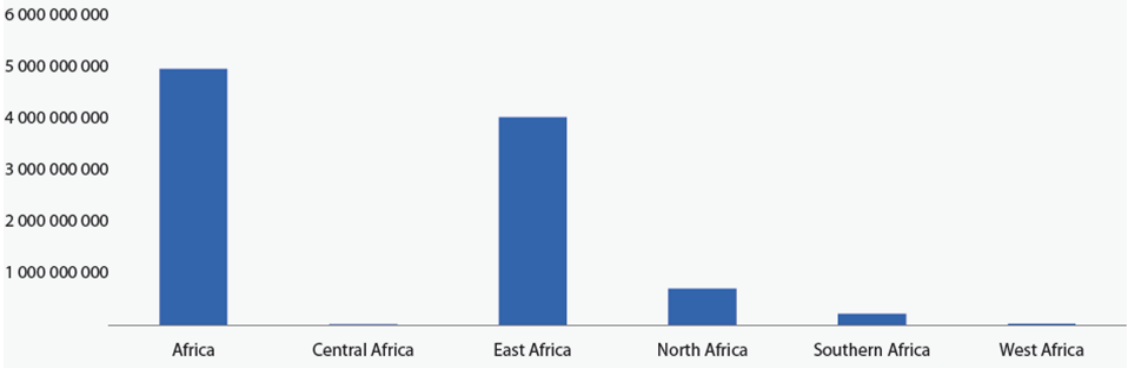

Figure 5. Freight volume (+) by air in Africa and the five regions in 2021 (United Nations, 2023)

Target 9.b.1 aims to enhance the share of medium and high-tech industry value added within the total value. During the two years of the COVID-19 pandemic, negative growth in the achievement of this target was experienced (as indicated in Figure 6). Specifically, the percentage of medium and high-tech manufacturing value added within the total manufacturing value added was lower in Africa than in other global regions between 2018 and 2020 (Andreonia & Avenyob, 2023). This discrepancy is attributed to the fact that African industry relies primarily on resource-based activities and tends to involve low-tech practices. However, there is a glimmer of progress: Africa witnessed a 2.41% increase in medium and high-technology industrial activity between 2018 and 2022, despite the socioeconomic problems introduced by the pandemic. This modest rise underscores the capacity of African countries to adopt innovative technologies in various economic sectors. To further stimulate economic transition and job creation, Africa must shift from resource-based and low-tech activities toward medium and high-technology endeavours (United Nations, 2024).

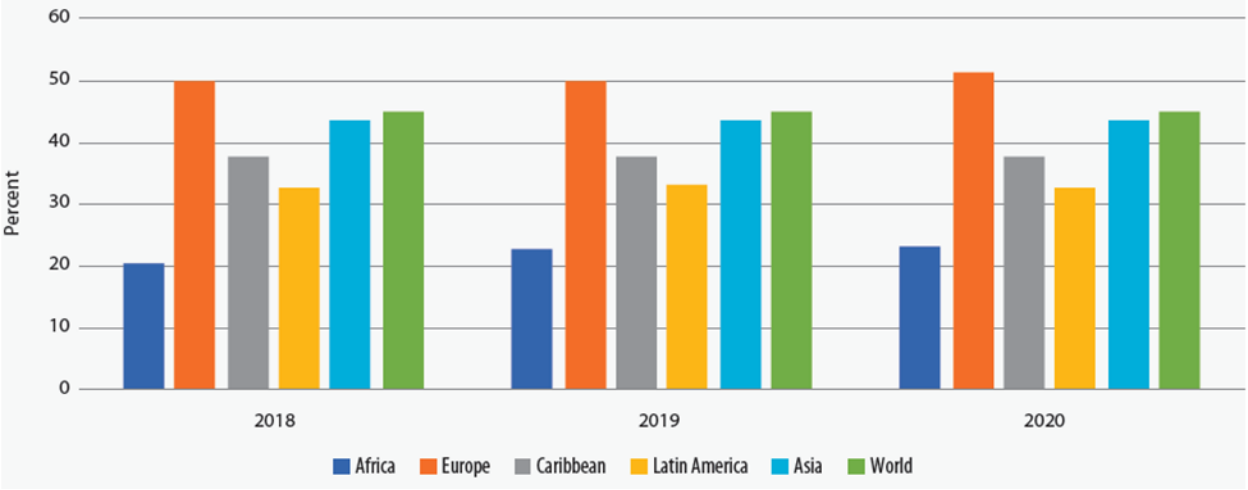

Figure 6. Percentage of medium and high-tech manufacturing value added as part of total value added at the global level, 2018 to 2020 (United Nations, 2023)

There are, however, significant variations in the proportion of medium and high-tech industry manufacturing value added within the total value added across different subregions of the African continent. Between 2018 and 2020, West Africa boasted the highest share, followed by North Africa and Southern Africa. However, the situation is not uniform across all African countries. For instance, in nations such as Algeria, Angola, Gabon, and Ethiopia, the share of medium and high-tech industry manufacturing value added has either remained relatively stable or declined since 2000 (World Bank, 2024). Several factors influence this share, including the capacity to produce, export, and adopt cutting-edge technology, as well as obstacles such as political instability, economic underperformance, and the rapid population growth.

Targets that must accelerate progress

Indicator 9.2.1 aims to increase manufacturing value added as a proportion of GDP and per capita. Manufacturing plays a pivotal role in industrialisation, which remains essential for strengthening economic resilience and boosting prosperity across the continent. Developing the manufacturing sector will make it possible to generate employment, enhance incomes, and fuel innovation, with positive ripple effects extending to other parts of the economy. However, recovery from the pandemic has been uneven globally. In Africa, the manufacturing value added as a proportion of GDP consistently lagged other regions between 2019 and 2022 (United Nations, 2023). African countries faced difficulties due to limited productive capacity, supply chain disruptions caused by the COVID-19 pandemic, the Russia–Ukraine conflict, a decline in global demand, and policy constraints in deploying fiscal stimulus measures to support the industrial sector. Small industrial enterprises continue to encounter significant obstacles in accessing credit (United Nations, 2024).

Between 2019 and 2021, the proportion of manufacturing employment relative to total employment, as measured by indicator 9.2.2, varied widely across global regions (Nguimkeu & Zeufack, 2024). Notably, Africa experienced a slight increase of 0.12 per cent during this period (United Nations, 2023). Specifically:

- North Africa boasted the highest manufacturing employment rate in 2021, standing at 11.55 per cent.
- Central Africa followed closely with a rate of 10 per cent.
- West Africa recorded an employment rate of 8.48 per cent.
- East Africa, despite having the lowest rate at 5.47 per cent in 2021, witnessed a 0.17 per cent increase between 2019 and 2021.
- On the other hand, Southern Africa observed a decline of 0.22 per cent in manufacturing employment as a share of total employment over the same period.

This surge in manufacturing employment across Africa may be attributed to the construction boom, which led to increased demand for manufacturing inputs such as cement, steel, and polyvinyl chloride (United Nations, 2023).

Indicator 9.3.2 focuses on the proportion of small-scale industries that have access to loans or lines of credit. These small-scale industrial enterprises play a crucial role in African economies, serving as major sources of employment and self-employment. In addition, they contribute significantly to the development of innovative technologies at the grassroots level of industrial production. Given their importance in income generation and poverty alleviation, overcoming the unique problems that they face is vital. Due to their limited resources and small size, these enterprises often struggle to withstand unexpected setbacks, such as the COVID-19 pandemic, unless they receive support from governments. Access to credit is particularly important for enhancing their competitiveness, which, in turn, can boost their contribution to GDP and job creation (United Nations, 2024). Disparities exist in terms of the percentage of small-scale industrial enterprises with credit access (United Nations, 2023):

- In Africa, the proportion of small industrial enterprises that secured bank loans or had lines of credit was significantly lower than in other regions throughout the world during 2022 and 2023, despite a slight increase in Africa during 2023. Within Africa, there are variations among countries. For example, approximately 37% of small-scale industries in Tunisia had access to financial services in 2020; by contrast, only 5.52% and 4.13% of small-scale industries in South Africa and Egypt, respectively, enjoyed similar access.
- Sub-regionally, Southern Africa had the highest proportion of small-scale industrial enterprises with a loan or line of credit in 2023, followed by East Africa and North Africa.
- The relatively low percentage of loans or credit lines granted to African small-scale enterprises can be attributed to factors such as lack of collateral, and credit history. Efforts are needed to improve the provision of financial services to these enterprises, which have the potential to play a pivotal role in Africa's economic transformation.

The data informing Indicator 9.5.2, which measures the number of researchers (in full-time equivalents) per million inhabitants, is available for only a limited number of African countries (Sooryamoorthy, 2023), making it difficult to assess progress in this area. Examples from three countries are included in Figure 7 to show the spatial disparities between countries between 2014 and 2020 (United Nations, 2023). In 2020, Tunisia boasted 1659 full-time researchers per million inhabitants, and Egypt had 837 full-time researchers per million inhabitants (Khorshid et al., 2023); Togo, on the other hand, had a modest 46 full-time researchers per million inhabitants. Over the period from 2014 to 2019 Egypt witnessed an increase of 163 researchers per million population; Togo experienced a more modest rise of 8 researchers per million inhabitants; and Tunisia experienced a decline, with the number of researchers per million population decreasing by 159. The factors contributing to this decrease in Tunisia could include insufficient funding and limited demand for research on the part of policymaking bodies.

Attending to the problems related to this SDG indicator is vital as a means to foster scientific development and innovation in the region (United Nations, 2023).

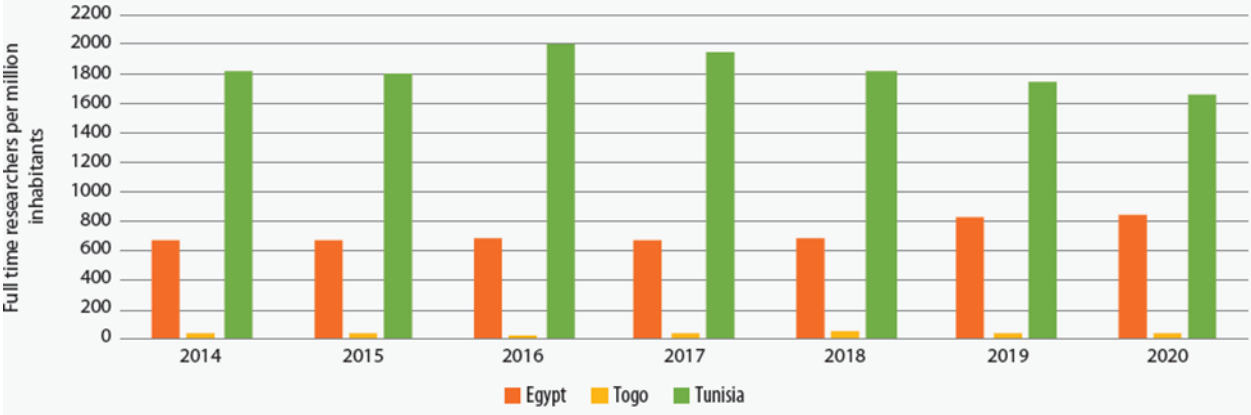

Figure 7. Number of full-time researchers per million inhabitants in Egypt, Togo and Tunisa, 2014–2020 (United Nations, 2023)

The situation related to Indicator 9.a.1, which pertains to total official international support (official development assistance plus other official flows) for infrastructure, is reflected in Figures 8 and 9. The total official flows for infrastructure development exhibited diverse trends between 2019 and 2020 across several African countries (Tandrayen-Ragoobur, Ongono, & Gong, 2023, United Nations, 2023):

- Ethiopia experienced an increase in flows from $874.4 million to $1,039.4 million (an 18.86% rise), despite the ongoing global response to the COVID-19 pandemic.
- Conversely, Nigeria witnessed a sharp decline, with flows plummeting from $852.2 million in 2019 to $471.9 million in 2020 (a 44.63% decrease).
- Although Egypt also faced an 18% decline in official flows between 2019 and 2020, it remained the continent's leading recipient of assistance, receiving a substantial $2.626 billion in 2020.
- Morocco followed closely, receiving $1.781 billion in assistance during the same year.

In general, total official flows were lower to countries in West, Central, and Southern Africa than to those in East and North Africa. For instance, Niger, Sao Tome and Principe, and Lesotho received $154 million, $9 million, and $4 million, respectively, in 2020.

These disparities among countries and subregions in Official Development Assistance receipts and other official flows for infrastructure in 2019 and 2020 can be attributed to varying national priorities (Ortega & Sanjuán, 2023). Some countries prioritised the health sector in response to the effects of the pandemic (United Nations, 2023).

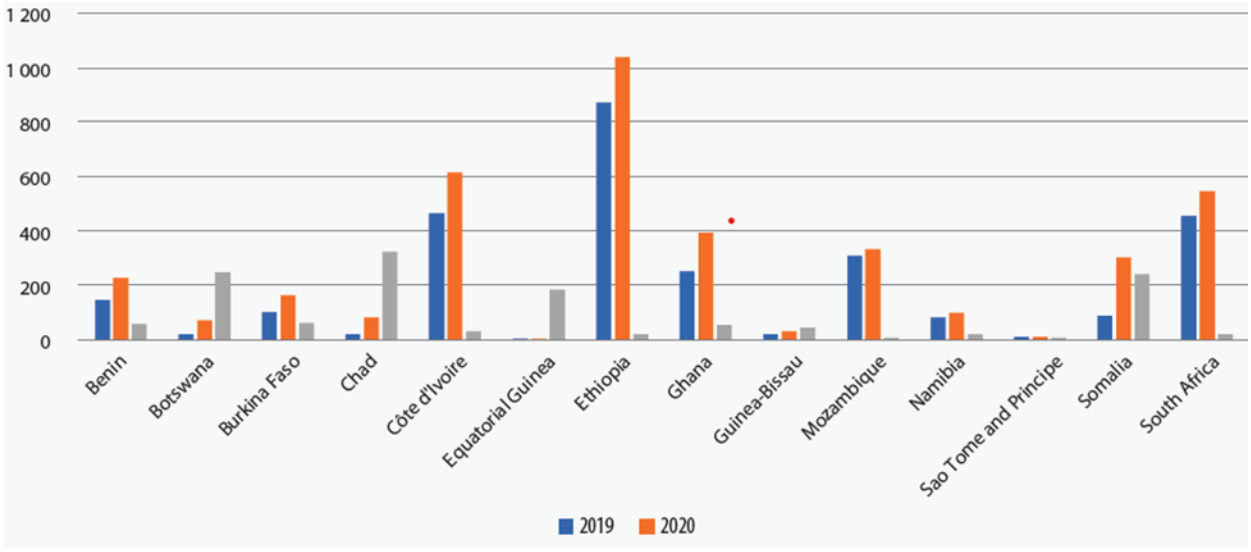

Figure 8. Increases in total official flows for infrastructure development, selected African countries, 2019–2020 (US$, millions) (United Nations, 2023)

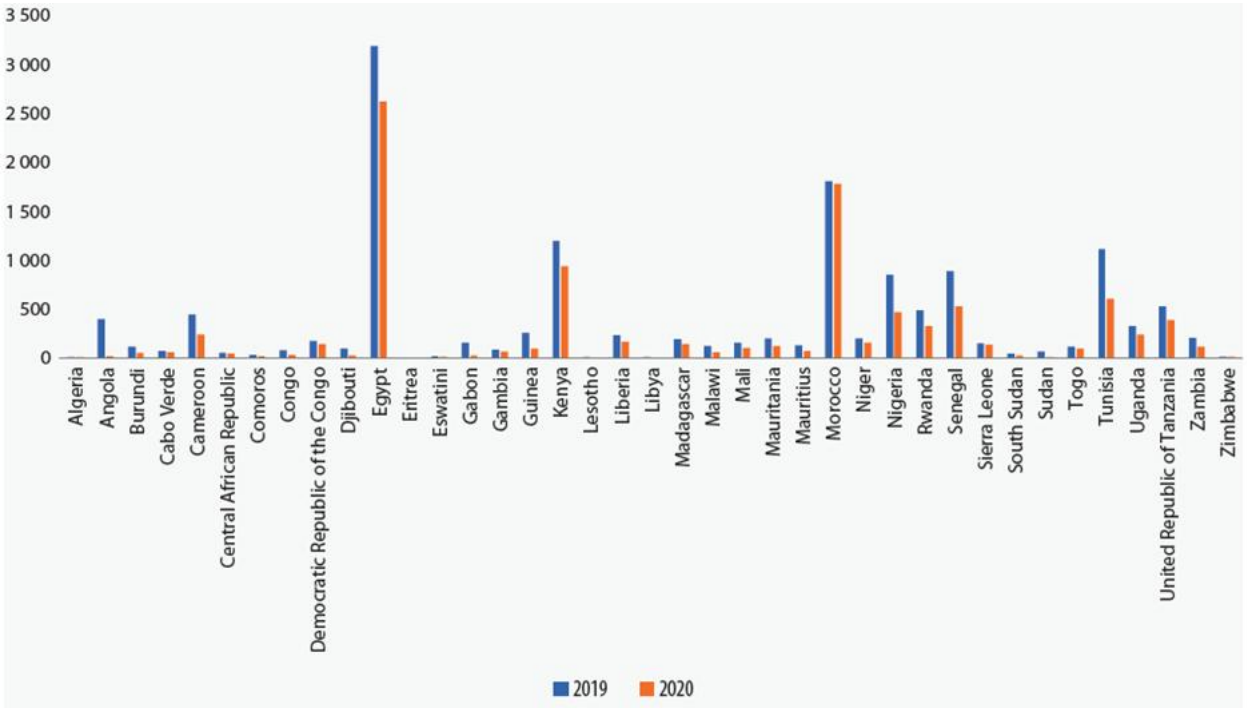

Figure 9. Decreases in total official flows for infrastructure development, selected African countries, 2019–2020 (US$, millions) (United Nations, 2023)

Maintain progress in achieving the targets

Indicator 9.c.1 focuses on the proportion of the population covered by mobile networks. In 2020, 2G mobile network coverage in Africa was robust (Choi, Laughlin & Schultz, 2021). On average, 89.24% of the total population across 54 African countries

had 2G coverage. Notably, Guinea-Bissau, Mali, and Namibia achieved 100% 2G mobile coverage, while 34 countries exceeded 90% coverage. However, Burundi, the Central African Republic, and South Sudan lagged with less than 60% 2G coverage (United Nations, 2023). Moving to 3G, approximately 75% of the population in 53 African countries had 3G mobile network coverage in 2020. In 30 countries, over 80% of the population had 3G coverage. Niger and South Sudan had the lowest coverage rates at 24% and 15%, respectively (Konte & Tetteh, 2023). Regarding 4G, 53% of the population in 48 African countries had access to 4G mobile networks, while in 21 countries, more than 60% of the population had 4G coverage. However, in countries such as Cameroon, Ethiopia, the Gambia, Niger, South Sudan, and the United Republic of Tanzania, less than 20% of the population had 4G coverage (Begazo, Blimpo, & Dutz, 2023). Despite uneven coverage, there was a 20% increase in 4G network coverage between 2017 and 2020, notwithstanding the socioeconomic obstacles posed by the COVID-19 pandemic (Figure 10). African nations have continued to invest in infrastructure and innovative technologies to bolster mobile networks. At this pace, Africa is poised to achieve the target by 2030. While overall progress is positive, countries with slower advancements must intensify efforts to enhance coverage in the years ahead.

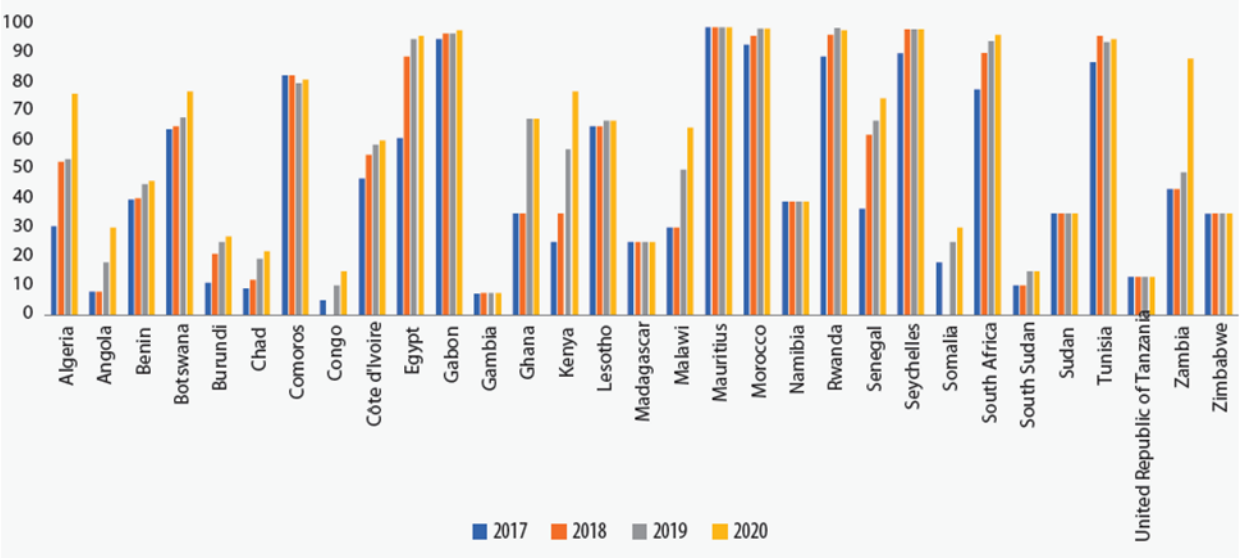

Figure 10. Percentage of the population to have 4G mobile network coverage in selected African countries, 2017 to 2020 (United Nations, 2023)

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4.3 Regional progress in Europe

Despite the negative effects of climate change, conflicts, and the COVID-19 pandemic on development, some European countries have made significant strides in meeting SDG 9, which aims to build resilient infrastructure, promote sustainable industrialisation, and foster innovation. This goal encompasses a number targets, each reached through initiatives tailored to both regional and transnational needs (Table 5).

Table 5. Regional progress in Europe

SDG 9 Targets	**Examples of Regional Progress in European Countries**
9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	Germany: Invested heavily in high-speed rail and renewable energy infrastructures, enhancing both local accessibility and cross-border connectivity (Wenner & Thierstein, 2020) Spain: Improved transportation networks in rural areas to bolster economic activities and accessibility (Carchano et al., 2021)
9.2 Promote inclusive and sustainable industrialisation, and by 2030 significantly raise industry's share of employment and GDP, and double its share in least developed countries	Italy: Focused on modernising its manufacturing sector to boost productivity and sustainable practices (Fava et al., 2021) Poland: Expanded industrial sectors in digital technologies and sustainable manufacturing, raising employment and economic contributions from industry (Stanisławski & Szymonik, 2021)
9.3 Increase the access of small-scale industrial and other enterprises to financial services, including	France: Implemented programmes to support startups and SMEs with easier access to loans and financial services (Fartash & Darehshiri, 2022)

affordable credit, and their integration into value chains and markets	Netherlands: Enhanced integration of small-scale enterprises into global value chains through innovation hubs and partnerships (Meurs et al., 2020)
9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies	Sweden: Leading in retrofitting industries towards sustainability with initiatives to reduce carbon footprint and increase energy efficiency (Boussaa et al., 2023) United Kingdom: Investments in clean technology and sustainable practices across various industrial sectors (Boakye et al., 2020)
9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors, encourage innovation and substantially increase the extent of and spending on research and development	Finland: High investment in R&D relative to GDP, focusing on technology and innovation in industrial sectors (Stenborg et al., 2021) Denmark: Renowned for substantial public and private sector collaboration in R&D, particularly in green technologies and pharmaceuticals (Østergaard, Holm & Park, 2021)
9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support	European Union programmes often extend support outside the region; an example is the EU–Africa Infrastructure Trust Fund, which enhances infrastructure collaboration between European and African countries (Bilal, Keijzer & Ahairwe, 2021)
9.b Support domestic technology development, research and innovation in developing countries, including a conducive policy environment for industrial diversification and value addition to commodities	European Union: Supports various initiatives aimed at fostering technology transfer and innovation in less developed regions through frameworks such as Horizon Europe, which also benefits developing nations by encouraging collaborative research projects (Kastrinos & Weber, 2020)
9.c Significantly increase access to ICT and strive to provide universal and affordable access to the Internet in least developed countries by 2020	Estonia: Known for its advanced digital infrastructure, provides expertise and technological support to developing countries aiming to enhance ICT accessibility (Butt, Pappel & Õunapuu, 2020) European Commission: Initiatives aimed at increasing digital inclusivity within and beyond Europe (Zancajo, Verger & Bolea, 2022)

In terms of developing quality reliable and sustainable infrastructure (Target 9.1), Germany has made substantial investments in high-speed rail and renewable energy infrastructure. This enhances both local accessibility and cross-border connectivity, promoting economic development and well-being in the region. Similarly, Spain has focused on improving transportation networks in rural areas, boosting economic activities and ensuring more equitable access to transportation services.

The promotion of inclusive and sustainable industrialisation (Target 9.2) is evident in Italy's modernisation of its manufacturing sector, which has aimed to enhance productivity and incorporate sustainable practices. Poland, on the other hand, has expanded its industrial sectors into digital technologies and sustainable manufacturing, thereby increasing the industry's share of employment and GDP.

In order to work towards achieving Target 9.3, which seeks to increase access to financial services for small-scale industries, France has implemented programmes that

facilitate easier access to loans and financial services for startups and SMEs. The Netherlands has enhanced the integration of these enterprises into global value chains through innovation hubs and partnerships, boosting their market presence.

Sweden and the United Kingdom have led efforts to upgrade infrastructure and retrofit industries for sustainability under Target 9.4. Sweden's initiatives focus on reducing carbon footprint and increasing energy efficiency, while the UK has invested in clean technologies and sustainable practices across various sectors.

The enhancement of scientific research and the upgrade of technological capabilities in industrial sectors (Target 9.5) are exemplified by Finland's high investment in R&D, particularly in technology and innovation within industrial sectors. Denmark has also been notable for its substantial collaboration between the public and private sectors in R&D, especially in green technologies and pharmaceuticals.

On a broader scale, the European Union has facilitated sustainable and resilient infrastructure development in developing countries (Target 9.a) through initiatives such as the EU–Africa Infrastructure Trust Fund, which enhances collaboration between European and African nations. Additionally, under Target 9.b, the EU supports various initiatives aimed at fostering technology transfer and innovation in less developed regions through frameworks such as Horizon Europe.

Finally, with regard to increasing access to information and communication technology (ICT) (Target 9.c), Estonia is known for its advanced digital infrastructure, providing expertise and technological support to enhance ICT accessibility in developing countries. The European Commission has also initiated several programmes aimed at increasing digital inclusivity within and beyond Europe. These initiatives collectively demonstrate Europe's commitment to achieving SDG 9 through diverse strategies that not only enhance regional capabilities, but also contribute to global developmental goals.

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4. Progress towards the achievement of SDG 9 by 2030

- How does your current life pattern affect the achievement of the SDG 9 targets?

4.1 Regional progress in Latin America

- In your opinion, will the countries in Latin America be able to achieve the SDG 9 targets by 2030? Why do you say so? What are the supporting and hindering factors?
- What are the main obstacles in the way of achieving SDG 9 in your region/country?

4.2 Regional progress in Africa

- In your opinion, will the countries in Africa be able to achieve the SDG 9 targets by 2030? Why do you say so? What are the supporting and hindering factors?
- What are the main obstacles in the way of achieving SDG 9 in your region/country?

4.3 Regional progress in Europe

- In your opinion, will the countries in Europe be able to achieve the SDG 9 targets by 2030? Why do you say so? What are the supporting and hindering factors?
- What are the main obstacles in the way of achieving SDG 9 in your region/country?

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5. Case studies

Learners will be able to:

- identify good practices in various regional case studies as these relate to the achievement of SDG 9.
- develop and apply a local project aimed at achieving SDG 9.
- use the knowledge presented in regional case studies to adapt to a more sustainable way of living.

This section is dedicated to presenting examples of good practices applied in countries throughout the world to support the achievement of SDG 9. These practices involve the adoption of a variety of approaches, as shown in Table 6. Additional examples can be found in the United Nations' SDGs Knowledge Platform.

Table 6. Examples of best practices related to the achievement of SDG 9

Title and geographic coverage	Objective	Related SDGs	Source
UNIDO Industrial Analytics Platform, Austria	The platform was developed to be an innovative data-based tool providing internationally comparable information on and in-depth analytical insights into the dimensions of inclusive and sustainable industrial development. It includes an SDG-9 Industry Tracker, which assists in monitoring countries' performance and progress towards the achievement of SDG 9 industry-related targets through accessible and engaging data visualisations and dashboards. The practice supports monitoring and guides industrial policy.	9	https://sdgs.un.org/partnerships/unido-industrial-analytics-platform
CARICOM Girls in ICT Partnership, Guyana	This initiative is a response to the need to raise awareness about ICT/STEM/STEAM opportunities and challenges and offer development programmes for girls and young women. The partnership coordinates and initiates projects involving students, teachers, parents, employers, academia, and policy-makers in CARICOM countries.	4, 5, 9, 17	https://sdgs.un.org/partnerships/caricom-girls-ict-partnership
Lockdown Economy, Netherlands	The Lockdown Economy was established as a volunteer-driven socio-economic and educational movement to help small businesses and self-employed professionals overcome the difficulties arising from the COVID-19 pandemic. Coordinated by an NGO, the programme uses innovation practices such as design thinking, agile, weekly scrum boards and standups. Participation is online, allowing greater participation.	4, 5, 8, 9, 10, 17	https://sdgs.un.org/partnerships/lockdown-economy
SDG Accelerator for established SMEs, Moldova	The pilot was an innovation programme for established SMEs. It provided a robust methodology for identifying and developing new business products and services that would contribute to the SDGs and help SMEs pursue a more sustainable, profitable and forward-looking product/service portfolio.	9, 11, 12, 17	https://sdgs.un.org/partnerships/sdg-accelerator-established-smes
Partner for the Industrial Innovation, Mexico	Group T, led by Grupo Industrial TV (GITV), is committed to the objective of being a partner in industrial innovation in Mexico, in that way contributing to the achievement of SDGs 8, 9 and 12. The aim is to introduce innovation in processes, tools, and machinery in the automotive, construction and transportation industries, among others.	9, 8, 12	https://sdgs.un.org/partnerships/partner-industrial-innovation-mexico
&HER, North America	&HER determines measurements and fit via AI Machine Vision and brings data directly to production, making it possible to manufacture bras customised to every body shape.	9, 12	https://sdgs.un.org/partnerships/her
National Strategy for Strengthening Smelting and Refinery Capacity, Chile	The objective of this national strategy is to strengthen and increase the capacity of foundries and refineries in Chile through the promotion of environmental, social and economic sustainability of the industry, the creation of more and better jobs, the development of productive chains , improving the traceability of Chilean copper production, raising environmental performance standards, as well as adding value to the national mining industry.	8, 9	https://sdgs.un.org/partnerships/estrategia-nacional-para-el-fortalecimiento-de-la-capacidad-de-fundicion-y-refineria

5.1 Latin America

This section presents the case studies selected from Brazil, Colombia and Mexico with the intention of highlighting good practices adopted in this region by showcasing the programmes, their results and impacts, and the lessons learnt. Each case study seeks to contemplate the main goal of SDG 9, that is, build resilient infrastructure (case study from Brazil), promote inclusive and sustainable industrialisation (case study from Mexico), and foster innovation (case study from Colombia).

5.1.1 Case 1: MDE: Medellin Smart City, Colombia

The details presented in this case study are derived from the content provided by the Inter-American Development Bank (2016) and ACI Medellín (2022).

Medellin, the capital of Antioquia province in Colombia (Figure 11), has a population of 2,464,322 residents, making it Colombia's second most populous city. Its economic landscape centres on key industries, with textiles leading at 20%, followed by chemical substances and products at 14.5%, food products at 10%, and beverages at 11%. The remaining 10% encompasses sectors such as metalworking, electricity, and electronics.

Figure 11. Location of Colombia in Latin America

Acknowledged as the most innovative city in 2013, Medellin has gained global attention for its transformative journey, earning accolades from the likes of the *Wall Street Journal*, Citi, and the Urban Land Institute. The Medellin, the Most Innovative City strategy, a collaborative effort involving universities, private entities, local government, and society, has stimulated investment in innovation, aiming to foster a sustainable economy through a blend of public and private initiatives.

This transformation has drawn international attention, underscoring Medellin's unique status as the only Colombian city with a comprehensive science, technology, and innovation plan. This plan outlines strategies for advancing fields such as healthcare, energy, and information and communication technology.

Once synonymous with security challenges, Medellin has evolved into a global hub of technological and social innovation. Through a series of strategic interventions, the city has embraced smart city principles, enhancing capacity and organisational structures in mobility, environmental management, and security. Future plans include consolidating

city services under a unified control centre, in that way streamlining the monitoring and management of urban operations.

The programme strategy

In terms of the MDE: Medellin Smart City initiative, Medellin is leading various projects aimed at fostering citizen engagement, promoting open government, driving social innovation, and ensuring project sustainability. These endeavours include the establishment of free internet zones, community centres equipped with ICT facilities, a collaborative platform called Mi-Medellin for Co-creation, open data initiatives, online transaction services, and more.

Another pivotal strategy is the implementation of the Smart Mobility System (SIMM), incorporating technology, an operations centre, and a suite of monitoring and control services. This system has produced tangible benefits such as accident reduction, enhanced mobility, and quicker incident response times.

In the realm of environmental conservation, Medellin has deployed the Early Warning System (SIATA), the Noise Monitoring Network, and the Air Quality Network, seamlessly integrated with the emergency response network. Additionally, the Integrated Metropolitan Emergency and Security System (SIES-M) represents a systemic approach fostering collaboration among more than 10 local and national government agencies, uniting security and emergency services.

These initiatives, characterised by their sustained nature, rely on operational frameworks that foster public–private partnerships and inter-agency agreements across various sectors. Academic institutions and entities specialising in innovation, science and technology actively contribute to these efforts, reflecting a collaborative ethos in support of advancing Medellin's smart city agenda.

Results and impact of the programme

In 2019, Medellín was placed 91st overall in rankings, showcasing strengths in cultural activities, green spaces, opportunities for lifelong learning, employment prospects, and recycling services. However, the city faced problems in terms of high levels of air pollution, public safety concerns, traffic congestion, and instances of corruption among public officials. A resident survey highlighted the most pressing issues, with air pollution, security, corruption, access to fulfilling employment, and road congestion ranking highest in terms of urgency.

Responding to these shortcomings, Medellín's city government formulated its 2030 Smart City Vision, drawing insights from metrics and approaches utilised in the IMD Index. This visionary plan aims to propel Medellín from its 91st position to a place among the top 50 within a decade, utilising a range of policy and legal tools. Key technological enablers identified include big data, blockchain, cloud services, digital/open government,

artificial intelligence, internet of things (IoT), and 5G/fibre, envisioned as enhancing Medellín's stature as a globally recognised smart city.

Medellín has emerged as a pioneer in leveraging IoT technology to enhance access to high-quality water. The city's public utility, EPM (Empresas Públicas de Medellín), has successfully implemented Colombia's inaugural smart aqueduct utilising IoT technology. Situated in the department of Sucre, this groundbreaking project encompasses an aqueduct equipped with over thirty IoT devices and data-driven instruments, enabling real-time monitoring of water flow, pressure, chlorine levels, turbidity, and pH levels. Notably, the system facilitates swift prediction and response to emergency situations. Executed in collaboration with Telemetrik and its subsidiary Aguas Regionales, the project has entered its second phase following its recognition by means of an honourable mention in the Innovation category of the Portfolio 2020 Awards.

Furthermore, Medellín's Integrated Traffic and Transportation Information Centre (CITRA Medellín) stands out as an artificial intelligence-driven system that plays a pivotal role in planning and managing mobility across the metropolitan area. This unique initiative involves a strategic partnership with the Government of South Korea, backed by an investment exceeding US$12 million. Integrated data from various sources, including the Medellín Metro, the Metropolitan Area of Aburrá Valley, the Medellín Intelligent Mobility System (SIMM), the Traffic Light Centre (CIOS), Regulated Parking Zones (ZER), the Mobility Secretariat, Security Secretariat, and Terminals Medellín, serve as the operational backbone for optimising metropolitan mobility.

Medellín is exploring the realm of smart tourism by embracing innovations such as an augmented reality (AR) powered city mobile application and real-time data processing. These advancements aim to empower tourism businesses to customise their services effectively. These endeavours form a crucial component of Medellín's Smart Destination initiative.

In particular, there are some areas that distinguish Medellín as a prime investment destination in the information and technology sector:

- At the heart of the city's economy lies technology: With over 2,500 technology companies operating in the information and technology (IT) sector, Medellín has established itself as a thriving hub. In 2021 alone, this sector contributed to the creation of 26,669 new jobs.
- Medellín is investing in an innovation ecosystem: Over 48,000 individuals are undergoing training in skill sets pertinent to the 4th Industrial Revolution. By 2023, Medellín will boast 21 specialised centres dedicated to fostering innovation and software proficiency. Notably, Medellín allocates over 1% of its GDP towards research and development endeavours, in sharp contrast to the national average of only 0.28% of GDP.

Links with targets and indicators of SDG 9

Smart cities are closely connected to SDG 9 through fostering innovation, building resilient infrastructure, and promoting sustainable industrialisation. They achieve this through investments in modern infrastructure, driving technological advancements, attracting industries focused on innovation, leveraging digital technologies, and ensuring equitable access to information and communication technology (ICT). Smart cities contribute to the objectives of SDG 9 by promoting inclusive and sustainable industrialisation, fostering innovation, and enhancing infrastructure development in a manner that improves urban living while being environmentally sustainable.

Sustainability and replicability

Initiatives such as those adopted by Medellín can help investors from both the public and private sectors establish strategic alliances with local companies for the development of new smart city solutions. These can also help with efforts to qualify more professionals in the greenfield sector. In addition, Medellin can serve as an example of a smart city to the Latin American market.

5.1.2 Case 2: Guadalajara, Mexico: Digital upskilling in a conflict zone

The description of this case in Mexico (location presented in Figure 12) was based on the reference provided by REACH Alliance (2020).

Figure 12. Location of Mexico in Latin America

Part of the maker movement, FabLabs (digital fabrication laboratories) serve as hubs for community engagement, entrepreneurship, creativity, and education. According to the Fab Foundation, established in 2009 to foster the global FabLab network, there are

over 1,600 FabLabs worldwide, with 27 registered in Mexico. These spaces not only promote creative and educational growth, but also serve as incubators for solutions to community development and global problems.

In 2018, the Nueva Santa Maria FabLab opened its doors to the Cerro community, situated within the la Parroquia de Nueva Santa Maria church. This FabLab endeavours to fortify Cerro's social fabric by providing avenues for social, educational, and economic empowerment. Established through a partnership between ITESO University and the local community, this initiative aligns with ITESO's Jesuit principles, emphasising human rights and equality. ITESO has a longstanding commitment to community development, particularly in marginalised neighbourhoods such as Cerro.

The strategy of the programme

The FabLab is jointly overseen by ITESO and CISAI, a high-impact social innovation centre within ITESO. However, ensuring its success and sustainability relies heavily on achieving self-sufficiency. It is imperative that the Cerro community be able to manage the FabLab independently, without external assistance. Community-driven initiatives are not new, as can be seen from the extensive literature discussing community-driven development (CDD). As CDD initiatives worldwide demonstrate improved development outcomes, ITESO has structured its social interventions accordingly. Moreover, the community itself has actively sought to take ownership of the FabLab's operations.

ITESO and CISAI have collaborated with influential individuals in Cerro who possess extensive community networks to oversee the FabLab's management. Within the church, a group of individuals with a broad social reach leads the day-to-day operations, informally referring to themselves as the "Mesa Coordinadoras" or "board of coordinators." While this mesa includes two ITESO-appointed members, their goal is to gradually reduce their involvement in decision-making. Similarly, community members within the mesa recognise the necessity of owning the FabLab so as to effectively engage disenfranchised youth, who are often the most difficult to reach.

Driven by the imperative of community ownership, operational self-sufficiency, and the need for success stories within the community, the Reach team collaborated with ITESO researchers to devise an operational framework. Together, they facilitated the design and implementation of two pilot programmes, which were executed by members of the mesa.

The Nueva Santa Maria FabLab is equipped with three key manufacturing machines: a laser cutter, a 3D printer, and a computer numerical control (CNC) router. Among these, the laser cutter stands out as the most utilised machine. To date, all courses organised by ITESO and Feciar (Feciar is an organization that provides educational to formal and informal educational institutions) have focused on training community members in the creation of various items using this equipment.

Results and impact of the programme

The second course, facilitated by a former FabLab instructor, aimed to train ten participants in 3D printing through a series of four consecutive sessions, each lasting three hours. This second pilot programme expanded on the initial curriculum developed by Feciar specifically for this FabLab. The first session served as an introduction to the FabLab's objectives, providing an overview of the subsequent sessions. The following two sessions focused on the acquisition nof technical skills, with a particular emphasis on mastering Inkscape design software. During the third session, participants had the opportunity to design, print, and engrave keychains as a practical exercise.

In the final session, individual designs were translated into personalised products, such as earrings or decorations, using both a 3D printer and a laser-cutter machine. The course concluded with a group photograph as an illustrative representation of motivation, confidence, achievement, and community development. This intervention aimed to foster interactivity, creativity, self-expression, collaboration, and engagement among participants.

An essential element for ensuring the long-term success of the FabLab lies in its capacity to forge alliances with technology-centric businesses and organisations. These partnerships hold the potential to enrich its educational offerings, paving the way for potential internship opportunities and career pathways for its graduates.

Links with targets and indicators of SDG 9

FabLabs, supported by initiatives such as the Reach Alliance, play a crucial role in advancing SDG 9 – Industry, Innovation, and Infrastructure. These fabrication laboratories serve as hubs for innovation, providing communities with access to cutting-edge technologies and tools for prototyping and manufacturing. By democratising access to advanced manufacturing capabilities, FabLabs empower individuals, especially those in underserved and marginalised communities, to participate in the global economy and contribute to local development. Through skills development, training programmes, and collaborative projects, FabLabs promote the growth of sustainable industries and foster entrepreneurship, aligning with SDG 9's objective of promoting inclusive and sustainable industrialisation. Moreover, FabLabs contribute to infrastructure development by fostering the creation of networks and ecosystems that support innovation and technological advancement, ultimately driving progress towards achieving SDG 9's targets.

Sustainability and replicability

Sustainability lies at the core of the FabLabs concept, with the FabLabs being supported by initiatives such as the Reach Alliance, ensuring their viability and impact over the long term. These labs embrace sustainability in multiple areas: environmental, economic, and social. In terms of environmental responsibility, FabLabs promote

sustainable practices by encouraging recycling, the use of eco-friendly materials, and the adoption of energy-efficient technologies in their operations. From the perspective of the economy, they foster local economic development by providing opportunities for entrepreneurship and job creation, particularly in sectors related to advanced manufacturing and technology, and from a social perspective, FabLabs promote inclusivity by offering access to resources and skills development programmes to individuals from diverse backgrounds, thereby contributing to community resilience and cohesion. The replicability of FabLabs further enhances their sustainability, as the model can be adapted and implemented in various contexts throughout the world. By documenting best practices, sharing resources, and facilitating knowledge exchange, initiatives such as the Reach Alliance make it possible to replicate FabLabs, amplifying their positive impact on sustainable development globally.

5.1.3 Case 3: Itaipu Binacional, Brazil

This case study in Brazil (Figure 13) is based on the report "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation – Case study: Itaipu and SDG 9" (Itaipu, 2022).

Figure 13. Location of Brazil in South America.

Established in 1974 by Brazil and Paraguay, Itaipu is a binational institution aimed at harnessing the power of the Paraná River, which marks the border between the two nations, for hydropower generation. Today, the Itaipu Hydropower Plant stands as the world's largest producer of renewable energy (ITAIPU, 2018). Since its establishment, Itaipu Binacional has been committed to sustainable development, as is evident in its holistic approach to fostering social well-being, economic advancement, and environmental preservation. Its initiatives have significantly contributed to the prosperity

of the Paraguayan and Brazilian regions. Recognised as exemplars of best practices, Itaipu's projects in the area align closely with the effective realisation of the United Nations 2030 Agenda for Sustainable Development and its Sustainable Development Goals.

The strategy of the programme

In the context of SDG 9, Itaipu has been actively involved in constructing vital infrastructure and promoting industrialisation while fostering research, development, and innovation. Its dedication to the sustainable development and prosperity of Paraguay and Brazil is evident through various actions and policies. These include the construction of cross-border bridges, the implementation of the Regional Infrastructure Development Program, and the Technological Update of the Itaipu Hydroelectric Power Plant. From its inception, the entity has supported industrialisation by providing clean and reliable electricity, enabling industries to thrive, expand, and create markets for their products and services. Additionally, Itaipu's initiatives in the areas of sustainable rural development and sustainable territorial management have further fostered economic growth. The entity has also supported important research, development, and innovative initiatives in the region through its scientific centres, such as the Centre for Advanced Studies on Dam Safety, the Electrical Systems Automation and Simulation Laboratory, the Territorial Intelligence Centre, and the Microgrids Pilot Project in Western Paraná.

Results and impact of the programme

Centre for Advanced Studies on Dam Safety (CEASB)

Established in 2008, CEASB collaborates with universities and research institutions to develop strategic solutions for dam safety. CEASB coordinates and executes research projects, fostering multidisciplinary collaboration and integrating various areas of knowledge. Through regular agreements with the Itaipu Technological Park, CEASB ensures ongoing collaboration and safety enhancements. Itaipu prioritises dam safety through rigorous inspection, maintenance, and investment in technology and personnel training, setting industry standards for safety protocols.

Key outcomes of this initiative include:

- Advancement of technical knowledge in dam safety through collaboration with universities and experts, resulting in numerous publications.
- Integration of new technologies to enhance analysis and improve dam safety operations.
- Support for research in refining modelling and simulation methods.
- Dissemination of findings through presentations and articles, and development of partnerships for training programmes.
- Collaboration with institutions and associations in the area of dam safety.
- Implementation of extensive performance monitoring involving the use of thousands of instruments.

- Provision of computer simulations for structural behaviour analysis.
- Regular issuing of reports for project monitoring.
- Review of published information to ensure accuracy.

Electrical Systems Automation and Simulation Laboratory (LASSE)

LASSE, located within the Itaipu Technological Park, plays a crucial role in testing and validating equipment and systems for electricity generation, transmission, and distribution. It aims to enhance Itaipu Binacional's technological self-reliance and supports the plant's technological advancement plan through research, development, and innovation projects. Since 2008, LASSE has been developing hardware and software solutions, fostering multidisciplinary collaboration among various stakeholders.

Through its research, development, and innovation initiatives, LASSE has generated valuable knowledge, efficient solutions, innovative products, and economic benefits, enhancing Itaipu's autonomy and contributing to the broader electricity sector in Brazil and Paraguay.

Since its inception, LASSE has attained the following milestones:

- Conducted over 70 technical and technological services in simulation.
- More than 70 papers presented at energy sector congresses and published in journals.
- Sustained employment for over 30 professionals at LASSE.
- Involved more than 50 researchers in LASSE projects.
- Implemented over 15 solutions at Itaipu.
- Currently pursuing over 25 ongoing research and development projects.

Itaipu monitors LASSE's progress and overall achievements through monthly reports, tracking key performance indicators.

Technological Updating of Itaipu Hydroelectric Power Plant

The Itaipu Hydroelectric Power Plant is undergoing a comprehensive technological update to maintain reliability and enhance performance. This initiative aims to modernise core control systems, integrating digital technologies and aligning with global standards. The update involves the systematic replacement and evaluation of equipment and systems across various plant components. The project, spanning 14 years with an investment of $660 million, began in 2006 with planning and analysis, followed by strategic development and basic project completion by 2018. The tender process for the update commenced in 2018, with workshops held to engage stakeholders and clarify bidding procedures. The update seeks to adapt to technological advancements, ensure operational safety, and improve efficiency.

The update process has now reached the tender phase. Monitoring of this process will involve project management and engineering management tools commonly employed

in the execution of major projects globally. Real-time supervision of all processes and tracking of results form part of the planned monitoring approach.

Development of International Standard for Sustainable Territorial Management

The objective of this initiative is to develop a methodology for quantitatively assessing sustainable development actions, with a focus on biodiversity conservation. Culminating in the establishment of international standards, Itaipu's sustainability efforts have the potential to serve as a model for other regions. Implementation of the initiative involves collaboration between Itaipu, LIFE, and the Itaipu Technological Park Foundation, with plans for drafting standards, conducting validation tests, and seeking accreditation by ISEAL. The initiative aims to replicate successful models across Brazil, Paraguay, and other countries committed to sustainable development and biodiversity conservation.

The project has achieved significant successes, including international dissemination and benchmarking, which underscore its innovative nature. Further notable achievements are the establishment of the main thematic focuses for work groups and receiving contributions from 36 experts across four areas of knowledge during the initial technical workshop. Integration of Brazilian and Paraguayan technical expertise beneath the Itaipu umbrella is a further significant accomplishment.

Monitoring will involve edited reports and public consultations, with a planned workshop facilitating critical analysis and collective validation by participating institutions.

Regional infrastructure development

The main objective is to drive economic growth in the region by improving infrastructure and enhancing trade opportunities. Initiatives include constructing two international bridges to boost connectivity, improving the international port and river dredging for smoother navigation, and revitalising airports to enhance operational capacity. These projects aim to increase regional integration, support trade logistics, and create new job opportunities.

The region benefits from improved safety, quality of life, and expanded trade opportunities as a result of infrastructure projects such as bridge construction. Itaipu's involvement is crucial for both economic development and strategic access to new markets, especially for Paraguay.

Territorial Intelligence Centre

The Territorial Intelligence Centre aims to promote science and research for sustainable development. It focuses on providing environmental information, fostering partnerships with research institutions, and conducting research in key areas such as

water security, biodiversity, climate, and territorial intelligence. Collaborations with universities enhance its research capabilities.

The Territorial Intelligence Centre has a diverse research team and aims to expand knowledge on natural resources while developing monitoring techniques for environmental and territorial management. Anticipated benefits include promotion of water security, improved institutional image, the consolidation of partnerships, and facilitation of discussions on sustainable development. The effectiveness of the initiative will be measured by its impact on public policy planning and decision-making processes.

Microgrid Pilot Project in Western Paraná

The project aims to establish a Microgrid Pilot Unit in Western Paraná, using renewable biogas from waste from pig farming. It seeks to develop and validate microgrid concepts for rural areas, identifying communities where distributed generation could be sustainable. Led by Itaipu and executed by the Itaipu Technological Park and CIBiogás, the initiative integrates renewable energy as a means to stabilise services, addresses environmental concerns relating to animal protein production, and supports global climate change goals. It began in 2018 and is expected to conclude by 2020.

The ongoing project aims to deploy microgrid pilot units in selected rural areas to generate clean electricity during grid power failures. Progress is monitored through periodic reports and meetings, with technical reports documenting microgrid performance to inform improvements in standards and legislation. The project also maps potential areas for future microgrid implementation to expand sustainable use.

Links with targets and indicators of SDG 9

Centre for Advanced Studies on Dam Safety (CEASB)

The Centre's activities are closely tied to Target 9.5, as they bolster scientific research, upgrade technological capabilities in the energy sector, foster innovation, and drive investment in research and development in both the public and private sectors.

Electrical Systems Automation and Simulation Laboratory (LASSE)

LASSE's activities align with Target 9.5 by advancing scientific research, enhancing technological capabilities, promoting innovation, and increasing investment in both public and private research and development.

Technological Updating of Itaipu Hydroelectric Power Plant

This initiative is aimed primarily at the achievement of Goal 9.4, which focuses on enhancing infrastructure and industries to ensure sustainability, improve resource efficiency, and promote the adoption of clean and environmentally friendly technologies and processes.

Development of International Standard for Sustainable Territorial Management

This important initiative is aligned with Target 9.3, as sustainability certification adds value by identifying territories, producers, and companies as sustainable and

biodiversity-friendly. This recognition enhances access to financial services, such as better credit terms, and integration into specialised markets and value chains.

Regional infrastructure development

The regional infrastructure development programme aligns with Target 9.1, focusing on creating quality, reliable, and sustainable infrastructure to support economic growth and human well-being. The construction of new bridges will not only enhance regional sustainable development, but also promote commercial, social, and cultural growth in the benefiting cities and communities. This investment in infrastructure is crucial for achieving Agenda 2030 goals in Brazil, as it aims to improve transportation systems, reduce regional inequalities, and enhance regional integration while ensuring accessibility and well-being for all.

Territorial Intelligence Centre

This initiative directly supports Target 9.5 by enhancing scientific research and technological capabilities, promoting innovation, and increasing investment in research and development. The establishment of the Territorial Intelligence Centre focuses on water security and sustainable regional development, aiming to boost public investment in science. It seeks to build technical expertise in strategic areas for sustainable development and expand the skilled workforce in the region.

Microgrid Pilot Project in Western Paraná

The project aligns with Targets 9.1, 9.2, 9.4, and 9.5, aiming to deploy microgrids powered by biogas from animal waste. These microgrids provide reliable electricity access to rural communities (Target 9.1) and support the development of legal and regulatory policies for their commercialisation (Target 9.2), potentially boosting rural producers' income and GDP. Itaipu's support for this project promotes the adoption of clean technologies (Target 9.4) and fosters innovation and research (Target 9.5) in sustainable waste management and distributed power generation for rural areas.

Sustainability and replicability

Numerous infrastructure projects are fostering regional integration and facilitating the growth of new industries, businesses, and markets. This can establish new regions as centres for innovation and scientific research in advanced technological systems. Taking Itaipu's holistic approach to sustainable development as an example, these initiatives have the potential to replicate successful models across Brazil, Paraguay, and other countries committed to sustainable development and biodiversity conservation.

5.2. Africa

5.2.1 Gorou Banda Thermal Power Plant (Niger)

Niger (Figure 14) is one of the world's poorest countries and is facing an economic crisis due to regional and international sanctions following the military coup. Niger ranks

189th out of 191 countries in the 2021 UN Human Development Index, and despite being the seventh largest supplier of uranium in the world, Niger ranks seventh among the world's poorest countries. According to the World Bank (2021), Niger has a total population of more than 26 million, and approximately 10 million people live in extreme poverty. Niger has a poorly diversified economy and is dependent on agriculture for 40% of its GDP. Despite initiatives to expand extractive industries, broad-based development has been hampered by poor infrastructure, extremely low education levels, and multiple concurrent climatic shocks such as droughts and floods. The increasing presence of violence, crime, and extremism adds to the daily plight of the population (Arslan, 2023; World Bank, 2021).

Figure 14. Location of Niger and neighbouring countries
(https://commons.wikimedia.org/wiki/Atlas_of_Niger#/media/File:LocationNiger.svg)

Niger has one of the lowest electrification rates in sub-Saharan Africa, at 12.2% in 2017, which improved to 18.8%, in 2019. Only one in seven Nigeriens has access to modern electricity services, and just 4% of rural residents have access through the national utility. Sustainable electricity infrastructure is key for industrial development, and without power, there is no viable path for economic growth and development – a situation which traps people below the poverty line. In 2020, Niger was flagged as having one of the lowest electricity access rates in the world at 19.5%, with wide disparities between urban and rural areas and across regions. Niger has always been heavily dependent on imports of cheap electricity from Nigeria and on costly domestic diesel-powered electric generation for its electricity supply (World Bank, 2021). As of September 2021, Niger's national generation capacity was reported as 284 megawatts, all of it derived from

expensive fossil fuels. The government of Niger aims to raise the electrification rate to 80% by 2035, with 30% of generating capacity derived from renewable sources. All the above-mentioned obstacles run counter to the aspirations of SDG 9, which seeks to achieve inclusive and sustainable infrastructure, industrial development and innovation coupled with enhanced research and increased access to finance services.

In response to electricity shortages in the country, the government established the Gorou Banda Solar Power Plant, which is equipped with 55,776 solar panels and is the largest solar park in Niger. Each of the solar panels generates 540 W of power, and collectively they represent the first grid-ready renewable energy source in the country. The plant, led by the Nigerien Electricity Company (Nigelec), was established on a 27-hectare site located just 12 km from the capital, Niamey (Salifu, 2023). The plant required an investment of just over 30 million euros, of which the EU provided 5.3 million euros. The French Development Agency (AFD) has contributed 23.6 million euros in the form of a loan, and the State of Niger has contributed just over 1.5 million euros. This project was also aimed at significantly reducing Niger's energy dependence on its neighbours, as it imports more than 70 MW of electricity (Africa Oil-Gas Report, 2023). Niger is very sunny, which is a great advantage for solar-generated electricity.

The objectives of the project were as follows:

- Increase renewable energy coverage.
- Reduce electricity imports.
- Invest in sustainable development of infrastructure.
- Attract foreign investors and developers.

Results and impact of the programme/project

The inauguration of the new Gorou Banda solar power plant on 5 July 2023 was a significant day for the Niamey region of Niger. This power station has subsequently contributed significantly to reducing load shedding in the Niamey region. This solar farm produces 53 GWh of electricity per year, enough to supply 70,000 homes or 500,000 people in the capital, Niamey, marking significant progress along Niger's path towards sustainable development and energy independence (Abdulrasheed, 2023). The plant is also expected to prevent the emission of up to 23,000 tonnes of CO2 per year (Africa Oil-Gas Report, 2023). This solar power plant underscores Niger's commitment to promoting renewable energy sources, reducing reliance on costlier and more environmentally damaging non-renewable energy sources. As such, the Gorou Banda solar power plant stands as a beacon of cleaner, more affordable energy for the people of Niger, fostering economic growth and environmental conservation (Abdulrasheed, 2023).

This project was also accompanied by the construction of the 330 kV Nigeria–Zabori–Niamey high-voltage lines on the border with Nigeria and Burkina Faso and the Zabori–Benin border as a public utility. Installing sustainable infrastructure facilitates electricity exchanges between the other member countries of the Economic Community

of West African States (ECOWAS). Boasting a robust capacity of 30 MWp, this state-of-the-art facility with solar mini-grids offers a cost-effective, fast pathway to delivering first-time energy access to 1,000 rural villages. The success of the Gorou Banda solar power plant ANPER has also served as a robust feasibility project to attract international mini-grid developers and private sector investment.

Obstacles encountered

Political instabilities and upheavals severely delayed the commissioning of the project by nearly two years. The solar farm, first conceived in 2018 as a 20 MW installation, was expanded to a capacity of 50 MW in 2020, and construction only began in 2021. The departure of most of the technical staff following the coup also contributed to delaying the commencement of operations, and as a result, the plant was brought online by the remaining technicians. This led to fears of potential operational risks, as the plant was not completed under the initially planned conditions and by the originally appointed technical staff.

Lessons learnt in terms of the achievement of specific SDG targets

This project relates directly to the achievement of SDG Targets 9.1, 9.3 and 9.4, which seek to develop sustainable, resilient, and inclusive infrastructure which is necessary for sustainable industrialisation and increasing access to finance and markets. With the aim of achieving these targets, the project:

- installed 55,776 solar panels each generate 540 W of renewable energy.
- received financial assistance from various foreign institutions and organisations and was able to attract developers to invest in clean energy in Niger.
- trained a number of staff members in machinery management to ensure the efficiency and sustainability of the infrastructure.
- has the capacity to reduce carbon dioxide emissions, thus promoting a clean and sustainable environment.

Sustainability and replicability

As a means to ensure that the solar panels are used to their full capacity, three Nigelec operators were trained in the operation of the specialised Sunbrush machine, designed to regularly remove dust from the panels so as to maintain their efficiency. Beyond its immediate utility, the Gorou Banda solar power plant will have a positive long-term impact on the environment. It is estimated that the facility will bring about a reduction of about 23,000 tonnes of CO2 emissions per year. This will be achieved by replacing conventional thermal power plants with this green energy source, underscoring the dual role of such initiatives in meeting energy demands and combating climate change. Considering that the African continent is associated with warm temperatures, solar power projects are feasible and can be replicated in other countries within the continent.

5.2.2 Dangote Refinery Project, Nigeria

Nigeria is the largest economy in Africa, with a population of more than 218 million in 2021 (World Bank, 2021) making it an attractive investment destination (Figure 15). Retail and wholesale sales comprise 16% of Nigeria's GDP, making these sales the third largest contributor, even though most are conducted through informal channels such as open markets, street vendors, and kiosks. Nigeria is the 13th largest oil producer in the world and the largest in Africa. Oil and gas exports accounted for more than 98% of export earnings, about 83% of federal government revenue, and more than 14% of the country's GDP in 2016. However, due to the recent fall in crude oil prices, export earnings from crude oil decreased significantly, leading to an economic recession in Nigeria between 2016 and 2017 (African Development Bank Group, 2023).

Figure 15. Location of Nigeria
(https://commons.wikimedia.org/wiki/Maps_of_Nigeria#/media/File:LocationNigeria.svg)

Real GDP growth fell to 3.3% in 2022 from 3.6% in 2021, precipitated mainly by a decline in oil production. Nigeria is estimated to hold approximately 37 billion barrels of proven oil reserves, the second largest in Africa after Libya. However, although Nigeria has substantial oil reserves with the potential for extraction, a lack of adequate gas infrastructure and fully functioning refineries has prevented the country from taking full advantage of this natural resource; owing to the failure of the state refineries, in association with poor maintenance, only 40% of the oil refineries in the country operate at full capacity, and as a result, fuel shortages plague the daily lives of its inhabitants. It is further estimated that Nigeria has about 176 trillion cubic feet of proven natural gas reserves; however, 70% of this gas is wasted due to flaring (African Development Bank Group, 2023).

To help the country end gasoline imports and spark a long-awaited oil sector revival, a petroleum project was proposed in 2013, located on the outskirts of Lagos, Nigeria's economic hub. However, due to delays, construction of the $19 billion facility commenced only in 2019, and operations on 22 May 2023. The Dangote Petroleum Refinery is the first privately owned oil refinery in Nigeria, established to produce diesel and aviation fuel totalling 350,000 barrels per day initially and up to 650,000 barrels per day when fully operational. The refinery was built with the contribution of 50% equity investment by Dangote and 50% debt finance by banks. The commercial loan component of the project was financed mainly by Nigeria's domestic banks, while the balance was sourced from foreign banks. The Central Bank of Nigeria (CBN) provided N125bn ($130m) to cover domestic currency requirements. The plant has received about 6 million barrels of crude so far from Nigeria's state oil firm, NNPC Limited, to kickstart its operation.

The intended objectives of the project were as follows:

- Boost refining capacity in a region heavily reliant on imported petroleum products.
- Put an end to frequent fuel shortages while also increasing the quality of fuel in circulation.
- Make at least 40% of the oil products available for export.
- Process a variety of light and medium grades of crude to produce Euro-V quality clean fuels, including gasoline and diesel as well as jet fuel and polypropylene.
- Improve infrastructure for sustainable industrialisation.

Although this project cannot be a silver bullet for Nigeria's energy crisis, the approach taken provided an important means to revive the sector and will undoubtedly help move Nigeria from being a major importer of refined petroleum products to being self-reliant in terms of domestic refining capacity. This refinery is projected to be Africa's biggest oil refinery and the world's biggest single-train facility. The refinery complex was developed on a 2,635-ha site in the Lekki Free Zone near the Lekki Lagoon, along the Atlantic coast. A jetty near the project site was built to receive heavy equipment for the construction. The geographical location of the refinery was intended to relieve congestion at the port of Lagos, and also to facilitate the export of some of Dangote's refined petroleum products to other African countries, as it is ideal for easy transhipment to international markets. This project contributes directly to the achievement of Target 9.3, which seeks to increase access to financial services and markets. The project led to the development of inclusive infrastructure which promotes inclusive industrialisation, particularly manufacturing and processing (Targets 9.1 and 9.3).

Results and impact of the programme/project

The plant was officially opened with the expectation that at full production capacity it would meet 100% of Nigeria's needs for gasoline, diesel, kerosene, and aviation jet fuel. Most local citizens were hopeful that the new plant would soon help reduce consumer

gas prices, which have tripled since the year 2022 (Asadu, 2024). When the plant is fully functional, it is expected to generate 9,500 direct and 25,000 indirect permanent jobs. At least 900 young engineers were trained in refinery operations abroad, mechanical engineers trained at GE University in Italy and process engineers received six months' training from Honeywell UOP. Others trained at Bharat Petroleum Corporation in Mumbai, India. Such enhancement of human capital is key for sustainable industrialisation and upgrading industrial technologies in Nigeria.

This project led to the development of infrastructure facilities on the site, which include a pipeline system, access roads, tank storage facilities, and crude and product-handling facilities. A marine terminal, including a breakwater, jetty and harbour, was also developed as part of the project. Other facilities developed to support the project include an administrative building, guardhouses, fire stations, and pump stations. In addition, the refinery complex also houses a fertiliser plant, which utilises the refinery by-products as raw materials, thus avoiding the generation of waste.

Ezeamalu (2024) states that Nigeria's expenditure on the importation of petroleum products tripled over five years, from $8.4bn in 2017 to $23.3bn in 2022, and it was projected that the country could spend up to $30bn annually by 2027 if it continues to rely on petroleum imports. However, the establishment of Dangote Petroleum Refineries has reversed all that. Aside from the nearly $30bn foreign exchange savings from the reduction in petroleum imports, the economy is projected to benefit from an extra $10bn in foreign exchange inflow through the export of refined petroleum products. Exporting at least 40% of refined petroleum products will significantly boost Nigeria's foreign exchange earnings and enhance exchange rate stability (Ezeamalu, 2024).

Obstacles encountered

Changes in the location of the refinery as well as the high actual costs compared with the anticipated costs delayed the construction processes and pushed back the completion date from 2019 to late 2022. As a result, loans had to be secured to ensure the completion of the refinery. Considering that the project start date and was postponed three times in four years, there were fears of diminished investor confidence. The COVID-19 pandemic and intricate plant infrastructure, such as a 435 MW power station, exacerbated repeated delays in the construction.

Lessons learnt in terms of the achievement of specific SDG targets

This project responds directly to Targets 9.1, 9.2, 9.3 and 9.5, which seek to develop sustainable, resilient, and inclusive infrastructure for sustainable industrialisation while increasing access to finance and markets and enhancing research related to industrial technologies. To develop sustainable industry, innovation and infrastructure as stated in SDG 9, this project was able to count the following among its achievements:

- It increased access to finance services, as the United States Trade and Development Agency provided a N250bn training grant for human resource development for the refinery operation.
- The inclusive and sustainable infrastructure was developed from scratch.
- The project made use of advanced technology to enhance extraction and processing.
- The project will undoubtedly make Nigeria self-reliant in terms of petroleum products, while exporting some to the international markets.

Sustainability and replicability

While the oil and gas sector has traditionally faced criticism for its environmental impact, the Dangote Refinery has incorporated modern technology to mitigate its environmental footprint. Efforts have been made to maximise energy efficiency, reduce emissions, and implement best practices in waste management. By setting new standards in environmental sustainability, the Dangote Refinery has the potential to inspire other players in the African oil and gas sector to adopt similar measures, promoting a greener and more sustainable industry. The successful operation of the Dangote Refinery could inspire greater regional collaboration among African countries. Through partnerships and joint ventures nations can pool their resources, expertise, and investment to establish refineries and related infrastructure. This collaborative approach promotes regional integration, spurs economic development, and reduces dependence on imported petroleum products from other jurisdictions outside the continent.

5.2.3 Hawassa Industrial Park (HIP)

Ethiopia (Figure 16) is one of the oldest nations in the world, but at present its socio-economic condition is less than satisfactory. It is the second most populous country in sub-Saharan Africa after Nigeria, with a population above 123 million in 2022. It is rated as one of the poorest and most heavily indebted countries in the world, with a per capita annual gross national income of $1,020. About 26% of the population of the country, mostly women and rural residents, live on an income of less than one dollar a day. Political instability is another serious problem in Ethiopia, giving rise to stagnant socioeconomic development (World Bank, 2021; Mohajan, 2013).

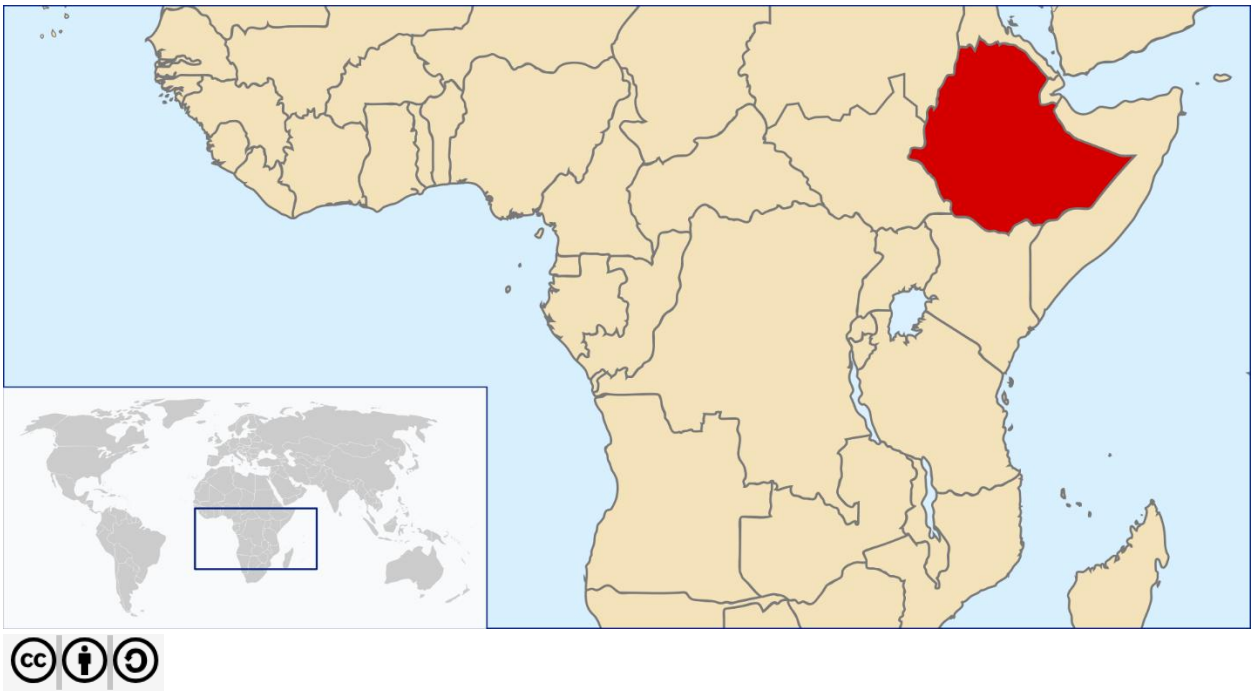

Figure 16. Location of Ethiopia and neighbouring countries (**https://commons.wikimedia.org/wiki/Maps_of_Ethiopia#/media/File:LocationEthiopia.svg**)

Although Ethiopia has emerged as one of Africa's fastest-growing economies (6.4% growth in the financial year 2021/22), its manufacturing sector is still far from being an engine of growth and economic transformation. This sector currently plays a marginal role in employment creation, exports, and output, and falls short in the stimulation of domestic linkages. As a result, only 5% of firms participated in exports between 1995 and 2020. The sector is dominated by small firms and resource-based industries, low-value and low-technology products, and weak inter- and intra-sectoral linkages. The manufacturing sector's export orientation has been low and stagnant (Oqubay, 2018).

The manufacturing sector represents only 4.6% of GDP and contributed 5% of total employment in 2023 compared with 5.9% of GDP in 2022, and many firms are operating at close to 30% capacity. There has been an exodus of foreign firms from many of the industrial parks, due mainly to conflict, suspension of the Africa Growth and Opportunity Act (AGOA), and the prevailing security situation. Out of nearly 5000 firms, close to 450 ceased production nationwide in 2023. The conflict in both Oromia and Amhara regions raises security concerns, and therefore creates difficulties for businesses. Ethiopian manufacturing satisfies only 38% of domestic demand, while 62% is satisfied through imports (UNDP, 2023).

Ethiopia has a diverse range of exports, including coffee, oilseeds, flowers, and textiles. However, the country's trade is heavily dependent on a few key markets, such as the European Union and China, and is also heavily reliant on a small number of key products, such as coffee. This makes the country vulnerable to market fluctuations and price changes. Furthermore, Ethiopia's trade is hindered by a lack of access to finance and by poor infrastructure, particularly transport infrastructure, which is a major constraint on economic growth. The country has a poorly developed road network and no rail network, making it difficult to move goods and people around the country. Additionally, the limited availability of transport services and the poor condition of the roads make it difficult to move goods to and from neighbouring countries (Ghosh, 2023). In Ethiopia, the inadequacy of infrastructure has been one of the major constraints to industrial development. The Ethiopian industrial policy implementation lacks effectiveness because of shallow policy guides and monitoring and controlling (Aynalem, 2019). All of the above have a crippling effect on the country's capacity to meet SDG 9, which strives for the sustainability of industry, innovation, and infrastructure.

To overcome shortcomings related to industrial development, the government of Ethiopia embarked on an industrialisation strategy based on creating special economic zones as centres of export-oriented light manufacturing. To achieve this, the government of Ethiopia funded the establishment of an industrial park on 13 July 2016. Hawassa Industrial Park (HIP) is an eco-industrial park located in Hawassa, a city with around 300,000 inhabitants in southern Ethiopia. The park was constructed under contract with the China Civil Engineering Corporation (CCECC), and it remains the largest in sub-Saharan Africa. This park focuses on the manufacturing of garments, apparel, and textiles, thus growing this industry. The first phase of Hawassa Industrial Park covers approximately 130 hectares of land, with the potential to expand up to 400 hectares (World Bank, n.d.).

The federal government of Ethiopia has adopted industrial park development as a strategy to attract investment in the manufacturing sector and accelerate the growth and development of the manufacturing sector as captured by SDG Targets 9.2 and 9.3. The growth and development of the manufacturing sector is expected to propel infrastructural development (Target 9.1) and economic growth resulting from the creation of more job opportunities, and the generation of foreign currency through export diversification, which is currently dependent on agriculture.

Results and impact of the programme/project

As of March 2019, Hawassa factories employed 24,000 local workers and 700 expatriates, the largest recorded number of jobs in Ethiopian industrial parks. The industrial park aimed to identify, select, grade, and train approximately 30,000 employees between 2020 and 2021. In 2021, at its peak, it employed over 35,000 workers. Hawassa Industrial Park is expected to generate more national revenue from exports and employ

more people than the rest of Ethiopia's textile and apparel manufacturing industries combined. It is envisaged that it will create 60,000 to 80,000 jobs and increase textile and apparel export revenue from $100 million to $1 billion (Oqubay, 2018).

The park resulted in the installation and development of infrastructure – roads, water, electricity, telecommunications, public service facilities, and convenient investment services to create a conducive environment for industrial clusters. The park is anchored by global textile firm, PVH (formerly Phillips Van Heusen), the owner of brands such as Calvin Klein and Tommy Hilfiger, but 20 other firms have invested as well. Although production started on a relatively small scale in late 2016, the first exports took place in mid-2017, thus increasing foreign direct investments and revenues. PVH alone expects to export US$100m worth of clothing each year from Hawassa. Despite the park being plagued by numerous challenges in 2022, in the last three months of 2022, the park indicated a potential revival of the sector by generating more than 32 million USD in revenue (Oqubay, 2018).

Obstacles encountered

Hawassa Industrial Park encountered serious problems in 2022, including factory closures which led to massive job losses, with some companies retrenching thousands of workers. This was caused by the United States government's decision to terminate Ethiopia's duty-free access to US markets, previously assured in terms of AGOA. The decision to terminate these preferential trade benefits was based on gross violations of internationally recognised human rights by the government of Ethiopia and other parties in the war in the northern part of the country. Since Ethiopia is a landlocked country, logistics was a major hurdle, given that all materials had to be routed through Djibouti. The Hawassa Industrial Park was Envisol's first large-scale international project requiring them to set up all infrastructure from scratch. Since this was the first project of its kind in the African continent and given the low availability of materials and infrastructure in Ethiopia, the company was required to import all machinery from India; this included items as basic as bolts and nuts. The entire skilled labour corpus responsible for the installation and commissioning also had to come from India. With clients and consultants being Ethiopian and the main contractor for the overall park being a Chinese company, several technical common-ground issues and language barriers had to be overcome (Envisol, n.d.).

Lessons learnt in terms of the achievement of specific SDG targets

The programme relates directly to Targets 9.1, 9.2, 9.3, and 9.4, which strive for sustainable and inclusive infrastructure and industrialisation while increasing access to financial services and markets. The following were achieved:

- Development of sustainable and inclusive infrastructure from scratch
- Increased foreign direct investment through exports

- Human skills transfer in the manufacturing industry
- Use by Hawassa Industrial Park of cutting-edge technology to treat and recycle more than 90% of the water it uses, which links with Targets 9.5 and 9B.

Sustainability and replicability

Hawassa Industrial Park is said to be the first sustainable textile and apparel industrial park in Africa, with state-of-the-art infrastructure and facilities. Designed, constructed, and operated as a green industrial zone, the park features a zero-liquid discharge (ZLD) facility, which minimises environmental impact by treating and recycling wastewater. This enables companies to meet stringent environmental standards required by international markets, allowing them to focus on exports. Other environmentally sustainable features include a rainwater capture system and the use of natural lighting and ventilation to conserve energy and improve working conditions. The project can be replicated elsewhere in the African continent.

5.3 Europe

5.3.1 Case 1

Finland: Helsinki Climate Street project (SDG 9, related targets: 9.1, 9.2, 9.4)

Economic and political circumstances

In Finland, it is anticipated that GDP will slow, coming to a standstill in 2023, and then show a modest growth of 0.9% in 2024. This growth is expected to pick up slightly to 1.8% in 2025. Although it is predicted that energy prices will decrease, private consumption is projected to recover moderately in 2024, despite the constraining effects of higher interest rates. Residential investment may face setbacks due to declining house prices. Unemployment is predicted to rise gradually until mid-2024 before beginning to decline, fuelled by economic expansion and an increase in employment opportunities.
Lower energy prices and subdued demand are anticipated to contribute to a decrease in headline inflation, from 7.2% in 2022 to 4.5% in 2023 and further down to 2.2% in 2024. Fiscal policy is set to remain expansionary, driven by planned boosts in defence and security spending, as well as moderate tax reductions, although this could exacerbate the mounting public debt. Fiscal consolidation might be warranted sooner, given this debt trajectory.

The focus is on increasing the participation of women and older people in the labour force as a way to overcome labour supply shortages in an aging society. This necessitates reforms to unemployment insurance. Furthermore, prioritising investments in decarbonisation initiatives remains crucial for sustainable development and environmental stewardship. Finland, as a northern European country, is particularly vulnerable to the effects of climate change. Paying attention to environmental sustainability and transitioning to a low-carbon economy while ensuring economic growth and social equity poses complex challenges.

Finland has a stable political landscape characterised by a parliamentary democracy. The country operates under a multiparty system, with elections held every four years to elect members to the parliament (Eduskunta). The president of Finland serves as the head of state but occupies a mainly ceremonial role, with executive powers vested in the prime minister, who is typically the leader of the majority party in parliament. Despite relatively low overall unemployment rates, Finland has faced difficulties with regard to structural unemployment, particularly in certain regions and among specific demographic groups. Solving this problem requires targeted policies and investments in education, training, and job creation (World Bank; OECD; European Economic Outlook, 2024).

Actions undertaken to improve the implementation of SDG 9

The Climate Street initiative, initiated in 2015 in Helsinki and neighbouring Vantaa, has identified three key streets, Iso Roba, Tikkurila, and Asematie, as testbeds for innovative, resource-efficient, and low-carbon solutions. Through collaborative efforts involving local residents, property owners, businesses, and NGOs, the Climate Street team aims to co-create and disseminate knowledge about climate-smart practices and technologies.

A significant focus of the initiative is on promoting energy efficiency and sustainability among residents. Workshops and events, such as the Happy Houses workshops facilitated by environmental organisation Dodo, have facilitated discussions among housing associations and residents, fostering awareness about reducing CO2 emissions and exploring solar energy options for homes.

The solar power campaign has been particularly successful, providing practical guidance on installing solar panels and supporting the establishment of the city's first apartment building solar power plant. Climate Street's technical and personal assistance has been instrumental in these endeavours.

Furthermore, the initiative has paid attention to the issue of food waste through agile pilots and crowd-sourced solutions. Initiatives such as "From Waste to Taste" utilise ingredients that would otherwise be discarded to produce snacks, while a partnership between a local NGO and a supermarket leverages a location-based social web service to redistribute unused food within the community.

Overall, the Climate Street initiative exemplifies a collaborative and multifaceted approach to resolving climate-related problems, fostering community engagement, promoting sustainable practices, and implementing innovative solutions to create more climate-resilient urban spaces (Urban Sustainability Exchange, 2024).

Results and impact

The implementation of pilot initiatives along Iso Roba, Tikkuraitti, and Asematie streets encompasses various endeavours, including the installation of environmentally

friendly lighting fixtures on restaurant terraces, the planting of vegetation suited to the climate, and the establishment of subterranean stormwater retention facilities. Additionally, pilot projects have introduced novel methodologies for monitoring energy consumption within buildings and mitigating food wastage in retail establishments.

The success of Climate Street can be attributed to its meticulous engagement with diverse stakeholders from its inception, fostering trust and collaboration. The project has achieved significant milestones, with tangible impacts already evident. Its sustainability is underpinned by the proactive involvement of educated and engaged residents, as well as ongoing collaboration among members of the business community, facilitated by networking initiatives. Moreover, the project's outreach extends to the younger generation, exemplified by events such as Earth Hour, which convened 1500 schoolchildren on Iso Roba to promote awareness of and education about climate conservation.

Lessons learnt on the way to achieving SGD 9

- Climate Street's success underscores the importance of comprehensive engagement with diverse stakeholders from the outset. By involving residents, businesses, NGOs, and other relevant actors, the project fostered trust, collaboration, and ownership, essential for sustainable development initiatives.
- The pilot initiatives introduced innovative approaches to offer solutions to infrastructural and environmental problems. From eco-friendly lighting installations to novel methods of monitoring energy consumption and reducing food wastage, these initiatives demonstrate the significance of embracing creativity and technology to achieve SDG 9 targets.
- The active participation of educated and engaged residents has been instrumental in the project's success. By empowering the community through education, awareness-raising, and involvement in decision-making processes, Climate Street has ensured the sustainability and effectiveness of its interventions.
- Climate Street's outreach efforts, including events such as Earth Hour, which involved schoolchildren, highlight the importance of engaging the younger generation in sustainable development initiatives. By instilling awareness and fostering a sense of responsibility among the youth, projects can lay the foundation for long-term progress towards SDG 9 and beyond.

Potential for replication

First, the adoption of innovative solutions such as environmentally friendly lighting fixtures and climate-resilient infrastructure demonstrates the feasibility of implementing sustainable practices within urban settings. These initiatives can serve as models for other countries seeking to enhance their infrastructure resilience and environmental sustainability.

Second, Climate Street's approach to stakeholder engagement, characterised by meticulous involvement of diverse actors from the outset, is crucial for fostering trust, collaboration, and ownership. Other countries can replicate this approach by actively engaging local communities, businesses, NGOs, and government agencies in the planning and implementation of infrastructure projects.

Third, the emphasis on education and outreach, including events such as Earth Hour, which incorporate the younger generation, highlights the importance of raising awareness and fostering a sense of responsibility among future leaders. Replicating similar outreach initiatives can help instil a culture of sustainability and environmental stewardship among the youth in other countries.

Overall, the experiences of Climate Street demonstrate that replicating initiatives focused on innovative solutions, stakeholder engagement, and education and outreach can contribute significantly to achieving SDG 9 targets in other countries.

5.3.2 Case 2

Spain: DIVERSITOURS (SDG 9, related targets: 9.1, 9.2, 9.3, 9.4, 9.5)

Economic and political circumstances

In the projected economic landscape of Spain for 2024 and 2025, GDP is anticipated to demonstrate moderate growth, with a projected expansion of 1.4% in 2024 and a subsequent increase to 2.0% in 2025. Central to this growth trajectory is the pivotal role of domestic demand as the primary driver of economic expansion. However, it must be pointed out that private consumption and investment growth are expected to undergo moderation, largely attributable to tight financial conditions and persistent inflationary pressures in 2024. Nevertheless, a resurgence in these aspects is envisaged for 2025.

External demand, a significant contributor to growth in previous years, is anticipated to provide relatively less support to economic expansion during the projected period. Inflationary trends are expected to exhibit a marginal increase, with projections indicating a rise to 3.7% in 2024, followed by a subsequent decrease to 2.3% in 2025. Concurrently, fiscal deficit reduction is anticipated over the projection period. However, it is imperative to underscore the necessity of robust and sustained fiscal consolidation efforts to effectively manage debt levels. Such consolidation is vital not only for debt containment, but also for creating fiscal space suitable for solving problems associated with aging demographics and facilitating expenditures aimed at fostering growth.

In endeavours to bolster productivity and innovation, concerted efforts to foster R&D initiatives are recommended. This entails cultivating partnerships between firms and research institutes to drive collaborative R&D projects. Additionally, mitigating regulatory disparities across various regions is necessary for cultivating an environment that will support innovation and economic growth. Overall, the economic landscape of Spain is characterised by a multifaceted interplay of factors requiring judicious fiscal management,

targeted investment in R&D, and regulatory harmonisation to stimulate sustained economic growth and prosperity.

Spain has a constitutional monarchy and a parliamentary democracy. The country is governed by a bicameral legislature consisting of the Congress of Deputies (Congreso de los Diputados) and the Senate (Senado). The prime minister (Presidente del Gobierno) serves as the head of government, leading the executive branch, while the monarch (currently King Felipe VI) occupies a largely ceremonial role (World Bank; OECD; European Economic Outlook, 2024).

Actions undertaken to improve the implementation of SDG 9

The DIVERSITOURS project aims to achieve its objectives through a comprehensive approach encompassing several phases and activities. First, areas for intervention were selected based on various criteria, including cultural diversity, migration history, social dynamics, and potential contributions to social, economic, and cultural development. The coordinating team and intercultural guides were then chosen, with the latter tasked with narrating personal stories related to culturally and historically significant locations within the neighbourhoods. Their selection criteria emphasised diversity, communication skills, ties to the community, and motivation.

A narrative for the neighbourhoods was constructed through an exploratory study, conducted in collaboration with social agents and citizens, focusing on historical, demographic, and socio-cultural aspects. Subsequently, intercultural guides underwent training based on the study's findings, focusing on participation in route design and communication skills.

Intercultural routes and visit maps were co-designed, incorporating community initiatives and development spaces, alongside personal narratives from the guides. Face-to-face routes were then implemented, ensuring elements such as accessibility, and optimal visitor numbers. Additionally, virtual reality (VR) content was developed, engaging young individuals with ties to the neighbourhoods in producing immersive experiences reflecting residents' narratives.

The project emphasises participatory engagement, involving local institutions, social entities, and citizen participation. The Bilbao City Council, social microenterprises such as KOOPSF 34, and cultural innovation associations such as MOVILTIK play leadership roles in project coordination, promotion, and communication. Citizen participation is facilitated through intercultural guides, neighbourhood residents, and active involvement of visitors in the tours.

Collaborations with various entities, including government entities, academic institutions, social foundations, and artistic collectives, further enrich the project's scope and impact. These collaborations enhance outreach, communication, and content development, contributing to the project's comprehensive and inclusive approach to

promoting cultural diversity, social cohesion, and community engagement within the participating neighbourhoods (Urban Sustainability Exchange, 2024).

Results and impact

The impact of the project is discernible across various dimensions, encompassing a diverse array of participants and garnering attention at local, national, and international levels. Participants in on-site visits have included political representatives, municipal and provincial technical staff, and international delegations, alongside educational institutions such as Entrepreneurial Leadership and Innovation Mondragon University and University of Deusto. During the period 2021 to 2023, 27 tours have been conducted, engaging 597 individuals, with a notable demographic composition of 60% women and 50% young people under 25. The majority of participants hail from Bilbao or Bizkaia, with only a small number of foreign tourists.

Additionally, more than 400 individuals took part in the virtual experience during the 2022 Loturak Festival; these comprised mainly students from seven city schools, and adults. Evaluation of the project's effectiveness has been facilitated through individual questionnaires, testimonials, and focus groups with intercultural guides and participants. On-site route assessments indicate an average satisfaction rating of 9.24 out of 10, with qualitative feedback highlighting the significance of learning about migration history firsthand and the inclusive nature of heritage interpretation.

Regarding virtual experiences, participants were intrigued by the immersive engagement with protagonists, resulting in heightened sensory perception. Following the virtual reality encounter, participants demonstrated a shift towards more positive perceptions of the neighbourhoods, with 97.2% recommending the activity for educational purposes.

To enhance effectiveness, a communication plan was devised, encompassing branding initiatives, creation of informational materials, institutional press releases, and utilisation of municipal and entity-linked social media platforms. These concerted efforts aim to amplify project visibility and engagement, fostering broader community participation and dissemination of project objectives and outcomes.

Lessons learnt on the way to achieving SGD 9

The project's journey towards achieving SDG 9 has yielded valuable insights and lessons that can inform future endeavours intended to promote sustainable development and innovation. First, the project's success underscores the importance of involving diverse stakeholders from various sectors, including political representatives, technical experts, educational institutions, and community members. This inclusive approach encourages broader support and participation, contributing to the project's impact at local, national, and international levels.

Furthermore, the project's emphasis on both on-site visits and virtual experiences highlights the effectiveness of employing multiple engagement strategies to reach a wider audience. The high degree of participation in both on-site and virtual experiences, particularly among women, young people, and local residents, underscores the relevance and appeal of the project's objectives and activities.

The evaluation methods employed, including individual questionnaires, testimonials, and focus groups, have provided valuable insights into the project's effectiveness and impact. The high satisfaction ratings and positive feedback from participants affirm the project's success in delivering meaningful experiences and fostering a deeper understanding of migration history and cultural heritage.

Moreover, the utilisation of a communication plan has been instrumental in amplifying the project's visibility and engagement, leveraging branding initiatives, informational materials, press releases, and social media platforms. This comprehensive communication strategy has facilitated broader community participation and dissemination of project outcomes, enhancing its overall effectiveness and sustainability.

Replicability

The project's inclusive approach, involving diverse stakeholders such as political representatives, technical experts, and educational institutions, demonstrates the importance of fostering broad-based support and collaboration. This model can be replicated by other countries to mobilise resources and expertise from various sectors towards achieving SDG 9 objectives.

Moreover, the project's use of both on-site visits and virtual experiences to engage participants illustrates the effectiveness of employing multiple engagement strategies. Countries can replicate this approach by designing versatile programmes that cater to diverse audiences and preferences, thereby maximising outreach and impact.

Additionally, the project's rigorous evaluation methods, including individual questionnaires, testimonials, and focus groups, provide valuable insights into its effectiveness and impact. Replicating countries can adopt similar evaluation frameworks to assess the outcomes of their initiatives and make informed decisions for future improvements.

Lastly, the project's communication plan, encompassing branding initiatives, informational materials, and social media engagement, underscores the importance of effective communication in amplifying project visibility and engagement. Replicating countries can develop comprehensive communication strategies to enhance awareness, participation, and dissemination of project outcomes, thereby fostering broader community engagement and support for SDG 9 initiatives.

5.3.3 Case 3

Lithuania: Vilnius Tech Park (SDG 9, related targets: 9.1, 9.2, 9.3, 9.4, 9.5)

Economic and political circumstances

Lithuania maintains a stable economic and political environment within the Baltic region. Economically, Lithuania has shown resilience and steady growth, bolstered by its integration into the European Union and the Eurozone. With a GDP of approximately $71 billion USD and a per capita GDP, PPP of around $48,000 USD, Lithuania's economy demonstrates moderate prosperity and potential for further development.

The country's economic growth is driven by a mix of factors including robust exports, particularly in the manufacturing and technology sectors, as well as growing domestic consumption and investments. Lithuania benefits from a well-educated workforce, relatively low labour costs compared with Western European countries, and a strategic location for trade within the Baltic Sea region.

Politically, Lithuania operates as a parliamentary republic, with a president serving as the head of state and a prime minister leading the government. Gitanas Nausėda currently serves as the president, while Ingrida Šimonytė holds the position of prime minister. The political landscape in Lithuania is characterised by stability and adherence to democratic principles, with regular elections and a multiparty system ensuring representation of diverse political viewpoints.

However, Lithuania experiences a number of problems, including emigration of skilled workers seeking opportunities abroad, demographic decline, and regional economic disparities between urban centres and rural areas. Additionally, the country has been affected by geopolitical tensions in the region, particularly concerning relations with neighbouring Russia and Belarus.

In response to these challenges, Lithuania has pursued policies aimed at promoting innovation, entrepreneurship, and infrastructure development. The government also prioritises European integration and cooperation within the EU framework, leveraging EU funds for various development projects.

Overall, Lithuania's current economic and political situation reflects a resilient nation with a stable governance structure and promising economic prospects. However, finding solutions to long-term problems such as emigration and regional disparities will be crucial for ensuring sustainable development and prosperity in the years ahead (World Bank; OECD; European Economic Outlook, 2024).

Actions undertaken to improve the achievement of SDG 9

Vilnius Tech Park, which has since 2016 operated under the guidance of adept technology hub administrators and a committee comprising representatives from entrepreneurial entities and the local municipality, has spearheaded the establishment of state-of-the-art facilities. These include a conference centre suitable for large-scale events, hackathons, meetings, product launches, and a variety of other activities and services. Sapiegos Corporate, an inventive initiative, serves as a nexus for collaboration

between corporations and entrepreneurs, facilitating access to the startup ecosystem's fresh ideas and investment prospects for established businesses.

The park's steadfast commitment to community engagement has yielded numerous groundbreaking initiatives. Notable among these is CodeAcademy, which equips individuals with highly sought-after skills such as programming, web design, and cyber security, seamlessly integrating theoretical knowledge with practical applications in prominent companies. A youth-oriented counterpart fosters proficiency in computer game design, branding, and web and mobile app development.

Moreover, the park serves as a hub for inherently community-centric enterprises, exemplified by Miesto Laboratorijos, which hosts a citizen's laboratory focusing on eco-gardening, where locals are invited to explore sustainable living practices.

Vilnius Tech Park has in addition significantly enriched the city's cultural landscape. The annual Culture Night, boasting over 100,000 attendees and showcasing a variety of arts and culture initiatives, now extends its reach to Sapieha Park, where Vilnius Tech Park is located.Throughout the year, the park collaborates on cultural events, such as sculpture exhibitions, and engages in municipal initiatives such as Create for Vilnius. Noteworthy in this regard is a proposed robot-guide designed to lead citizens and visitors on excursions, with plans for implementation in Sapieha Park in the near future (Urban Sustainability Exchange, 2024).

Results and impact

Vilnius Tech Park currently stands as the foremost and most intricately interconnected information and communication technology (ICT) hub within the Nordic and Baltic regions. An area covering eight hectares has undergone rehabilitation, yielding office space of more than 9,000 square metres. This at present accommodates over 65 innovative enterprises, drawing foreign technological endeavours and adept individuals.

The Tech Park has greatly enhanced Vilnius's visibility as a tourist destination, evidenced by an upsurge in visitor numbers and growth in the number of local excursion enterprises, which is increasing annually.

Sapieha Park has evolved into a sought-after destination for leisure activities within the city and enjoys widespread public support, with startups also eager to operate in this popular space.

Lessons learnt on the way to achieving SGD 9

- The rehabilitation work undertaken to transform Vilnius Tech Park demonstrates the importance of investing in revitalising existing infrastructure. By repurposing a vast expanse of land and buildings, the project made effective use of available resources to create a modern ICT hub, showcasing the significance of sustainable infrastructure development.
- The success of Vilnius Tech Park underscores the importance of fostering a vibrant and interconnected community. Through the creation of an environment that

encourages collaboration and innovation, the park has attracted a wide variety of enterprises and skilled individuals. This highlights the pivotal role of community engagement in driving technological advancements and economic growth.

- The project's contribution to enhancing Vilnius's visibility as a tourist destination underscores the interconnectedness of sustainable development goals. By creating an attractive hub for technology and innovation, Vilnius Tech Park has not only spurred economic growth but also contributed to the promotion of tourism, thereby supporting SDG 8 (Decent Work and Economic Growth) and SDG 11 (Sustainable Cities and Communities).
- Vilnius Tech Park's evolution into a hub for leisure activities and community engagements reflects the importance of fostering an innovation ecosystem. By providing a platform for creative exchange and collaboration, the park has facilitated the development of new ideas and ventures, highlighting the role of innovation in driving sustainable development.

Replicability

The successful development of Vilnius Tech Park offers valuable insights for other countries seeking to implement SDG 9. First, the rehabilitation of existing infrastructure demonstrates the potential for repurposing underutilised spaces to create innovative hubs. Second, fostering a vibrant community of tech enterprises encourages collaboration and innovation, highlighting the importance of building strong ecosystems. Third, leveraging technology to enhance tourism can boost economic growth and promote sustainable development. Finally, transforming public spaces such as Sapieha Park into centres for leisure and community engagement showcases the potential for revitalising urban areas. By replicating these actions, other countries can advance towards achieving SDG 9, promoting inclusive and sustainable industrialisation, and fostering innovation.

Assessment

5. Case studies and best practices

- List 5 good practices that support the implementation of SDG 9 in your country.
- What could your own contribution be to the achievement of SDG 9?
- Identify a situation in your country that would qualify as a case study that reflects a best practice in terms of achieving the SDG 9 targets. Briefly discuss this case study and state how the best practice could contribute towards achieving SDG 9.

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6. Exercises and assessment

Based on the SDG 9 targets and concepts, this section of the manual begins with a set of exercises that users (professors, lecturers and teachers) can use with their students to stimulate ideas, and identify solutions and new initiatives for sustainable development. The level of detail and complexity of these exercises can be regulated according to the educational level of the students. This is followed by a set of shorter assessment questions covering all the sections in this manual, and requiring shorter, more to the point answers. Users can decide whether they want to use the exercises and the assessments as provided, adapt them according to their own local contexts and needs, or use them as examples and then develop their own exercises and assessments accordingly.

6.1 Exercises

Case study analysis: Lecturers can either provide students with real-world case studies (some examples are available on the Urban Sustainability Exchange website, and additional resources can be accessed from the Springer Nature website) related to SDG

9, or ask students to look for cases and bring these to class. Students can analyse these cases, identify the challenges and opportunities related to SDG 9, and propose sustainable solutions.

Group discussions and debates: Lecturers can organise group discussions and debates on various aspects of SDG 9, such as the role of resilience, innovation and technology. The discussions could include the way in which SDG 9 connects with the other goals, and promote the analysis of different perspectives.

Guest lectures: Students can be asked to invite guest lecturers to class; these could be guest speakers from relevant industries, innovation agencies, or government agencies who would share their experiences and insights and practical knowledge related to SDG 9.

Good practices: Choose one practice on the good practices platform (https://sustainabledevelopment.un.org/partnerships/goodpractices), and present it to and discuss it with the group: What are the lessons learnt, and how can it be replicated in other contexts? Compare and discuss the data on economic growth in Latin America, Africa and Europe.

6.2 Assessment

1. Introduction to the SDGs

- List the five areas of critical importance to which the 17 SDGs are linked, and explain why these are referred to as the 5 Ps.
- Explain the link between the MDGs and the SDGs.
- Explain how the SDGs differ from the MDGs.

2. Defining SDG 9

- What are the main areas covered by SDG 9?
- What is the focus of the first five targets of SDG 9?
- What is the focus of the last three targets of SDG 9?

2.1 Significance of SDG 9

- What progress has been made towards achieving SDG 9 by 2030?
- Discuss the main characteristics of the key aspects of SDG 9: Innovation, Industrialization and Infrastructure.

2.2 Interdependencies of SDG 9

- How is SDG 9 interconnected with the other SDGs? Which other SDGs will be most affected if Goal 9 is not achieved? Give reasons for your answer.
- Select any three SDGs and briefly explain how they interact with SDG 9. Use examples from your region to illustrate your explanation.

2.3 Advantages of SDG 9

- What would the main advantages be for the world if SDG 9 is achieved?

- Select any two of the targets of SDG 9 and explain the specific benefits that will be achieved if these targets were attained. State what the advantages would be for your specific region.

2.4 Obstacles to the achievement of SDG 9

- What are the difficulties standing in the way of achieving SDG 9 in your country? Which are the main barriers? How can they be overcome?

3. Overview of global crises that have negatively affected the achievement of SDG 9

- Identify at least three (3) global crises that have negatively affected the achievement of the targets of SDG 9, and explain what the impact of each of these crises has been.

3.1 Climate change

- How has climate change exerted a negative impact on progress in the areas of innovation and industrialisation?
- How are these negative impacts perceived in your region?

3.2 COVID-19

- What effects has the COVID-19 pandemic had on the targets of SDG 9?
- How are these effects perceived in your region?

3.3 Conflict

- Explain how conflicts exert a negative effect on efforts to achieve SDG 9.

How are these impacts perceived in your region?

4. Progress towards the achievement of SDG 9 by 2030

- How does your current life pattern affect the achievement of the SDG 9 targets?

4.1 Regional progress in Latin America

- In your opinion, will the countries in Latin America be able to achieve the SDG 9 targets by 2030? Why do you say so? What are the supporting and hindering factors?
- What are the main obstacles in the way of achieving SDG 9 in your region/country?

4.2 Regional progress in Africa

- In your opinion, will the countries in Africa be able to achieve the SDG 9 targets by 2030? Why do you say so? What are the supporting and hindering factors?
- What are the main obstacles in the way of achieving SDG 9 in your region/country?

4.3 Regional progress in Europe

- In your opinion, will the countries in Europe be able to achieve the SDG 9 targets by 2030? Why do you say so? What are the supporting and hindering factors?
- What are the main obstacles in the way of achieving SDG 9 in your region/country?

5. Case studies and best practices

- List 5 good practices that support the achievement of SDG 9 in your country.
- What could your own contribution be to the achievement of SDG 9?
- Identify a situation in your country that would qualify as a case study that reflects a best practice in terms of achieving the SDG 9 targets. Briefly discuss this case study and state how the best practice could contribute towards achieving SDG 9.

7. Concluding remarks

This module was written with the aim of providing an introduction to the main aspects of SDG 9 – Industry, Innovation and Infrastructure, while also covering the impacts of various crises on the achievement of this goal in the regional contexts of Latin America, Africa and Europe. Case studies and good practices were also included to support teaching, with examples given of strategies adopted in the regions studied to support resilient infrastructure, sustainable industrialisation, technology development and innovation. Finally, exercises and assessment questions are suggested.

The module can either be used as presented here, or adapted according to the needs of teaching staff interested in applying it in their course/class. The variety of targets, challenges and resources related to SDG 9, as well as its connection with other goals, reinforce the importance of this module for all study areas. We recommend that teaching staff encourage students to reflect on their own perceptions and experiences in relation to the topics relating to industrialisation and infrastructure, discuss the prospects for technology development and innovation, and explore the role of different sectors and actors in contributing to SDG 9 and to the overall aims of the 2030 Agenda.

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