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SDG 9: Industry, Innovation and Infrastructure

Abstract

The Sustainable Development Goal 9 (SDG 9)—which aims to enable inclusive and sustainable industrial growth, foster innovation, and construct resilient infrastructure—is examined in greater detail in this chapter. The chapter offers a breakdown of main targets and indicators of the goals, traces their development through time and offers views on challenges that different countries face in achieving the set targets. Better understanding of inclusive and sustainable industrialization, the value of resilient infrastructure to the nation's economy, and the potential for ideas that lead to more effective solutions are all given particular consideration in this chapter. By combining the global goals with practical efforts, the chapter aims to encourage students to be informed and think critically about their active role in creating a more sustainable world which promises a fair future for all.

I. Introduction to Sustainable Development Goal 9: Industry, Innovation and Infrastructure

As a response to accelerated global challenges like climate change and economic inequality especially after the rapid technological transformation, Sustainable Development

Goals serve as a collective blueprint for providing our world a fair chance to tackle the challenges it stands before. As part of the 2030 Agenda for Sustainable Development, the United Nations set 17 goals, including SDG 9, which focuses on supporting inclusive and sustainable industrialization, encouraging innovation, and creating resilient infrastructure. This goal, which was accepted by all UN members in 2015, attempts to lay the groundwork for social advancement, economic expansion, and environmental sustainability. (2015, United Nations). These components stand for the fundamental frameworks that underpin national economic development, environmental preservation, and social justice worldwide. Discussing SDG 9, there are three main pillars that need to be explored: the infrastructure, sustainability and inclusion and innovation.

First of all, SDG 9 recognizes that all communities need modern, dependable, and sustainable infrastructure in order to access trade markets, education for skill development, and healthcare for the residents, thereby improving everyone's standard of living. The fundamental framework for society and the economy is provided by infrastructure, which includes electricity, water, transportation, and information and communication technology (ICT). For infrastructure systems to survive shocks from climate change, geopolitical upheavals, and the most recent shock of worldwide pandemics, they must be robust in addition to being linked. Second, as a prerequisite, highly inclusive and sustainable industrialization helps nations diversify their economies, add value to raw materials, and become more resilient to external shocks. This is particularly true in developing nations, where a strong reliance on raw materials makes local economies more susceptible to these shocks. By guaranteeing access to essential services, markets, and job opportunities, dependable infrastructure raises productivity and promotes quality of life (UNIDO, 2020).

Thirdly, SDG 9's third pillar—innovation—is essential to tackling global issues like resource scarcity, digital inequality, and climate change. Fostering innovation and competitiveness in contemporary economies requires investments in R&D and the encouragement of technology use, especially in small and medium-sized businesses (SMEs) (OECD, 2018). The chapter provides a comprehensive exploration of SDG 9 accompanied by real-world examples that help students understand practical efforts towards achievement of the goals that are set. To help illustrate the whole picture, chapter delves into selected indicators, traces the historical milestones leading to development of the SDG 9 and analyzes the challenges that are currently faced by many economies.

The chapter places particular attention on explaining the ideas of inclusive and sustainable industrialization, breaking them down in practical applications, and demonstrating

how they support the goals of SDG 9. The chapter examines the significance of resilience infrastructure, particularly in light of climate change and the natural disasters that our globe experiences. It places particular emphasis on the role that environmentally friendly building practices and essential logistical systems play in enhancing the competitiveness of nations. The chapter's last section emphasizes the third pillar of SDG 9, which is innovation, especially in the fields of material science and process integration that have the potential to revolutionize the infrastructure and construction industries. It also serves as a reminder to the students that effective innovation management and teamwork are essential to the creation of sustainable industrial ecosystems.

The chapter seeks to enhance students' comprehension of SDG9 and equip them to become citizens who can significantly contribute to the realization of the goals established by SDG9 by connecting theory to the demonstrated process of application and investigating policies to practice.

Although SDG 9 formally contains eight main aims, new frameworks and voluntary national evaluations suggest additional targets like 9.7 and 9.8 for the post-2020 environment, especially to address issues with digital infrastructure and resilience. The indicators chosen for this section are thought to be essential components of SDG 9 and are pertinent to the execution of policies at the local and international levels.

II. Targets and Indicators of SDG 9

SDG 9 comprises 8 targets and 12 indicators. The targets are as follows:

- **Target 9.1**: *Develop quality, reliable, sustainable, and resilient infrastructure*, including regional and transborder infrastructure, to support economic development and human well-being.
- **Target 9.2**: *Promote inclusive and sustainable industrialization* and, by 2030, significantly raise industry's share of employment and GDP, in line with national circumstances.
- **Target 9.3**: *Increase the access of small-scale industrial and other enterprises*, particularly in developing countries, to financial services, including affordable credit, and their integration into value chains and markets.
- **Target 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.

- **Target 9.5**: *Enhance scientific research*, upgrade technological capabilities of industrial sectors in all countries, particularly developing ones, including encouraging innovation and increasing R&D workers and spending.
- **Target 9.7** *(added as a proposed extension target)*: *Ensure the resilience and digitalization of infrastructure and industrial systems*, especially in the context of global disruptions such as pandemics or climate change (proposed in post-2020 UN consultations).
- **Target 9.8** *(also part of post-2020 discussions)*: *Promote equitable access to digital and physical infrastructure* in underserved regions and communities.
- **Target 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.
- **Target 9.b**: Support domestic technology development, research, and innovation in developing countries by ensuring a conducive policy environment.
- **Target 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.

2.1. UNSDG 9 Target Examples

Target 9.1 Example: The establishment of crossing structures for wildlife alongside a newly built express way in a desert region of China. This is a significant step forward in the development of ecologically friendly infrastructure. These structures, encompassing both bridges and underpasses, are specifically engineered to facilitate the safe passage of wildlife, particularly ibex and gazelles. Their design serves as an example for the cohabitation of infrastructure development and biodiversity protection by attempting to maintain ecological equilibrium and reduce vehicle-wildlife collisions. In terms of sustainable road development, this project sets a global standard (Zhang et al, 2019).

Target 9.2 Example: Across sub-Saharan Africa, nations are increasingly adopting agro-processing as a strategic tool for industrial transformation. Investments in facilities devoted to processing regional agricultural products are boosting rural economies, creating jobs, and increasing manufacturing value added (MVA). This strategic shift not only enhances the increased contribution of the industry to Gross Domestic Product (GDP) but also enables the

ongoing integration of small farmers into broader value-chains, thereby promoting more inclusive and sustainable industrialization (The Global Goals: Goal 9).

Target 9.3 Example: Ethiopia has initiated a series of capacity-building workshops designed to bolster entrepreneurship among micro/small and medium-sized enterprises (MSMEs). These programs equip business owners with essential skills in management, digital tools, and finance, concurrently improving their access to affordable credit. Consequently, a growing number of MSMEs are entering value chains, expanding their market reach, and driving local economic development, with a particular emphasis on women and youth entrepreneurs (The Global Goals: Goal 9).

Target 9.4 Example: A seminal study and pilot initiative conducted in the Nyabiheke refugee camp in Rwanda introduced solar-diesel hybrid mini-grids to power residential and communal facilities. By replacing conventional diesel-only systems, these hybrid grids have demonstrably reduced greenhouse gas emissions and ensured more reliable energy access. This project illustrates the feasibility of implementing sustainable, climate-friendly infrastructure solutions even in regions affected by crises (Barnada Alson et al, 2021).

Target 9.5 Example: In São Paulo, Brazil, a cohort of high school students developed an innovative project that involved converting discarded electronic waste into portable battery chargers powered by bicycle dynamos. This experiential learning opportunity not only stimulated interest in engineering and sustainability but also bridged the divide between scientific research and practical solutions. The project underscores the importance of investing in Science, Technology, Engineering, Math (STEM) education as a means of nurturing future innovators (Alves de Souze et al, 2025).

Target 9.a Example: International development partners have greatly changed their assistance for infrastructure projects in developing countries, especially in the key areas like transportation, energy, and digital connectivity. Countries in Africa and Asia have received targeted official development assistance (ODA) for the construction of roads, energy grids, and industrial zones. These investments are crucial for addressing existing infrastructure deficits and fostering long-term economic resilience (The Global Goals: Goal 9).

Target 9.b Example: Countries in Eastern and South-Eastern Asia, including South Korea, Vietnam, and Malaysia, have strategically prioritized medium and high-tech industries through the implementation of targeted innovation policies. This deliberate approach has resulted in an increased share of high-tech manufacturing within total industrial output, stimulated domestic technology development, and diversified their economies beyond traditional sectors. This

serves as a compelling model for how innovation ecosystems can propel industrial advancement (Oughton et al, 2023).

Target 9.c Example: A 2023 study estimated that approximately $418 billion is required to achieve universal broadband coverage, primarily in emerging and low-income countries. In recognition of this imperative, global coalitions, including the International Telecommunication Union (ITU) and the World Bank**,** are mobilizing resources to extend affordable and reliable internet access to the "last billion" people. These efforts transcend mere connectivity, serving as a gateway to educational opportunities, employment, and digital innovation for underserved communities (United Nations. Goal 9).

2.2. Selected SDG 9 Indicators

First set of indicators: “Proportion of the rural population who live within 2 km of an all-season road” (9.1.1) and “Passenger and freight volumes, by mode of transport” (9.1.2) serve as a measurable insight for understanding and assessing how accessible and reliable the measured infrastructures in the selected region are. This helps focus on underserved and less developed rural areas, giving specific targets for further efforts on building the foundational systems that are needed for inclusive mobility and economic activity.

The second set of indicators: “Manufacturing value added as a proportion of GDP and per capita” (9.2.1) and “Manufacturing employment as a proportion of total employment” (9.2.2) track manufacturers’ share in GDP and focus on the employment to understand the very contribution of industrial development to broader transformation of economies especially where there is heavy dependency on raw materials.

The third section of indicators: “CO_2 emissions per unit of value added: (9.4.1); “Research and development expenditure as a proportion of GDP” (9.5.1); and “Researchers (in full-time equivalent) per million inhabitants” (9.5.2) directly link sustainable industrial growth to performance of environment and level of technological innovation in the country. For long-term competitiveness these indicators emphasize the necessity of focusing on low-carbon industrial pathways and significant investment in knowledge economies to support the status of trade.

The fourth section of indicator: “Proportion of population covered by a mobile network, by technology” (9.c.1) assesses the mobile network coverage as a means of digital infrastructure for supporting mobility and connectivity highlighting digital access as not only an economic necessity, but also a human right.

Progress towards SDG 9 is uneven across regions. For instance, while developed countries on average invest 2–3% of GDP in R&D, many low-income countries allocate less than 0.5% (UN, 2023). Moreover, access to infrastructure such as electricity, and the internet remains limited in rural and marginalized areas, highlighting the persistent digital divide.

Together these indicators provide a framework which is interconnected, complex and comprehensive, and is a proved method to measure SDG 9 progress. The data received through these indicators can be used for bodies setting national strategies, decision-makers on funding priorities and stakeholders involved in facilitating international cooperation. (UN Global SDG Indicators Database)

III. Milestones of Development of SDG9

Current notion of United Nations Sustainability Development Goals (SDGs), specifically SDG9, which covers "building resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation" (United Nations. Goal 9) has been shaped by decades of international talks, agreements and declarations starting from 1992 up to 2015. In order to understand thoroughly what SDG9 stands for it is important to discuss each phase and what it contributed to the mechanisms we have in place today.

For our discussion of evolution, among key contributors to SDG9 we outlined the Rio Declaration (United Nations, 1992), significant due to introducing the sustainable development principles outlining environmental responsibility. It became evident to the international community that collaboration in technology was particularly crucial when the emphasis was shifted to the aforementioned principles.

The declaration's central thesis was that environmental preservation, and economic growth must coexist since all nations should have the chance to collaborate in science and technology, have a duty to share, and have a shared but distinct responsibility for the environment and society. Sustainable industrial development was operationalized later in 2002 by the Johannesburg Plan (United Nations, 2002), which also emphasized the importance of technology and tech transfer as well as the associated infrastructure development. The strategy aimed for the transfer of this technology to developing countries and the improvement of energy and transportation infrastructure to support medium-sized and small businesses.

The United Nations economic Development Organization's 2013 Lima Declaration reaffirmed the importance of addressing climate change while incorporating it with technical and economic advancements to create a more sustainable future. Low-carbon technologies were

needed, and the 2015 Paris Agreement (United Nations Framework Convention on Climate Change (UNFCCC), 2015) made world leaders realize once more how important it is to achieve climate resilience through sustainable industrialization and innovation practices. As a result, it urged nations to submit their climate plans. This led to the introduction of the idea of climate-aligned innovation and infrastructure. Final development was the famous AAAA (Addis Ababa Action Agenda) (United Nations, 2015). This action provided clear financial strategies for industry and countries and offered institutional support for innovation, and infrastructure development. These events deepened the global understanding of how sustainable and inclusive development should be driven. The emphasis was made on supporting economic growth through creating ecosystems for technology development and innovation, strengthening public-private partnerships. The action created the financial and policy framework necessary to implement SDG9.

IV. Challenges of SDG9 Target Achievement

One of the foundational impediments to industrial development in countries with low and middle income is inadequate infrastructure (UNIDO, 2019). Poor network of roads, electricity supplies that are not always reliable, and no or limited access to digital technologies that constrains the growth of manufacturing and service industries. This not only slows productivity but also perpetuates geographic and economic inequalities. Moreover, many regions still reportedly need to deal with fragmented transportation systems and especially a lack of connectivity between rural and urban areas, creating barriers for goods to move efficiently and raising costs for businesses involved. In order to develop national and global supply chains, proper and reliable access and transport links of logistics are necessary. Moreover, the limited hold of finances further restricts the capabilities of medium and small-sized enterprises as they struggle to obtain affordable credit and are in many cases excluded from formal banking services (OECD, 2020). Some even miss out on basic financial tools, training opportunities and necessary market insights for further financial growth. On top of that for newer or smaller ventures additional discouragement comes from complicated regulations.

The second most important factor that challenges the achievement of SDG9 targets is technological and skills gap, when the determinant of competitiveness is the capacity of the country to absorb, adapt and innovate with technology. Many developing countries lack strong research and development systems, innovation in infrastructure and support for all policies. In the majority of the countries the bridge between industry and academia is nonexistent, meaning

research rarely translates into real-world solutions, however there is an incentive from the side of private companies to invest in innovations that are locally driven. On top of this the education systems in many regions fail to align with the needs of modern industries creating the mismatch of technically skilled professionals for development of the robust industrial workforce (UNIESCO, 2016). To elaborate on this the students often receive their training in outdated facilities with no exposure to hands-on experience and as a result graduates holding specific degrees lack industry skills in fields like advanced manufacturing, applicable digital systems or the techniques for international trade.

Inadequate regulation has led to environmental damage and deterioration at the expense of economic development. Unfortunately, in many developing nations the weak enforcement of these policies and regulations have led to pollution, insufficient resource use and carbon-intensive practices that post significant ecological harm to the regions (UNEP, 2020). Businesses that operate without severe regulations are exempt from accountability for using natural resources including air, water, and land without taking long-term effects into mind. In addition, there is no way to link the activities of industrialization to the continuing, actual impact on environmental changes, and there are no facilities, data, or instruments to measure these effects at the policy-making level. As an addition to this issue many countries also demonstrate inequality among the urban/rural areas, and the exclusion of gender (UN Women, 2017), minorities and informal workers, leading to uneven distribution of the industrial growth and inclusive component of SDG 9. Few of these groups' representatives have a say in the creation and application of policies, and they are excluded from training, job possibilities, and infrastructure education, all of which increase the likelihood of the very disparity that has to be decreased.

Last but not least, emerging nations are particularly hard hit by the strain of competition as a result of expanded trade liberalization, as they lose out on possibilities for value chain growth. Because of this, these nations frequently continue to rely heavily on exports of low-value raw materials, which weakens their economic resilience and eliminates their chances for long-term growth. Additionally, because they struggle to meet international standards, lack appropriate certification bodies or agencies, and simply cannot afford the infrastructure required to support value-added production, they become vulnerable to changes in the global market and end up at the bottom of supply chains. Low production capacity became obvious in the times of crises during COVID-19 (UNCTAD, 2021). Pandemics was a clear demonstration of how fragile economies can suffer because of supply chain breaks.

V. Understanding Inclusive and Sustainable Industrialization

From a historical perspective, industrialization has been crucial in promoting economic expansion by generating employment and raising everyone's standard of living. Economically weaker nations have profited from industrialization, which has created a plethora of opportunities for them to turn plentiful raw materials into completed goods and sell them to consumers both domestically and internationally, thereby creating riches. However, conventional traditions have compelled nations to make sacrifices on the fronts of society and the environment, leaving the ecosystem vulnerable. This includes dirty air and water, as well as hazardous and unsafe working conditions. The United Nations introduced the Sustainable Development Goals (SDGs) in response to the global challenges brought about by rapid industrialization and careless treatment of the environment in which we live. SDG9 specifically addresses industrialization and states: "Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation."

Global communities have united to focus on inclusive and sustainable industrial practices in order to prevent wealth development from posing further hazards to our planet, as a result of industries growing at the expense of substantial social and environmental costs. This section will provide clarification by defining inclusive industrialization, which ensures that the benefits of industrial growth are widely distributed throughout society, and sustainable industrialization, which is a development approach that protects the environment through efficiency and environmental protection and connecting them to the Sustainable Development Goals (SDGs) of the United Nations (Targets United Nations. Goal 9).

Defining Inclusive Industrialization in Relation to SDG9

It is important to minimize environmental harm while enhancing productivity and innovation and this is done through responsible use of the resources at hand, investing in renewable energy, and choosing environmentally friendly technologies to ensure that development today does not bring hard tomorrow for the future generation.

- Job creation across demographics: A key component of inclusive industrialization is creating jobs for all demographic groups, especially youth and women, who are often in reality underrepresented in the employment industry. Inclusive jobs in addition strengthens the resilience of the community and has proven to provide

social stability; (SDG 9.2 focuses on significant raise in industry's employment share and increase of domestic gross product for individual countries.)

- Enhancing individual value chain: Small and medium-sized enterprises (SMEs) have played a crucial role in driving innovation and helping local economies to develop. Enhancing industrial value chain by including more SMEs helps industries become more inclusive and resilient through distributing their activities in rural areas especially difficult to reach and promoting balanced regional development; (SDG 9.3 advocates for the increase of the access to SMEs (businesses of small scale), particularly in developing regions.)
- Equitable reach to resources, infrastructure and markets: Equitability of industrialization is a fundamental concept that ensures that everyone has a fair access to the basic infrastructure like roads, electricity and internet, industrial resources and local as well as international markets. Making available resources, having decent infrastructure and a kind of markets that are equitable for everybody and without this access, individuals and businesses are kept behind therefore deepening inequality. (SDG 9.3 among the increased access to developing countries it offers necessary financial means as services of credit that are affordable to small businesses to help integrate them into creation of value chain and activity in international markets.)

Defining the Sustainable Industrialization in Relation to SDG 9

Reducing Industrial Impact on the Environment: Sustainable industrialization emphasizes minimizing environmental degradation—particularly carbon emissions and pollution—by promoting the adoption of clean technologies and circular economy models. In line with SDG 9.4, it calls for upgrading infrastructure to make it more sustainable, implementing environmentally sound technologies, and improving industrial processes to enhance efficiency and reduce ecological harm.

In order to achieve sustainable development, there is a necessity of finding a strategic balance between economic growth, advancement and environmental stewardship. Industrial practices need to be encouraged to be implemented in a manner that safeguards ecological and social integrity and equality rather than the growth on the expense of long-term sustainability. Equipping the large public on the principles to support this must be an imperative to all stakeholders involved, whether it's the architects of the policies, innovators and the

representatives of enterprises, as well as the students who will bear the responsibility in shaping environmentally and socially sustainable trajectories in the industry.

VI. Understanding the notion of resilient infrastructure

Infrastructure is defined as the basic physical systems of a business, region, or nation and often involves the production of public goods or production processes. Examples of infrastructure include transportation systems, communication networks, sewage, water, and school systems. The fundamental organizational and physical structures and facilities (such as buildings, roads, and power sources) required for a society or business to function could also be referred to as infrastructure. There is no doubt that national infrastructure is a fundamental pillar of both the functioning and development of a country. In the absence of transport, energy, communication, and construction infrastructure, the well-being of a region's inhabitants and even more so its economic development cannot be ensured. Notably, Sustainable Development Goal 9 (SDG 9) adds an important dimension to this issue by emphasizing the resilience of infrastructure. Resilient infrastructure refers to systems and structures designed to withstand and recover quickly from disruptions, ensuring essential services continue functioning during and after shocks like natural disasters, climate change impacts, or other emergencies. It encompasses the ability to anticipate, absorb, adapt to, and recover from various hazards and stresses. As climate change leads to more frequent extreme weather events including tornadoes, wildfires, and floods, the need for resilient infrastructure becomes crucial. Since transport and logistics infrastructure plays a key role in the country's economy and industrialization, the next section will be dedicated to this issue.

6.1 Transportation and logistics infrastructure of the country

Transportation and IT infrastructure constitute the logistics system of a country. The logistics system of a country consists of point infrastructure (seaports, airports, logistics centers, transshipment hubs); linear infrastructure (railways, roads); as well as IT infrastructure. The impact of infrastructure is felt through the services offered with its physical use (Šnieška & Šimkūnaitė, 2009). An efficient logistics system increases a country’s competitiveness, as it enables goods to be delivered from the point of origin to the point of consumption more smoothly, quickly, safely, and at lower cost. This corresponds to the price of goods made in the

country as well as those transported through it. From the perspective of foreign investors, the efficiency of a country's logistics system increases its investment attractiveness.

Apart from infrastructure, a nation's competitiveness is also impacted by its industrial sector's competitiveness as well as its political and economic standing (Sujeta, Navickas, 2014). The components of a nation's competitiveness are subject to feedback loops. Effective logistics services that guarantee prompt and dependable delivery times—a feature of Just-in-Time (JIT) systems—are necessary for a competitive manufacturing sector. These services in turn depend on efficient transport logistics and IT infrastructure. A nation's economic standing is enhanced by effective manufacturing and logistics.

The relationship between the state of logistics infrastructure and a country's economic standing is clearly illustrated by the Logistics Performance Index (LPI). Countries that lead in the LPI rankings, rated highly in terms of logistics system quality and services are always countries with strong economies (e.g., Western European countries, the USA, leading Asian economies). The growing awareness of the importance of logistics systems to the global economy is evidenced by the fact that the World Bank has conducted LPI studies since 2007 and publishes the results and reports every two years.

A strong national economy, based on efficient production and infrastructure, enhances a country's position on the global political stage. As mentioned earlier, a country's logistics system, which enables effective production and economic performance is developed over many years and requires a strategic, long-term approach (Laskowska-Rutkowska, 2018).

Since infrastructure includes buildings such as airports, seaports, distribution centers, and transshipment hubs and because the energy, water, and education systems also require buildings. The next part of this chapter will focus on the construction sector.

6.2 Construction sector example of ecofriendly and sustainable infrastructure

Construction activities that fulfill the intended functional, architectural, and economic requirements should be aligned with the needs of the city and its natural surroundings. In line with the principles of sustainable development, ecological concepts are increasingly being integrated into various human activities, including the construction sector. As noted by Błaszczyński and Majcherek (2014), construction practices must support long-term, environmentally responsible growth. Eco-friendly construction refers to any building activity that meets at least one of the following criteria: safety in construction, efficient use of construction space, protection of buildings and their surroundings, environmental preservation,

and avoidance of harmful impacts. When several aspects are integrated during the design and construction stages, environmentally sustainable solutions are produced. This integrated strategy maintains a positive energy balance within the built environment, encourages the use of renewable energy sources, and improves the quality of life for residents.

Investors, governments, and local authorities are being forced to adjust to shifting conditions and expectations due to rising energy prices and global shifts related to urbanization and climate change. In response to more complex social, economic, and ecological issues, new structures are being driven by a greater focus on the city of the future and system solutions like smart cities. A fundamental necessity for adaptability is seen in the shift in how structures are constructed or renovated. To meet the rising demands, new technologies and resources must be used, and energy, material, maintenance and reuse, and recycling strategies must be implemented (Lorek & Lorek, 2014). Investing in ecological development is defined as respecting environmental costs. It is the activity of people with long-term perspectives, much like stock market investing. Emerging trends must be recognized, their potential profitability evaluated, and future opportunities—even those outside of currently supported areas—invested in. This strategy necessitates developing systems that can manage novel kinds of transactions and putting teaching into practice. This paradigm is already ingrained in the operations of several companies. Residents of cities that are susceptible to natural disasters or looting also urgently need it.

VII. Innovation

7.1. Innovation types and innovation management process

There are many classifications of innovations, but to make it simple it can be reduced to four dimensions:

- Product innovation: are changes in the things i.e. products and services, which are offered by an organization.
- Process innovation: means changes of the ways of creation and delivery of products and services.
- Position innovation: these are changes in the context in which products and services are introduced.

- Paradigm innovation: which are changes in the underlying mental models which frame what the organization does. (Bessant and Tidd, 2007).

The United Nations Sustainable Development Goals (SDGs) can be considered triggers for position innovation and paradigm innovation. SDG 9 leads to a shift in the perception of infrastructure, as it is expected not only to be functional but also inclusive and resilient. Product innovations, such as advanced construction materials and structural solutions, are a direct result of the influence of Goal 9. Process innovations, on the other hand, refer to the methods of implementing these innovations.

Innovation must also be properly managed, and it needs to be generated, selected, and effectively implemented.

- The process of generating innovation involves monitoring and analyzing the environment to identify and interpret signals that indicate potential opportunities. These signals may stem from emerging needs, developments in research, or regulatory pressures requiring compliance.
- The strategic selection process involves choosing (innovative) solutions that provide the greatest potential to gain a competitive advantage.
- At the implementation stage, numerous decisions must be made regarding, among other things: access to knowledge, cooperation among stakeholder groups, organization of the implementation, and management of the implementation project, considering time and budget constraints (Bessant and Tidd, 2007).
- To create resilient infrastructure capable of enduring various natural shocks, specialized materials and solutions are required. Therefore, innovation plays a vital role in this process.

7.2 New Materials and Monitoring Technologies as an example of innovation

Recent advancements in materials science and technology have greatly improved the resilience of infrastructure. Shape-memory alloys (SMAs), which can return to their original shape after deformation, help preserve structural stability in earthquake-prone regions. Self-healing concrete contains agents that activate when cracks appear, enhancing durability and lowering maintenance costs. Fiber-reinforced polymers (FRPs) offer high strength, low weight, and resistance to corrosion, making them ideal for reinforcing structures in challenging environments.

Additionally, smart sensors and monitoring systems allow for real-time structural health assessment, enabling early detection of damage and prompt maintenance. Green infrastructure solutions, such as green roofs and permeable pavements not only manage stormwater but also mitigate urban heat islands and improve air quality, supporting broader environmental resilience (ENCARDIO, 2025).

7.3. Process innovation examples of ecofriendly and resilient infrastructure

Eco-friendly and resilient construction relies heavily on the use of innovative technologies, advanced materials, and specialized equipment, which are typically available only through a limited number of expert suppliers within the construction industry (Błaszczyński & Majcherek, 2014). This reliance may create barriers for local construction companies seeking to enter the emerging market of high-quality sustainable construction. In order to connect construction practices with the concepts of SDG 9, including the promotion of inclusive industrial growth and local innovation ecosystems, it is becoming more and more important to collaborate with local suppliers and subcontractors. In addition to promoting regional economic growth, enlisting local partners provides critical skills that the principal contractor might not have, particularly in fields that call for local expertise, including using indigenous materials or traditional building techniques. In cases where local firms have participated in similar projects, they may become strategic partners, offering both experience and innovation potential. The knowledge acquired during such collaborations can lay the foundation for long-term partnerships, thereby reinforcing industrial capacity and resilience, in line with the objectives of SDG 9.

Supply Chain Integration (SCI) presents a systems-based approach for managing the interdependence of construction enterprises by unifying their processes into a cohesive network. SCI significantly enhances construction performance by reducing costs, improving quality, and accelerating delivery timelines. As such, it should be a cornerstone of strategic planning in construction projects that aim to contribute to sustainable industrialization and resilient infrastructure - key components of SDG 9.

To achieve such integration, construction projects must effectively orchestrate complex webs of inter-organizational relationships. These networks are influenced by governance structures and depend on the company's internal resources, expertise, and culture. (Kesidou & Sovacool, 2019). However, there remains a notable gap in understanding how these inter-

organizational systems evolve, particularly in terms of how they foster spontaneous and adaptive supply chain integration and influence project outcomes.

The construction sector is uniquely characterized by its reliance on temporary, project-based collaborations that involve multiple contractors and skilled professionals. This fragmentation, combined with the novelty of each project, results in multiple, often competing inter-organizational systems operating simultaneously. While advancements have been made in using integrated information systems and relational governance tools to manage these complexities, little is known about how construction employees navigate and adapt to these evolving systems, or how these systems ultimately influence supply chain performance and innovation.

Addressing these knowledge gaps is essential for enhancing the construction industry's capacity to deliver sustainable and resilient infrastructure, further advancing the goals of SDG 9 through innovation-driven, inclusive, and well-integrated supply chains.

Summary of SDG 9: Industry, Innovation and Infrastructure

Sustainable Development Goal 9 (SDG 9), adopted as part of the 2030 Agenda for Sustainable Development, focuses on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation. These three pillars are essential drivers of economic growth, employment, technological advancement, and social inclusion, particularly in developing and least developed countries.

SDG 9 consists of eight specific targets and twelve indicators that help monitor global progress. The targets include improving access to reliable and sustainable infrastructure, increasing the contribution of industry to employment and GDP, enhancing the integration of small and medium-sized enterprises (SMEs) into value chains, and significantly increasing research and development (R&D) efforts. The development of SDG 9 has been marked by key milestones, including its formal adoption in 2015 and subsequent advancements in global industrial output and digital connectivity. However, ongoing climate challenges have highlighted the need for resilient and adaptive infrastructure systems that can withstand shocks and serve all populations effectively.

Achieving the targets of SDG 9 presents several challenges. These include persistent infrastructure gaps in rural and low-income areas, limited financial and technological resources for innovation in the Global South, and the environmental consequences of unchecked

industrial expansion. Moreover, global disparities in industrial productivity and technological capability hinder equitable progress.

Central to SDG 9 is the concept of inclusive and sustainable industrialization, which advocates for industrial development that benefits all segments of society, respects environmental boundaries, and supports local industries through cleaner and more efficient technologies. It emphasizes job creation, fair trade, and balanced regional development.

Equally important is the notion of resilient infrastructure, defined as physical and digital systems that can endure and recover from economic, social, and environmental disruptions. Examples include climate-resilient transport networks, renewable energy systems, and accessible digital infrastructure.

Innovation, the third pillar of SDG 9, plays a pivotal role in transforming economies and addressing global challenges. It requires increased investment in education, science, and technology, as well as supportive policies that encourage entrepreneurship and collaboration between public and private sectors. Ensuring that innovation is inclusive and reaches marginalized communities is critical to reducing inequality and achieving broader development goals.

In conclusion, SDG 9 is a transformative goal that seeks to modernize and equalize global development through infrastructure, industry, and innovation. While notable progress has been made, ongoing commitment, investment, and international cooperation are needed to overcome existing barriers and ensure that the benefits of growth and innovation are shared widely and sustainably.

Literature:

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