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Comparative Analysis of the Construction Industry in the EU and the Arab States of the Persian Gulf (GCC) and Its Impact on Environmental Sustainability

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ABSTRACT

This study examines the environmental sustainability performance of the construction industries in the European Union (EU) and the Gulf Cooperation Council (GCC) between 2013 and 2023. Using comparative analysis and secondary data from Statista, the European Commission, and the International Energy Agency, the research evaluates differences in regulatory frameworks, emission trends, and technological adoption. Results show that the EU achieved a 17.6% reduction in building-related CO_2 emissions and a 25% decrease in PM2.5 air pollution, supported by binding energy efficiency standards and renewable energy integration. In contrast, the GCC recorded a 9% rise in CO_2 emissions and only 8–10% improvement in air quality, reflecting limited regulatory enforcement and climatic constraints. The findings highlight that effective decarbonisation depends on policy coherence, technological innovation, and regional cooperation, positioning the EU as a regulatory model and the GCC as a region in transition toward sustainable construction practices.

ABSZTRAKT

A tanulmány az Európai Unió (EU) és az Öböl-menti Együttműködési Tanács (GCC) építőiparának környezeti fenntarthatósági teljesítményét vizsgálja a 2013–2023 közötti időszakban. A kutatás összehasonlító elemzést és másodlagos adatforrásokat (Statista, Európai Bizottság, IEA) alkalmaz a szabályozási keretek, a kibocsátási trendek és a technológiai fejlesztések értékelésére. Az eredmények szerint az EU-ban az épületekhez kapcsolódó CO_2-kibocsátás 17,6%-kal, a PM2.5 légszennyezettség pedig 25%-kal csökkent, amit a szigorú energiahatékonysági előírások és a megújuló energiaforrások integrációja tett lehetővé. Ezzel szemben a GCC-országokban a CO_2-kibocsátás 9%-kal nőtt, a levegőminőség pedig csupán 8–10%-os javulást mutatott. Az eredmények rávilágítanak arra, hogy a sikeres dekarbonizáció kulcsa a szabályozási következetesség, a technológiai innováció és a regionális együttműködés, amelyek terén az EU mintaként, a GCC pedig fejlődő régióként azonosítható.

Introduction

The construction industry is increasingly recognized as a crucial sector in advancing environmental sustainability, given its significant role in global carbon emissions and resource utilization. Within the EU, efforts to enhance sustainability in construction have been ongoing, with particular attention to reducing energy consumption and carbon footprints. This approach represents a broader alignment with environmentally responsible strategies and long-term ecological objectives. Key measures include the adoption of circular economy principles, adherence to sustainable building standards, compliance with energy efficiency requirements, and the promotion of innovative green technologies. These strategies aim to decrease environmental harm while optimizing resource use and minimizing waste.

To align with global environmental goals, the EU has introduced bold targets to position its construction industry as a leader in sustainable practices. The global construction industry is valued at USD 12.74 trillion in 2023, with revenues projected to reach $15.46 trillion. Within this context, the EU has committed to achieving net-zero emissions across the global construction sector by 2050 and ensuring that all new buildings meet net-zero standards by 2030 (United Nations Environment Programme, 2020; Nations, 2021). These objectives align with international efforts to mitigate climate change and reduce greenhouse gas emissions. The construction sector contributes 39% of total global CO2 emissions, with operational activities accounting for 28% and embodied emissions from building materials and processes making up 11% (Council, 2019). This substantial environmental footprint highlights the importance of robust regulatory measures and innovative practices. International frameworks such as the EU taxonomy system, OECD recommendations, and analyses by the International Energy Agency provide comprehensive guidelines to support sustainable construction practices.

In the Gulf Cooperation Council (GCC) region, construction has historically been driven by rapid urbanization and oil-revenue-based economic growth. However, GCC countries are increasingly integrating sustainable practices into their construction sectors as they transition towards diversified economic models. The construction industry plays a central role in addressing environmental challenges while accommodating infrastructure demands. Today, the GCC is leveraging its construction sector to incorporate sustainable solutions, addressing long-term environmental and economic challenges tied to its oil-dependent economy.

In summary, the EU and GCC regions illustrate different approaches to embedding sustainability into construction practices. By focusing on sustainability-driven policies in the EU and diversification strategies in the GCC, both regions demonstrate the transformative potential of the construction industry in reducing environmental harm and fostering resilience. These regional strategies contribute to the broader goal of positioning the construction sector as a leader in global environmental sustainability efforts.

Impact of the construction industry on environmental sustainability

Analysis of recent years shows that the construction industry has not shown sustainable development, and what is more, the English term "take make, dispose off" has created a linear economic model (Malin zu Castell-Rüdenhausen, 2021). This model illustrates the persistent dependence of the sector on extractive and consumption-based practices that disregard resource regeneration. The construction and infrastructure sectors, especially construction, maintenance and demolition, are responsible for a large share of natural resource use and waste generation. Such practices collectively contribute to escalating material depletion and carbon emissions, underscoring the necessity of transitioning toward circular and low-impact approaches.

This ambitious target has made it necessary to rethink building practices to achieve greater sustainability, resource efficiency and carbon reduction. Reaching these objectives requires a paradigm shift that integrates life-cycle thinking, eco-design, and responsible material selection across all stages of construction. The nature of the construction industry ranges widely. It encompasses diverse actors, technologies, and supply chains, the interconnections of which magnify its overall environmental footprint. Its complexity, importance and necessity determine the need for further research and regulation. Hence, developing coherent frameworks that balance economic growth with environmental accountability remains a central challenge. As mentioned above, the construction industry is divided into residential, commercial and infrastructure. Although these sub-sectors differ in scale and function, they share similar environmental responsibilities and opportunities for emission reduction. Construction is currently the third largest source of CO_2 emissions globally. This figure places the sector among the most influential contributors to anthropogenic climate change. As shown in data from the National Climate Data Center[1] . These empirical observations emphasise the direct correlation between construction activities and climate indicators, such as global temperature rise and sea-level increase. The average surface temperature of the Earth has risen by 0.07°C per decade since 1880. In addition, the average sea level has risen by 21-24 cm since 1880, as of 2019[2,3] (Seung.Hyeong Lee, 2021) . These long-term physical changes highlight the cumulative effect of unsustainable industrial development on planetary systems. As indicated in the 2019 Global Status Report on Buildings and Construction, the UN Environment Programme estimates that the construction industry is responsible for 28% of global energy-related CO_2 emissions (39% if construction emissions are included) [4](International Energy Agency, 2019). This substantial share confirms the sector's pivotal role in global decarbonisation efforts and the urgency of adopting transformative mitigation strategies.

The use of innovative and low-carbon products with a long life cycle can significantly reduce the loss of the built project. Such innovations not only extend structural longevity but also reduce embodied carbon through improved material efficiency and durability. The construction process consists of four main phases: the design phase, the production of raw materials, the transport of materials and the on-site construction phase. Each of these stages presents unique opportunities for intervention, where design optimisation and technological innovation can yield measurable reductions in emissions. These phases have been shown to be responsible for about 1%, 90%, 3% and 6% of total CO_2 emissions respectively (Min-Seop Seo, 2016) (Xianwei Wang, 2015) (Fischedick, 2014) (T. Jafary Nasab, 2019). The overwhelming dominance of emissions from raw material production underscores the need for targeted innovation in material science and process decarbonisation.

Environmental footprint of buildings

The sustainability of the construction industry has become a central issue for the European Union (EU) and the Gulf Cooperation Council (GCC) countries due to the differences in the economic structure and environmental challenges of the regions. Both regions face significant

[1] National Centers for Environmental Information. (n.d.). *Data tools: Search*. Retrieved November 22, 2024, from https://www.ncdc.noaa.gov/cdo-web/search

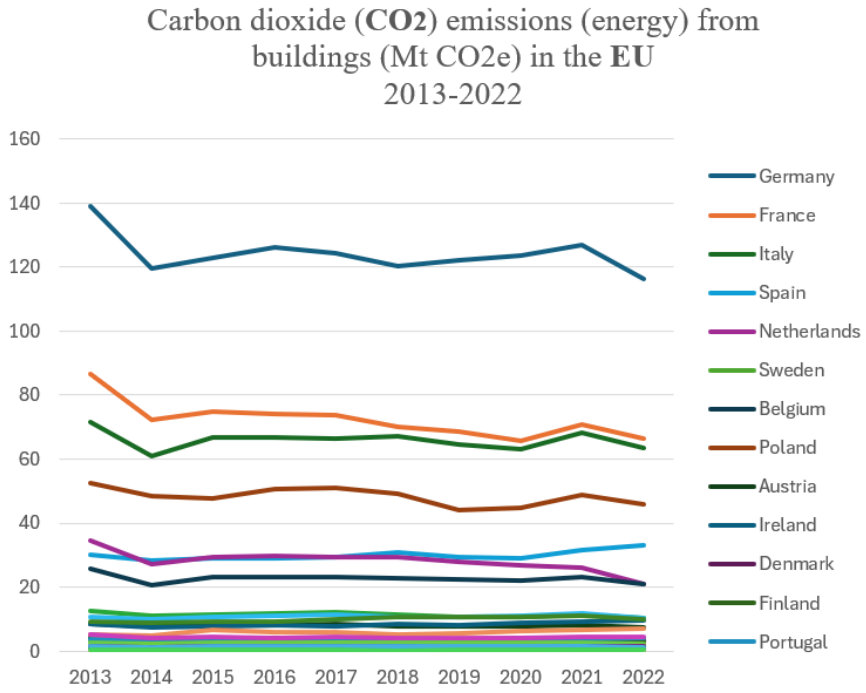
[2] National Centers for Environmental Information. (2019) *Global climate report - Annual 2019*. Retrieved November 22, 2024, from https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/201913

[3] National Centers for Environmental Information. (2020). *Global climate report - Annual 2020*. Retrieved November 22, 2024, from https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202013

[4] World Green Building Council. (n.d.). *World Green Building Council*. Retrieved November 22, 2024, from https://worldgbc.org/

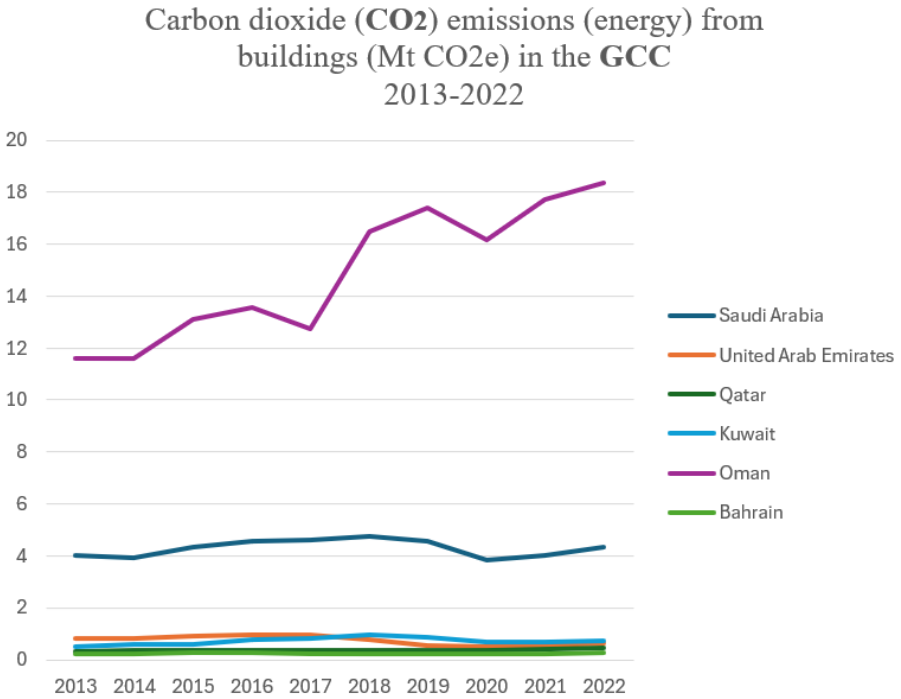
challenges in reducing emissions generated by the construction industry, but their strategies to achieve sustainability differ significantly. Key areas for promoting sustainability in the construction sector include optimising the use of materials, increasing energy efficiency and promoting recycling, all of which can contribute to reducing carbon emissions and reducing the ecological footprint.

Table 1 - CO2 emissions from EU buildings



Source: own editing based on *Statista and European Commission*

Table 2 -GCC CO2 emissions from buildings



Source: own editing based on *Statista*

Energy efficiency, sustainable building standards, green infrastructure and reducing the ecological footprint

Energy efficiency is one of the most critical factors for the sustainability of the construction industry. The EU has introduced strict energy efficiency regulations that require new buildings to be low energy and encourage the renovation of existing buildings. The spread of passive houses and zero-energy buildings is particularly noticeable in Northern Europe, where these buildings have minimal energy consumption and significantly reduce carbon emissions. Despite this, there is increasing attention in the region to integrating renewable energy sources such as solar energy. The UAE and Qatar have introduced green building standards to optimise insulation and energy consumption, which could contribute to the long-term uptake of sustainable building practices. In the EU, green roofs, optimisation of water use and natural ventilation systems have become increasingly common, especially in urban areas. Such solutions not only play a role in reducing the urban heat island effect, but also in increasing biodiversity and efficient management of stormwater, which is an area where the GCC regions should develop the most. The development of green infrastructure in the GCC region has been slower, but some initiatives, such as Dubai's Green City project, have already achieved progress. These strategies focus on expanding urban green spaces, improving energy efficiency and optimising water management.

Technological innovation and automation

Innovative technologies and automation play a key role in promoting the sustainability of the construction industry. A number of projects in the EU are already using robotic and 3D printing technologies to optimise material use and increase workflow efficiency. The use of digital building information models (BIM) also contributes to improving energy efficiency and minimising defects, thus helping to achieve sustainability goals. In the GCC countries, automation is also a promising solution for introducing more sustainable construction practices. Smart building technology is becoming particularly vital in the extreme climatic conditions of the region, where reducing energy consumption is key to sustainability.

Regulatory frameworks and cooperation

Developing a comprehensive regulatory framework and strengthening international cooperation is essential for both the EU and the GCC to promote the sustainability of the construction industry. The EU's stringent environmental standards promote the reduction of carbon emissions and the widespread use of green technologies. Achieving carbon neutrality in the construction industry is a key priority of the EU Green Deal, which has triggered a major wave of innovation in the sector. Sustainability regulations in the GCC countries have not yet reached a similar level of integration, but a growing number of countries are taking steps to promote sustainable construction practices.

Different development, same goals

In the EU, existing regulatory frameworks and technological developments support the development of a sustainable construction industry, while the GCC countries face challenges in energy-intensive sectors. Promoting innovation, improving material use and waste management, and wider adoption of sustainable building solutions are key challenges for both regions.

European Union (EU): Between 2013 and 2022, CO_2 emissions from buildings in the European Union showed a steady downward trend, decreasing by approximately 15% across the decade. Germany, France, and Italy the three largest emitters reduced their combined emissions from 297.2 Mt CO_2e in 2013 to 246.1 Mt CO_2e in 2022. Northern and Western European countries (Sweden, Denmark, Finland) maintained the lowest emission intensity per

capita, reflecting the success of long-term energy efficiency policies and widespread adoption of low-carbon building standards. In contrast, some Central and Eastern European states (Greece, Hungary, Romania) exhibited moderate fluctuations due to slower policy implementation and dependence on conventional heating systems. Overall, the data confirm that EU-wide building decarbonisation policies under the Green Deal and the Energy Performance of Buildings Directive (EPBD) have yielded measurable progress toward emission reduction.

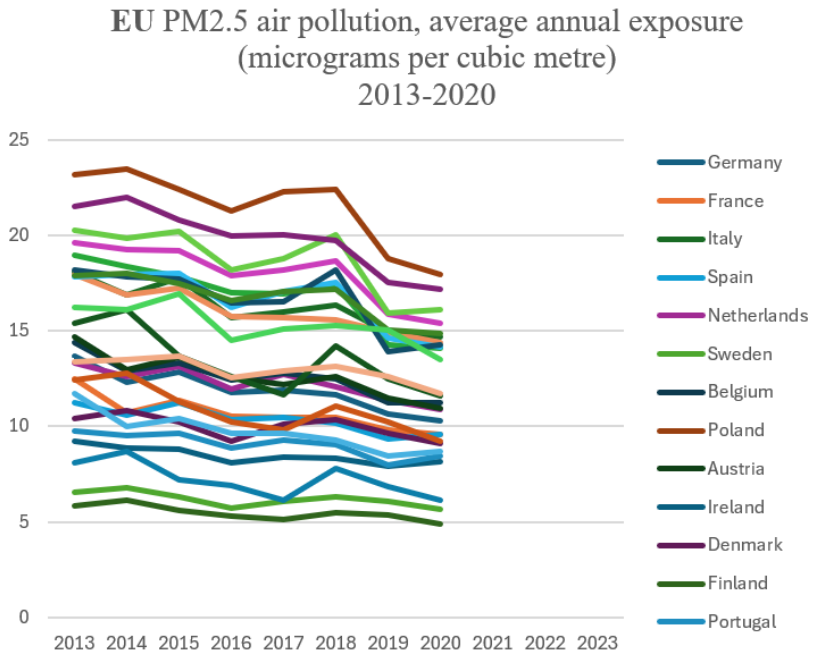
Gulf Cooperation Council (GCC): In the GCC, the opposite trend is visible. Total building-related CO_2 emissions increased by approximately 42% between 2013 and 2022, driven mainly by rapid urbanisation and high energy consumption for cooling. Oman's emissions nearly doubled from 11.6 Mt CO_2e to 18.3 Mt CO_2e, becoming the dominant contributor to regional totals. Saudi Arabia remained the second-largest emitter, fluctuating around 4 Mt CO_2e annually. Meanwhile, smaller states such as Bahrain, Qatar, and Kuwait exhibited relatively stable but non-declining emission levels. Despite new sustainability programs like Estidama (UAE) and QSAS (Qatar), the lack of binding efficiency regulations and continued fossil-fuel dependence limit overall progress.

Comparative interpretation: The comparative data highlight a clear divergence in emission trajectories: the EU demonstrates regulation-driven decarbonisation, while the GCC reflects growth-driven emissions persistence. Between 2013 and 2022, average CO_2 emissions per building in the EU fell by ~1.7% annually, whereas in the GCC they rose by ~4.6% annually. This gap underscores the decisive role of policy enforcement, climate conditions, and energy source diversification in determining sustainability outcomes.

Air pollution

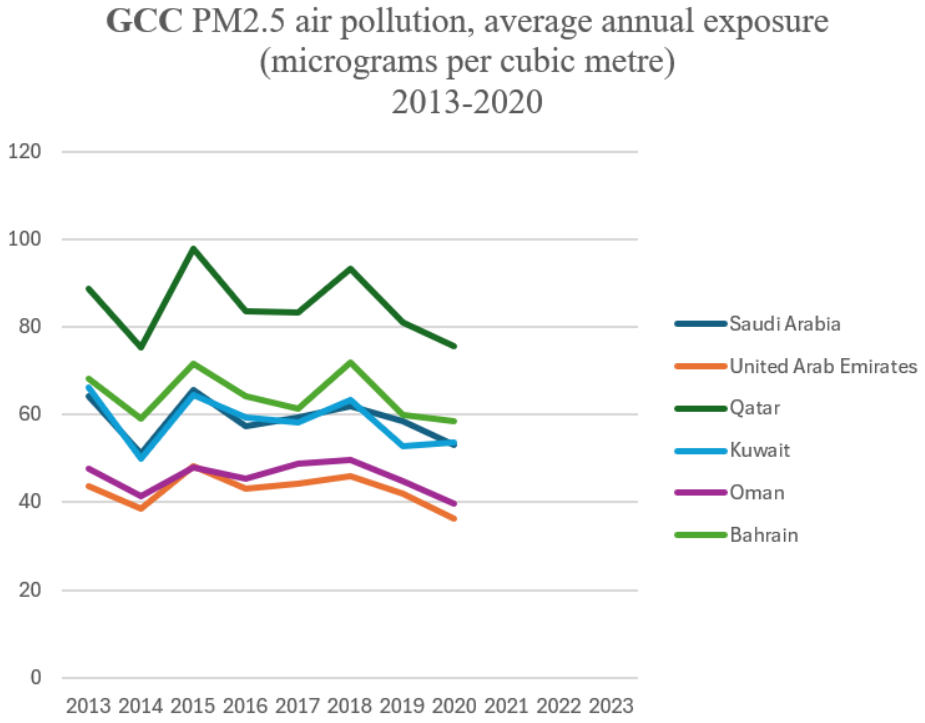
Sustainability aspects of air pollution and the construction industry are a major concern in both the European Union (EU) and the Gulf Cooperation Council (GCC) countries. In both regions, the intensity of construction activities has significant environmental impacts, particularly in terms of PM2.5 particulate pollution, which poses serious public health and ecological problems.

Table 3 - EU air pollution between 2013 and 2020



Source: own editing based on *Statista*

Table 4 - GCC air pollution from 2013-2020



Source: own editing based on Statista

The role of the construction industry in air pollution

In the EU, the reduction in PM2.5 pollution is mainly the result of strict environmental regulations, building standards that prioritise energy efficiency and the increased use of renewable energy sources. Construction processes are characterised by the use of low-emission materials and technologies, which in the long term reduce the environmental impact of the construction industry. In contrast, the construction industry in the GCC countries relies heavily on fossil-based energy sources and conventional material use, which significantly increase PM2.5 pollution. Intensive construction projects, such as the construction of the FIFA World Cup infrastructure in Qatar or large-scale investments in Saudi Arabia, have contributed to the increase in pollution. The challenge for the region is how to find more sustainable solutions within the existing economic and technological framework.

Impact of economic and cultural factors on sustainability

Sustainability differences between the EU and GCC countries are partly due to different economic priorities and cultural contexts. In the EU, sustainability objectives are supported by both the public and policy makers. In countries such as Germany and Sweden, building codes strictly require the use of environmentally friendly technologies, which contributes to the reduction of PM2.5 levels and the uptake of green building solutions. In the GCC countries, the sustainability goals of the construction industry are often overshadowed by the dominance of the oil industry and rapid urbanisation. However, the examples of the UAE and Oman show that progress on sustainability is possible if the right regulatory frameworks and technological solutions are in place.

Challenges and opportunities in reducing air pollution

Reducing air pollution from the construction sector in both the EU and the GCC depends on technological innovation and the evolution of the regulatory environment in the sector. The EU's goal is for the sector to achieve full carbon neutrality, but this will require significant investment and technological innovation. For the GCC region, achieving sustainability targets is more challenging due to extreme climatic conditions and a heavy reliance on fossil-based energy sources. Although these technologies initially entail significant costs, in the long term they can contribute to reducing the environmental impact of the construction industry.

European Union (EU)

Between 2013 and 2020, average PM2.5 exposure across EU countries fell by 25%, dropping from around 16 μg/m³ to 12 μg/m³. Northern states such as Sweden, Finland, and Denmark achieved reductions of over 12-17%, maintaining the cleanest air in Europe (5–7 μg/m³). In contrast, Italy, Poland, and Greece reported smaller decreases of roughly 18-23%, remaining in the 15–20 μg/m³ range. The overall decline reflects the combined impact of the EU Ambient Air Quality Directive, the Green Deal, and growing reliance on renewable energy and efficient building standards.

Gulf Cooperation Council (GCC)

PM2.5 levels in the GCC remained five to seven times higher than in the EU, averaging 55–80 μg/m³ throughout 2013–2020. Despite slight improvements of 14-18% in the UAE and Oman after 2018, Qatar, Kuwait, and Saudi Arabia continued to record extreme concentrations, often exceeding 70–90 μg/m³. Persistent reliance on fossil fuels, intense construction activity, and desert dust remain the main drivers of air pollution. The absence of a unified regional regulation limits consistent progress across the bloc.

Comparative interpretation

From 2013 to 2020, the EU achieved roughly a 25% reduction in PM2.5 exposure, while the GCC's achieved a more modest reduction of around 16%. The contrast highlights that sustained improvement depends on policy enforcement, diversified energy systems, and coordinated air-quality governance areas where the EU is substantially ahead.

Material and methodology

The research examines the environmental sustainability strategies of the construction industry in the European Union (EU) and the Gulf Cooperation Council (GCC), focusing on modernization efforts and their environmental impact. The analysis evaluates the environmental footprint of buildings, air pollution, and the implementation of sustainability objectives within each region's regulatory and policy frameworks.

Data were collected from reliable sources, including the World Bank, International Energy Agency (IEA), European Commission, OECD reports, and academic publications. The research employs quantitative methodologies.

The study highlights regional comparisons of environmental impacts and sustainability practices. While limitations in secondary data availability affected some analyses, the research spans the period 2013–2023, emphasizing trends and progress in sustainable construction across both regions.

Conclusion

The construction sector is responsible for 39% of global carbon emissions, so the use of energy-efficient technologies and sustainable materials is essential. Circular economy models in the EU can serve as a model for GCC countries, especially in waste management and material use. Industry 4.0 digitalisation and automation are essential to increase efficiency, both in production and in the operation of buildings. The development of smart buildings and green technologies can be identified as a common goal in both regions. A more in-depth analysis would require the development of common indicators to better measure the environmental, economic and social impacts of construction projects. Greater public support and more tendering opportunities for the production of low-carbon building materials would facilitate the procurement of the necessary technologies and equipment. Furthermore, a deeper analysis is needed to compare sustainable building practices and regulatory frameworks in the EU and GCC countries, taking into account local climatic and social conditions.

A question that arises is: In today's world, where 'sustainability' is becoming an increasingly fashionable term, how can we separate the real issues from those that are merely marketing gimmicks? The question also raises the dilemma of the credibility of innovative materials how can we distinguish and make sure that new materials that do not have a long history, extensive experimentation, extensive research and practical experience are truly sustainable solutions and not just part of a fashion wave that may later have a negative impact on the environment or human health?

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