Review

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A CRITICAL EXAMINATION OF THE CONSTRUCTION SECTOR IN TÜRKİYE IN TERMS OF SUSTAINABILITY

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ABSTRACT: The construction sector is of critical importance for economic growth and employment creation. However, it also has significant environmental impacts, including high energy consumption, extensive use of natural resources, and substantial waste production. Currently, the construction sector in Türkiye accounts for 35% of the country's total energy consumption, making it a significant energy consumer. Research conducted in European countries indicates that buildings account for 40% of all energy consumption and 36% of all CO2 emissions. It is believed that a similar situation exists in Türkiye. Furthermore, the long lifespan of structures built in this sector is of great importance to sustainability. The contribution of poor-quality and unhealthy structures to environmental stress highlights the role of the construction sector in sustainability.

This study addresses the impacts of strategic goals such as the design and construction of sustainable building models, the recyclability and reuse of building materials, energy efficiency, and the reduction of CO2 emissions in the construction sector. The findings indicate that integrating energy efficiency and renewable energy technologies is crucial for the Turkish construction sector to move toward a sustainable future. In this context, it is recommended that the Turkish construction sector implements the necessary steps and engages in strategic planning to achieve its sustainability goals. The findings of this study emphasize the pivotal role and significance of the construction sector in this regard.

Keywords: Sustainability, Construction Sector, Carbon Footprint

1. ECONOMIC IMPORTANCE OF CONSTRUCTION SECTORS

The construction sector plays a pivotal role in the development of infrastructure for all industrial branches and contributes significantly to national economies' growth. In developing countries, the sector is of particular importance for establishing basic infrastructure, ensuring technology transfer, and training local labor forces. Globally, the United States and Japan represent the largest construction market globally. In terms of world service exports, construction services account for 4% of global service exports. The countries with the highest shares of global construction service exports are those of the former Eastern Bloc countries, Europe, and Asia [1].

It is imperative that the construction sector undergoes significant advancement to meet the growing needs of developing countries. There is a considerable demand for construction projects in sectors such as airports, transportation, power plants, dams, and bridges, which

serves to illustrate the significance of the construction sector. According to data from 2012, the construction sector accounted for 7.5 trillion dollars, representing 13.4% of global production [2]. The comprehensive analysis of the data reveals that the construction sector is among the leading sectors driving the global economy. The interdependence of numerous sectors in the construction industry and the incorporation of diverse specialized fields under the umbrella of construction demonstrate the pivotal role of high-budget construction projects in the advancement of the sector and its global economic influence. Consequently, it can be posited that a multitude of factors influencing the construction sector exert a direct impact on the global economy [3]. The state of the economy has a direct impact on the construction sector in Türkiye, as it does in all countries around the world. The construction sector is a significant contributor to the Turkish economy, offering a wide range of employment opportunities. The proportion of GDP and construction investments represents a crucial factor in economic growth. The chart below illustrates the evolution of the construction sector's contribution to Türkiye's GDP over time. The construction industry growth rate is presented in Figure 1.

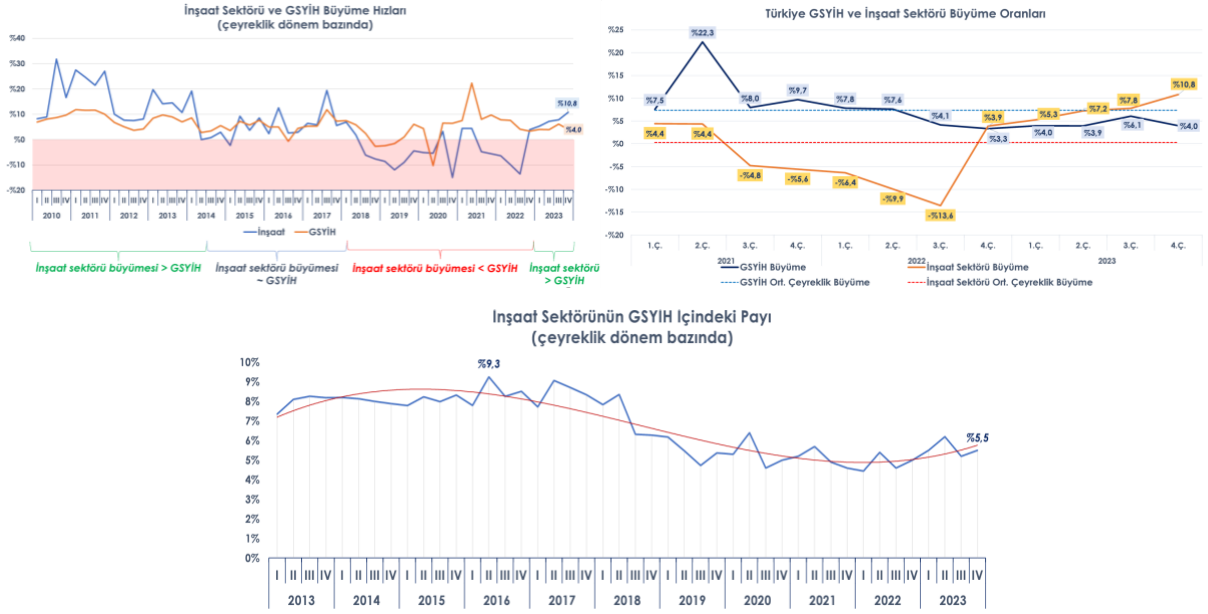

Figure 1. Growth rates of the construction industry [4]

Figure 1 presents data from 2010 to 2023. Upon examination of the graph, it is evident that between 2010 and 2018, the growth rate of the construction sector frequently exceeded that of the GDP. This indicates robust performance relative to overall economic growth. From 2018 onwards, a notable decline in the growth rate of the construction sector is observed, frequently falling below the GDP growth rate, indicating a deceleration in construction activities. In approximately 2019, the construction sector experienced a pronounced decline, approaching a negative growth rate of approximately 20%. It subsequently struggled to recover until a slight positive increase was observed around 2022-2023.

The second graph presents observations from 2021 to 2023. The data indicate that in 2021, the construction sector experienced significant fluctuations, with a period of rapid growth in the first quarter followed by a subsequent decline. In 2022, the construction sector experienced negative growth in the second and third quarters, with a substantial decline of 13.6% in the third quarter. A recovery was observed in 2023, with the growth rate of the construction sector reaching 10.8% in the third quarter, indicating a notable rebound. The average quarterly growth rate of the construction sector, with the exception of a few instances, remained below the GDP growth rate.

The third graph covers the period from 2013 to 2023. As the third graph illustrates, the proportion of the construction sector in GDP began at approximately 9.3% in 2013 and subsequently declined over time. Despite fluctuations, a discernible downward trend in the proportion of the construction sector in GDP is evident, with the figure falling to approximately 5.5% by 2023. This trend indicates that following a period during which the construction sector constituted a significant proportion of the economy, its relative contribution decreased over time.

To summarize, the construction sector's contribution to GDP was as follows: From 2013 to 2017, the proportion of the construction sector in GDP averaged approximately 8%, peaking at 9.3% in certain quarters. The most recent data from the fourth quarter of 2023 indicate that the sector's share is 5.5%.

As evidenced by Eşkinat and Tepecik [5], construction activities continue to be a global phenomenon. The construction sector encompasses the establishment of infrastructure required by new technologies and the construction of transportation routes, communication networks, and buildings. The construction sector plays a significant role in national economies by providing infrastructure for all industrial branches. In developing countries such as Türkiye, the construction of basic infrastructure, training of local labor, and the facilitation of technology transfer are crucial aspects of the sector [6].

The construction sector contributes to the economy not only through direct construction activities but also through numerous sub-sectors linked to it. Areas such as the production of construction materials, logistics, financing, real estate, and architecture are expected to benefit from the revitalization of the construction sector. Consequently, the expansion of the construction sector creates economic opportunities for many other industries. For instance, implementing a housing project necessitates the production and transportation of materials such as steel, cement, and wood. This, in turn, stimulates employment and production capacity in these sectors [7].

2. Challenges Faced by Constructment Indifaction

2.1. Economic Fluctuations

The construction sector is significantly affected by economic fluctuations. The economic crisis of 2018 and the subsequent pandemic have resulted in a significant decline in the sector. The table below illustrates the growth rate of the construction sector and the impact of economic fluctuations.

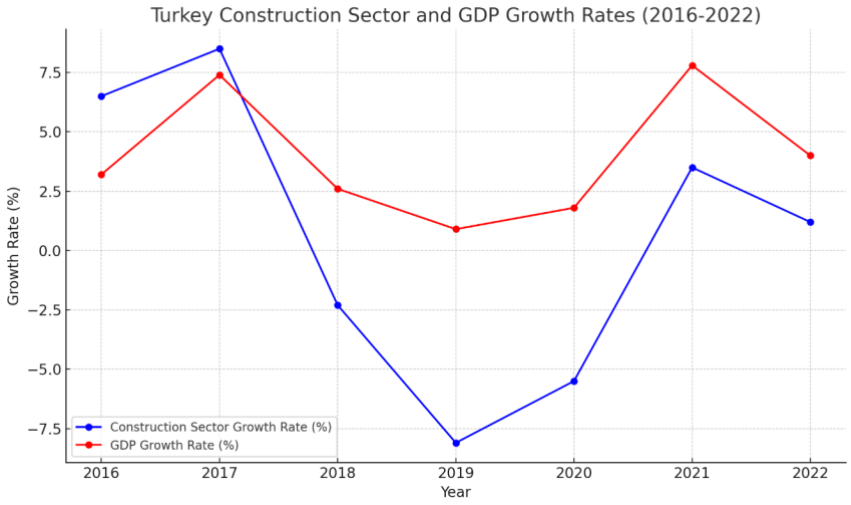

Figure 2. Türkiye Construction Sector and GDP Growth Rates

Figure 2 presents a comparative analysis of the growth rates of the Türkiye construction sector and the overall GDP from 2016 to 2022. The data highlight several key trends and insights: **Higher Volatility in the Construction Sector; The** construction sector demonstrates significantly higher volatility than the overall GDP. This trend is evident from the sharper fluctuations in the blue line representing the construction sector's growth rate. For instance, the sector experienced substantial growth at approximately 7.5% in 2017, followed by a severe contraction of approximately -7.5% in 2019. **Economic Cycles and Sensitivity**; The construction sector is highly sensitive to economic cycles. The sector's performance mirrors broader economic trends but with greater intensity. The marked decline in growth during 2019 corresponds to a period of economic slowdown, whereas the recovery post-2020 aligns with overall economic improvement. **Potential for High Growth**; Despite its volatility, the construction sector shows potential for high growth. During periods of economic expansion, such as 2017 and 2021, the sector's growth rate outpaced GDP growth. This potential can be strategically harnessed through investments and supportive policies. **Need for Sustainable Practices**; The graph underscores the need for sustainable practices and policies within the construction sector. To mitigate risks associated with economic downturns, the sector should adopt sustainable construction techniques, improve resource efficiency, and ensure regulatory stability. **Long-Term Stability**; Ensuring long-term stability in the construction sector requires balanced regulatory measures. Policymakers should focus on creating a supportive environment that promotes sustainable growth. This includes providing incentives for innovation and implementing counter-cyclical fiscal policies to stabilize the sector during economic downturns.

By examining these trends, it becomes clear that while the construction sector holds significant growth potential, sustainable practices must be implemented to mitigate volatility and ensure long-term stability.

In addition, by examining Figure 2, the graph highlights the volatility of the construction sector compared to the overall GDP. Although the sector shows potential for high growth, it is also more susceptible to economic downturns, emphasizing the need for sustainable practices and policies to mitigate risks and ensure long-term stability [4].

2.2. Environmental Impact

Given the construction sector's reliance on the exploitation of natural resources, its environmental impact is significant. A number of factors, including carbon emissions, water consumption and waste production, present significant threats to the environmental sustainability of the sector. The graph below illustrates the contribution of the construction sector to carbon emissions in Türkiye [8].

Figure 3. The contribution of the construction sector to carbon emission in Türkiye

The chart shows a general upward trend in the construction industry's carbon emissions over the seven-year period. Starting at approximately 220 metric tons in 2016, emissions increased steadily, peaking at approximately 520 metric tons in 2022. This trend marks a significant increase in the environmental impact of the construction industry. Although the general trend in the chart is upward, significant fluctuations are also noted. For example, emissions rise sharply from 220 metric tons in 2016 to about 349 metric tons in 2019, then decrease slightly before rising again. Such fluctuations can be attributed to varying levels of construction activity, regulatory changes, and economic factors affecting the industry. Additionally, the chart highlights the impact of potential economic and policy changes on carbon emissions. Periods of rapid increases in emissions may correspond to economic booms or reduced regulatory oversight; Decreases may indicate economic slowdowns or stricter environmental regulations. The significant increase in carbon emissions highlights the increasing environmental impact on the construction sector. This situation requires urgent measures to improve sustainability practices in the sector. Reducing carbon emissions through innovative construction technologies, increased efficiency, and stronger regulatory frameworks is critical.

In summary, the bar graph highlights a clear and concerning upward trend in carbon emissions from the construction sector in Türkiye from 2016 to 2022. This underscores the urgency of adopting sustainable practices and implementing robust policies to mitigate the environmental impact of this critical economic sector.

3. ENERGY EFFICIENCY, CLIMATE CHANGE, AND THE ITS EFFECTS ON THE CONSTRUCTION SECTOR

Energy efficiency is defined as the ability to provide the same services using less energy. In the construction sector, energy efficiency can be applied across a wide range of areas, including building design and materials, as well as heating, cooling, and lighting systems. Given that buildings account for approximately 40% of Turkey's total energy consumption in Türkiye, the implementation of energy efficiency measures can result in significant savings [8].

The construction sector plays a pivotal role in terms of energy consumption and carbon emissions. A considerable amount of energy is consumed, and greenhouse gases are emitted throughout the construction, utilization, and demolition phases of buildings. In this context, the pursuit of energy efficiency and combating climate change are of paramount importance for the sustainability of the construction sector.

Currently, the impact of climate differences and local data on the formation of urban areas is not adequately considered. The construction of buildings, street widths, and construction materials is not informed by data on climate and environmental features, resulting in the creation of uniform structures. However, in a country with diverse climatic zones, this production method results in the formation of hotter microclimates in regions with high temperatures and colder microclimates in regions with low temperatures. Consequently, there is a significant loss of energy in building designs. Given that 35% of consumed energy is used in buildings, addressing this issue is vitally important. A review of the energy consumption data from the previous decade reveals that although the EU and OECD countries exhibited energy consumption rates of 18.8% to 16.4%, our country exhibited a significantly higher rate of 31.2%. This indicates that our energy consumption is increasing, and this increase is more pronounced in buildings [9,10].

The three principal areas of focus in the context of climate change are energy efficiency, renewable energy technologies, and the reduction of CO2 emissions. Energy efficiency and CO2 emissions are closely related to the construction sector. In the European Union, buildings account for 40% of all energy consumption and 36% of all CO2 emissions. Furthermore, numerous studies and reports indicate that the continuous needs of buildings, such as heating and lighting, account for more than one-third of the world's total energy consumption [11].This demonstrates the considerable consumption in the construction sector. Consequently, numerous countries have established strategic objectives and enacted legislation with the objective of enhancing energy efficiency and reducing CO2 emissions. When these targets are considered and evaluated for the construction sector, it is important to pay attention to reducing carbon emissions across all fields and productions, designing and constructing buildings that enable people to live energy-efficient lives, and preparing the necessary infrastructure for implementing sustainability practices [12].

Significant quantities of energy are consumed during the production and utilization phases of buildings in the construction sector. Research conducted in EU member states has demonstrated that approximately half of the total energy consumed by these countries is used during the production and use of buildings. When transportation activities are included in the calculation, the figure rises to 75% [13,14]. Similarly, it is believed that this situation is applicable to Türkiye. Figure 4 illustrates the distribution of energy consumption by sectors in Türkiye.

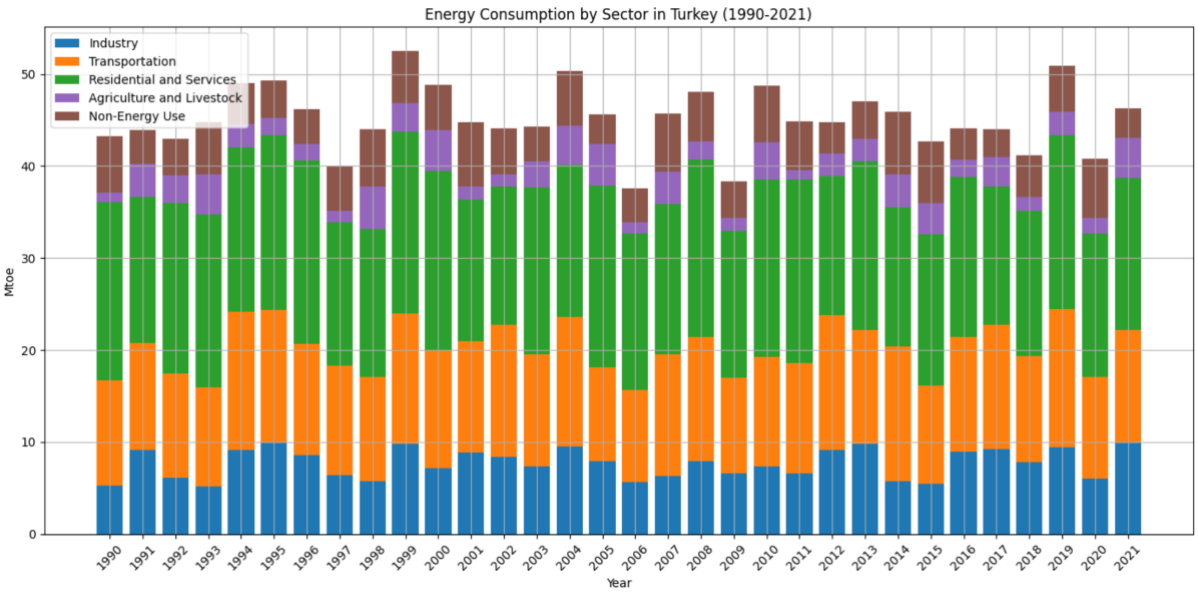

Figure 4. Sector energy distribution

Upon examination of Figure 1, it becomes evident that the total final energy consumption of sectors in Türkiye exhibited a notable increase in 2021, with a 191.3% surge compared to 1990, a 75.9% rise compared to 2005, and a 9% growth compared to 2020, reaching 123.14 Mtoe. The substantial increase in final energy consumption in Türkiye can be attributed to economic growth. However, to qualify for development, energy intensity must also decline, and this should be considered alongside energy efficiency. For example, in the EU-27 countries, final energy consumption decreased by 9% over the last 10 years as of 2019, due to efficiency improvements.

In 2021, the industrial sector (33.8%) and residential and services sectors (31%) constituted the largest share of final energy consumption in Türkiye, followed by the transportation sector (24.8%) and agriculture and livestock sectors (4.2%). The proportion of non-energy consumption was 6.3%.

In comparison with European Union countries, in 2021, the highest share of final energy consumption in the EU-27 was in the transportation sector (29%), followed by the residential sector (28%) and the industrial sector (26%). The service sector accounted for 14% of the total, while the agriculture and livestock sector contributed 3% [15].

4. RESOURCE USE AND WASTE MANAGEMENT

Waste materials generated by civil engineering structures during natural disasters, demolitions, or construction processes are classified as construction waste. Examples of construction engineering waste include excavated soil obtained during the construction phase of an engineering structure, wood, metal, concrete, concrete blocks, bricks, asphalt and bituminous materials, aggregate, gypsum board and its derivatives, carpet and textile derivatives, and materials such as paint, varnish, and their derivatives ordered in excess of the required amount during the construction or demolition of buildings for any reason [16]. Figure 5 illustrates the waste generated during the construction and demolition of buildings.

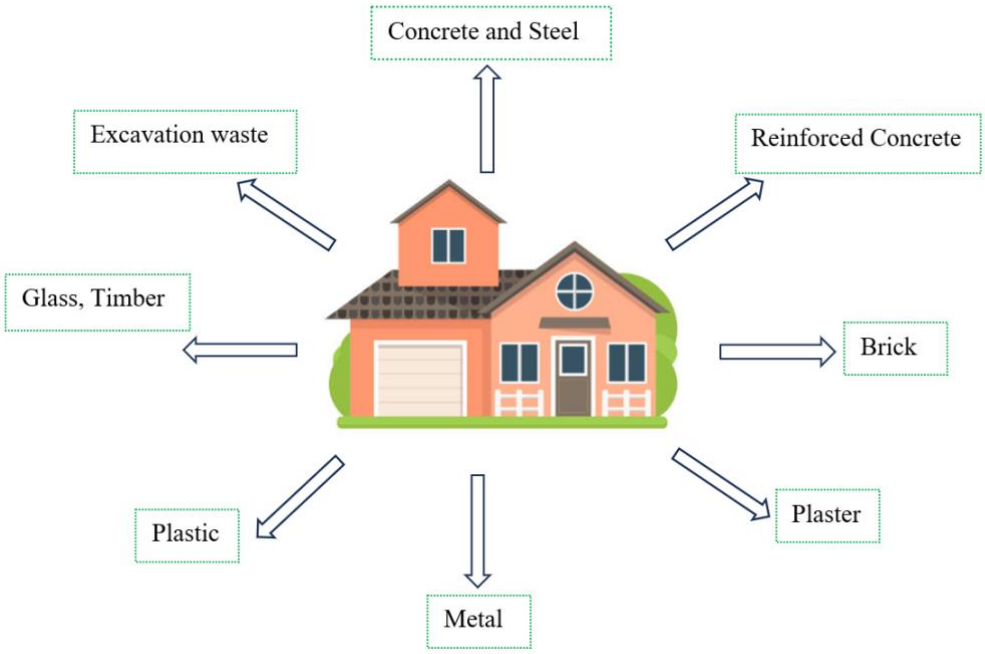

Figure 5. Construction waste from the construction or demolition of residential buildings

The construction sector is renowned for its extensive use of resources and waste generation. In the absence of effective management, construction waste can lead to significant environmental problems. To achieve a sustainable construction sector, it is necessary to implement widespread recycling and reuse practices.

The construction legacy of the 20th century is characterized by the significant quantity of waste generated from construction and demolition activities. In developed countries, measures have been implemented since the 1970s in accordance with environmental legislation with the objective of preventing waste from causing harm to the environment and human health. In addition, waste management policies have been developed. Nevertheless, waste recovery efforts only gained momentum after the 1990s. In the United States, industrial facilities produce in excess of 500 million tons of potentially reusable waste each year. Although these materials could become valuable due to their chemical and physical properties when reused or recycled, they are often disposed of as waste [17].

Given that approximately 10% of the environmental impacts generated during the life cycle of a building are due to the building materials used, the importance of material selection becomes prominent [18]. The use of materials that are predominantly reusable and recyclable serves to mitigate the environmental impacts of the construction sector. This approach can help prevent the uncontrolled disposal of structural waste from the construction sector, which could otherwise lead to the pollution of soil and water sources. The potential for the recovery of building materials and components, including concrete, metal, steel, wood, ceramic, plastic, and glass, arising from the production, construction, renovation, repair, and demolition activities of buildings, is considerable [19].

5. SUSTAINABILITY IN TURKISH CONSTRUCTION SECTORS

The concept of sustainability can be defined as the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs. Based on this definition, it can be said that the goal of sustainability is to meet our current needs without

jeopardizing the capacity of future generations to meet their needs [20]. In a world where natural resources are rapidly depleting, sustainability must become a priority [21]. The concept of sustainability is currently being discussed in all areas of interest. At the core of this issue is damage to the environment and ecology, and sustainability is proposed as a solution [22].

The necessity to provide people with habitable spaces and the fact that residential construction constitutes a significant proportion of the sector's activities can be regarded as two pivotal factors. The rationale behind the importance of the construction sector for sustainability is that the structures constructed in the sector will endure for an extended period, as poorly constructed and unhealthy buildings will contribute to environmental stress for an extended duration. Moreover, the construction sector, which is regarded as the primary driver of the economy and is in close interaction with other sectors, will set an example for other sectors with each step it takes toward sustainability [23]. In order to achieve sustainability in the construction sector, various building models that cause less harm to the natural environment and use natural resources more wisely should be designed. These building models should be evaluated separately for each country [24].

In recent years, the recovery and reuse of waste arising from various reasons has gained importance. During the production and use phases of buildings in the construction sector, millions of tons of solid waste are generated. In general, three main benefits are expected from recovery and reuse activities in the construction sector. These include a reduction in the demand for natural resources, a reduction in the energy spent on the production and transportation of building materials to construction sites, and an evaluation of solid wastes, thereby reducing the harm to the natural environment [13].

The growing consumption of non-renewable resources and the associated challenges of transferring these resources to future generations have prompted the development of novel planning and strategic approaches in the construction sector. In the construction sector, sustainability should be compatible with low-cost, economic, social, and environmental issues during the planning, construction, and demolition phases [25].

Despite the numerous problems caused by the construction sector, its environmental, economic and social roles have made the sector indispensable and have led to the emergence of new ideas about the need for sector development to be environmentally compatible. When these ideas are related to the concept of sustainable construction, the objective is to select building materials that are reusable and consume less energy, thereby reducing waste production [2].

Sustainability should consider the choice of materials, the supply of raw materials, and the total energy required for processing and transport. Design and construction play an important role in the efficient use of building materials. Planning in advance how building materials will be handled at the end of the economic or physical life of buildings is crucial to sustainability. Today, buildings are often renovated frequently, and many are demolished before the end of their useful life, generating large amounts of waste. In addition, oversized buildings consume more energy than necessary; thus, it is important to optimize their size. Maintaining unused old buildings is also an additional economic burden, so measures to re-use buildings at the end of their lives are a good approach to sustainability. Recycling or displacing waste from the demolition of expired buildings is one of the most important steps to be taken in the construction sector for sustainability [20-24].

Interest in environmental issues in Türkiye began in the 1970s, but environmental awareness and sustainability practices have only recently found a place in Turkeyn society [22]. In order to promote sustainability in our country, the selection of construction sites, environmental protection, use of ecological materials, reduction of carbon emissions, use of natural resources

for heating and cooling systems, lighting, insulation, and meeting the quality of life through natural methods, as well as ensuring that these practices are applied in future buildings, should be given the necessary importance, and the necessary infrastructure should be provided [2].

5.1. Strategies for Sustainability

Developing countries require significant advances in the construction sector to meet their growing needs and ensure sustainable economic development. Areas such as transport, power plants, airports, dams, bridges, and settlements account for a significant proportion of national economies. Although it is difficult to categorize construction projects, a generally accepted classification is as follows:

- Housing
- Commercial construction
- Industrial structures
- Heavy-engineering structures

Despite the environmental problems caused by the construction sector, its ecological, economic, and social functions make it indispensable. This situation, leading to the emergence of new ideas for development in harmony with nature, can be summarized under the concept of sustainable construction. Sustainable construction aims to improve the sector by using reusable and energy-efficient building materials while considering increasing costs and waste reduction [26].

The concept of sustainability is often confused or used synonymously with the term "green," which is not fully inclusive. However, there is a fundamental difference between the two concepts, which is related to environmental considerations. Figure 6 shows the scope and differences between the two concepts.

Figure 6. The scope of green and sustainable buildings [27,28]

With the emergence of the concept of sustainable development, new concepts such as eco-friendly buildings, green buildings, and smart buildings have also emerged. In particular, the

term "green building" carries meanings related to being environmentally friendly and ecological [29]. The main objectives of green buildings are to be safe, healthy, comfortable, durable, and economical for users and the environment. These buildings are designed with social and environmental factors in mind. During the design phase, the climatic conditions and local characteristics of the building's location are considered. This ensures that buildings are efficient in their use of energy and water. In addition, the use of renewable energy sources is encouraged, and waste is minimized. The materials used in green buildings are also environmentally friendly and sustainable.

The benefits of green buildings go beyond those of standard buildings. These types of buildings provide a healthier living environment for their occupants due to their high levels of indoor air quality. Energy and water savings are fundamental features of green buildings, and they reduce operating and maintenance costs. In addition, the reduction in waste production provides significant environmental and economic benefits. As pointed out by Güzelkokar and Gelişen [30], green buildings on average are 28% more efficient than standard buildings. This higher efficiency makes green buildings more economically viable in the long run. Thus, green buildings play an essential role in future building design in terms of both environmental and economic sustainability.

5.1.1. Green Building Practices

There are certifications that are used to evaluate green buildings. It has been observed that not every country has its own certification system, and the use of internationally recognized certifications is becoming more widespread [28, 31]. Green building certifications, such as LEED and BREEAM, aim to improve the energy efficiency and environmental performance of buildings. These certifications provide the essential criteria for sustainable building design and construction [32]. In addition, green building certifications (LEED, BREEAM, etc.) and the use of sustainable materials can help reduce the environmental impact of the construction sector. These practices support environmental sustainability by increasing energy efficiency and reducing waste production. In Türkiye, incentive policies and awareness campaigns are important to promote the widespread adoption of green buildings.

5.1.2. Advantages of Green Building Certifications

Green buildings offer a number of benefits. First, the construction and use of green buildings significantly reduce operating costs. These buildings have lower operating costs because of reduced energy and water consumption and require less maintenance and repair. These cost benefits maximize economic performance throughout the life cycle of the building. In addition, the construction of green buildings creates new markets for green products and services, expands existing markets, and helps shape these markets. This will contribute to the growth of the green economy and the development of sustainable business models.

From an environmental perspective, green buildings play an important role in preserving and enhancing biodiversity and ecosystems. These buildings are designed to conserve and renew natural resources, thereby supporting environmental sustainability. Green buildings also improve air and water quality, reduce negative environmental impacts, and minimize waste production.

The social benefits of green buildings are also remarkable. These buildings have a positive impact on the comfort and health of their occupants, improving their overall quality of life. Improved indoor air quality and healthy living conditions contribute to the overall health and

well-being of the occupants. In addition, green buildings minimize the impact on local ecosystems and promote sustainable use of natural resources.

Green buildings are highly efficient in terms of energy and water conservation. These buildings encourage the use of renewable energy sources, thereby reducing the carbon footprint. Improved waste management and minimized environmental impact helps green buildings achieve their environmental sustainability goals.

In summary, green building certification offers numerous economic, environmental, and social benefits. These buildings play a critical role in achieving sustainable development goals and setting the standard for future building practices.

5.1.3. Innovative Technologies

The use of innovative technologies in construction offers significant sustainability benefits. For example, building information modeling (BIM) technology allows buildings to be managed more efficiently throughout their lifecycle. In addition, 3D printers and modular construction techniques can reduce material waste and increase construction speed.

Benefits of innovative technologies:

- Accuracy and efficiency in project design and management are improved.
- Material waste is reduced, minimizing environmental impact.
- Construction processes are accelerated and costs are reduced.

5.1.4. Policies And Regulations

Government policies and regulations that promote sustainable building practices play a critical role in improving the sustainability of the sector. For example, mandatory energy efficiency standards and renewable energy use can lead to significant changes in the sector. In Türkiye, there is a need for the implementation of sustainable building policies and increased monitoring.

Policy and regulatory recommendations:

- Tax incentives and subsidies to encourage the use of renewable energy.
- Mandatory energy efficiency standards.
- Regulations to promote the use of sustainable materials.
- Incentive policies for recycling and waste management.

5.1.5. Education and awareness

There is a need to increase the level of knowledge and awareness about sustainability among those working in the construction sector and the general public. Educational programs on sustainable construction techniques and materials should be organized and all stakeholders in the sector should be made aware of the issues.

Educational and awareness-raising activities:

- Courses and seminars on sustainable building techniques are held in universities.
- Certification programs for professionals working in the sector.
- Public awareness campaigns and media support.

6. CARBON FOOTPRINT OF THE CONSTRUCTION SECTOR

The carbon footprint is the total amount of greenhouse gas emissions caused by human activities. The construction sector contributes significantly to carbon emissions through its production processes, energy consumption, and use of materials. The main sources of the construction sector's carbon footprint are shown in Figure 7.

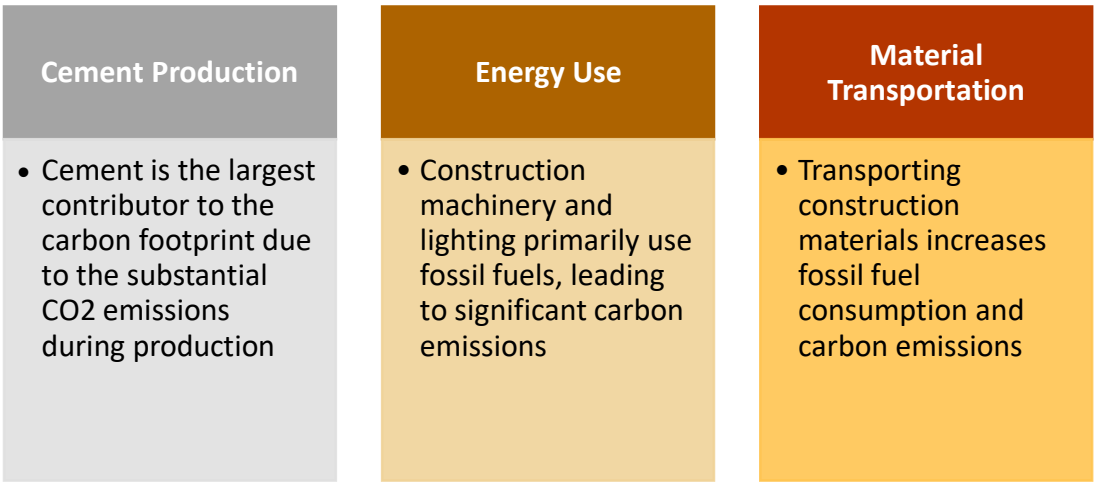

Figure 7. Main sources of carbon emissions in the construction sector

When analyzing carbon emissions in the construction process, they can be categorized into the construction phase, use and maintenance, and demolition and recycling. Carbon emissions during the construction process are shown in Figure 8.

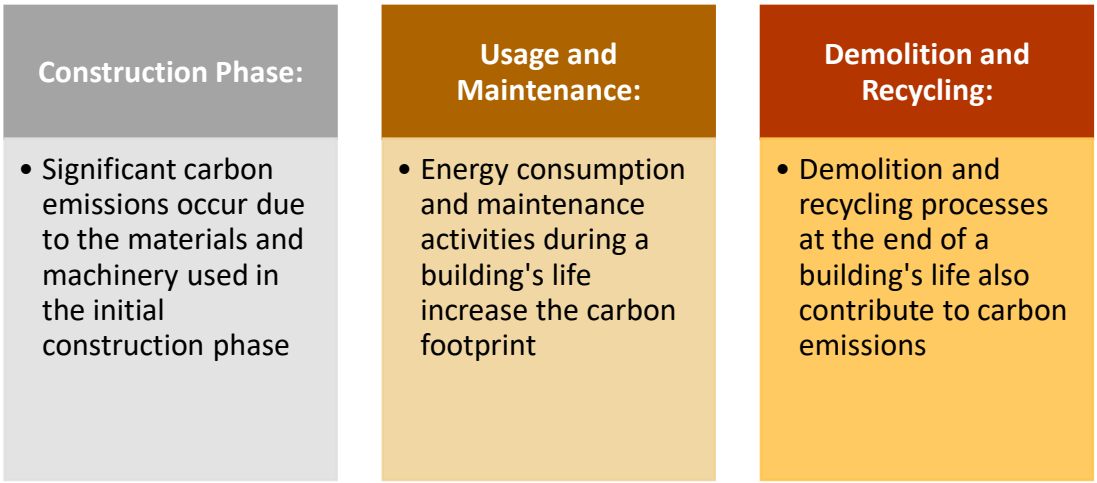

Figure 8. Carbon emissions during construction

In a research paper, Onat [33] examined the carbon footprint of the construction sector in Türkiye from 2000 to 2009. According to the analysis, around 60% of emissions in the Turkish construction sector occur in the supply chain. If the energy sector is included, then it rises to around 70%. There were no significant changes in the overall situation between 2000 and 2009, with carbon emissions generated within the sector (due to on-site construction activities) ranging between 25% and 20%. The Global Distribution of Carbon Emissions from the Turkish Construction Sector between 2000 and 2009 is shown in Figure 9.

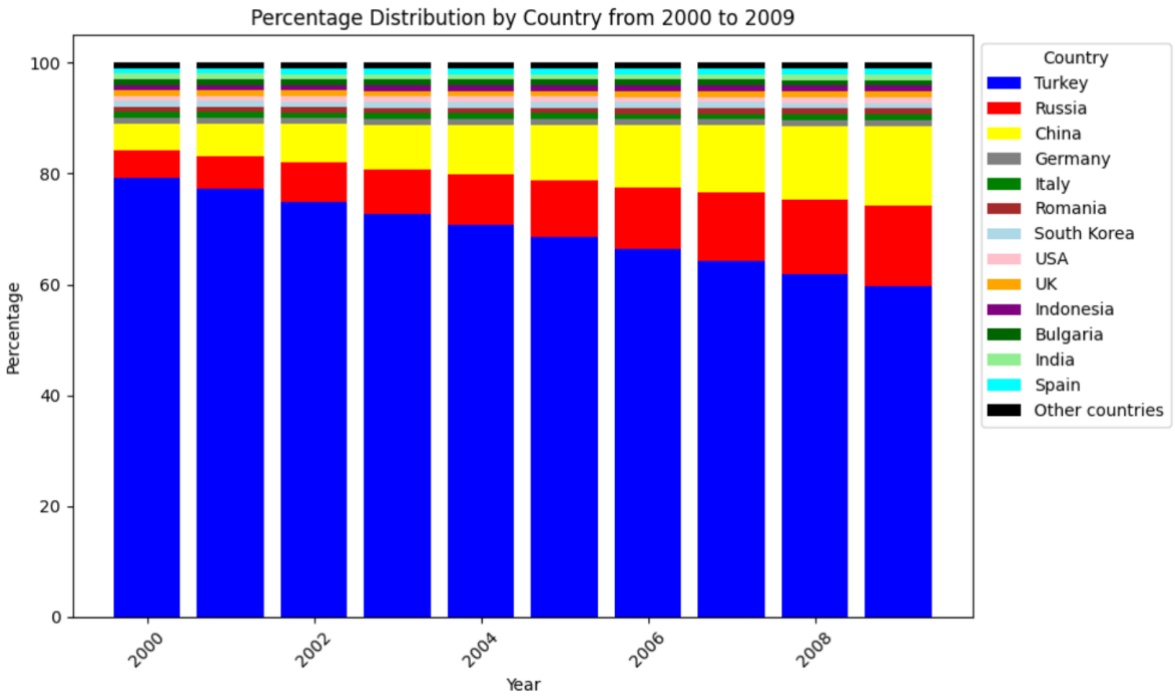

Figure 9. Global Distribution of Carbon Emissions from the Turkish Construction Sector between 2000 and 2009

7. CONCLUSION

This study evaluates the current state and future strategies of the Turkish construction sector in terms of sustainability. Recognizing the significant role that the construction industry plays in Turkey's economic growth and employment, it is imperative to address the substantial challenges it faces in terms of environmental impacts and energy consumption. To achieve sustainable development goals, the sector must adopt more conscious and strategic measures for energy efficiency, carbon emissions reduction, renewable energy utilization, and waste management.

The study identified the following key findings: Energy Efficiency and Carbon Emissions: The energy consumption and carbon emissions of buildings in Türkiye are of critical importance in achieving the sustainability targets that have been set. It is of utmost importance to promote the use of innovative technologies that enhance energy efficiency and reduce carbon footprints.

Renewable Energy Utilization: Integrating renewable energy sources into buildings is a pivotal strategy for reducing energy consumption and minimizing environmental impacts. Encouraging the extensive implementation of technologies such as solar panels, wind turbines, and geothermal energy systems can significantly decrease reliance on fossil fuels and reduce greenhouse gas emissions.

Sustainable Material Use and Waste Management: The construction industry should promote the use of recyclable and environmentally friendly materials and develop robust waste management strategies. This approach reduces the consumption of natural resources and mitigates the associated environmental impacts. Emphasizing the use of materials like recycled concrete, reclaimed wood, and eco-friendly composites can contribute to a circular economy.

Education and Awareness: Raising awareness and education about sustainability among construction sector employees and the public is crucial for achieving the sector's goals. Organizing educational programs and awareness campaigns will help inculcate sustainable practices across all levels of the industry and foster a culture of environmental responsibility.

Policies and Regulations: Implementing government policies and regulations that promote sustainable construction practices can lead to significant changes within the sector. Mandating energy efficiency standards and the use of sustainable materials reinforce sustainability efforts. Policies should also include incentives for green building certifications and penalties for non-compliance with environmental regulations.

Future Recommendations;

Integration of Innovative Technologies: Utilizing technologies such as building information modeling (BIM) will facilitate a more efficient management of buildings throughout their lifecycle. BIM can enhance the design, construction, and operation phases by better planning, resource management, and sustainability assessment.

Green Building Certifications: The widespread adoption of certifications such as LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method) will improve the energy efficiency and environmental performance of buildings. These certifications set standards for sustainable design and construction practices and drive the industry toward higher sustainability benchmarks.

Government Incentives: Increasing government incentives for renewable energy and energy efficiency will promote the spread of sustainable practices within the sector. Financial incentives, tax breaks, and subsidies for green technologies can accelerate the adoption of sustainable practices and reduce initial cost barriers associated with these technologies.

In conclusion, The Turkish construction sector must adopt a comprehensive and strategic approach to achieving sustainability goals. Enhancements in energy efficiency, carbon emission reduction, sustainable material use and waste management are essential for ensuring both environmental and economic sustainability within the sector. Collaboration among all stakeholders, including government bodies, private enterprises and the public, is crucial for significant progress toward sustainability objectives.

By integrating these strategies, the Turkish construction sector can significantly reduce its environmental footprint, contribute to national sustainability goals, and set a precedent for other industries to follow.

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