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# Carbon Neutrality in the Building Sector of the Global South—A Review of Barriers and Transformations

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**Abstract:** This work provides a review of economic, technical, sociocultural, political, and technological barriers that impede carbon neutrality in the building sector of countries in the Global South. These barriers include limitations in public and professional awareness, knowledge, and skills in the construction industry, the lack of ambitious energy codes and green building rating systems, the lack of green financing schemes and investment, costs of materials and technology, and limitations in regulations. Finally, this article recommends five transformations to address the critical barriers and enable net-zero emission status in the building sector of countries in the Global South. These transformations include environmental data collection, stringent building energy codes, and green building system certifications, lifecycle-based thinking and circular design, education enhancement and workforce development, and net-zero emission business practices.

**Keywords:** Global South; carbon neutrality; barriers; transformations; economic; sociocultural barriers; politic; technology

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## 1. Introduction

The environmental challenges that humanity faces in the 21st century demand urgent attention. Climate change, characterized by rising global temperatures, is a pressing challenge with negative effects on the environment, society, public health, and the global economy. Caused by excessive concentrations of anthropogenic carbon dioxide, methane, and nitrous oxide in the atmosphere [1], climate change leads to an increase in heat-related illnesses, melting ice, rising sea levels, disruptions in ecosystems and food production, increased frequency and intensity of natural disasters, damaged infrastructure and properties, increased healthcare costs, and water insecurity [2]. Although mitigation efforts have been made to address climate change in the Global South, it remains a significant issue, as emphasized by the IPCC [2,3]. There is, therefore, an urgent need to significantly reduce greenhouse gas emissions (GHG) globally and control the rising global warming to below 1.5–2 °C above preindustrial levels, as committed to by the countries signing the Paris Agreement [4]. While climate change affects people in both the Global North and Global South, carbon emissions, and climate change are projected to have more severe impacts in the Global South in the future. The populations in low- and middle-income countries of the Global South, who are least responsible for climate change, are particularly vulnerable to these effects due to the lack of access to climate information, unprepared infrastructure, lack of financial resources, and other limitations [5]. It is also estimated that up to 90% of the additional 2.5 billion people projected to live in urban areas by 2050 will be concentrated in cities in Asia and Africa and will be exposed to increased climate-induced risks [2].

While there are varying definitions for 'Global North' and 'Global South', Fuhr [6] outlined five approaches to determine Global South countries in the context of carbon emissions, including non-OECD member countries, countries with a 'very high' Human

Development Index, low-income countries defined by the World Bank, countries not included in the 1990 Kyoto Protocol's Annex, and countries belonging to the Group of 77. In this work, we use 'Global South' interchangeably with 'developing countries' as those countries that are less economically and politically developed, mostly located in the southern hemisphere [6]. In many cases, these countries are projected to make up a significant segment of the world's urban population and, therefore, their contributions to carbon neutrality are essential. Examples include India, Indonesia, and Bangladesh with populations of over 1.4 billion, 275 million, and 171 million people, respectively [7]. Large segments of the population in the Global South lack access to reliable and affordable energy and safe water [8]. It is reported that about 2.2 billion people globally lack safely managed drinking water [9], and more than 770 million people lack access to electricity, most of whom live in Africa and Asia [10]. The population growth, along with the growth of economy, industrialization, urbanization, and improvement of the quality of life in these countries, has significant implications for GHG emissions and the consumption of natural resources, fossil fuels, and water [11,12]. These countries are also essential components of the global supply chain through their production of goods and products; therefore, they have significant potential to affect carbon neutrality worldwide.

The main objective of this research is to shed light on the barriers to carbon neutrality in the building sector of the Global South and propose transformation measures to address them. The extant literature on this subject is limited as previous studies either have a global scope [13] or tend to focus on specific countries within the Global South, such as Iran [14], Turkey [15], and Kazakhstan [16]. In this article, we provide a comprehensive survey of the construction carbon neutrality barriers common to Global South countries, categorizing them into economic, technical, sociocultural, political, and technological barriers.

## 2. Methods

This review was completed through a survey of relevant data and literature on carbon-neutral and sustainable built environments in the Global South. We used Google Scholar and Web of Science as two main comprehensive sources of scholarly work to identify relevant studies. The studies identified by these two sources also often appear in other databases. Additionally, these databases present robust citation data to ensure the quality of reviewed articles. We limited this review to publications since 2000 using combinations of multiple keywords, including 'sustainable construction', 'high-performance buildings', 'carbon neutrality', 'Global South', and 'barriers'. We used the year 2000 as the starting point of time for this review because sustainable development in construction gained particular international attention in 1999 following the publication of Agenda 21 on Sustainable Construction by the International Council for Research and Innovation in Building and Construction (CIB), which addressed the need for an internationally agreed agenda on Sustainable Construction [17].

While terms such as 'sustainable buildings', 'high-performance buildings', and 'carbon-neutral buildings' vary in scope and depth, the barriers to developing these types of buildings are often common in the Global South, and we, therefore, used these terms interchangeably in the review methodology. We used multiple combinations of keywords shown in Figure 1 to identify the relevant literature. The first phase of screening for inclusion yielded 78 articles that were then filtered based on their relevance to the scope of review. We only considered research studies that focused on investigating barriers in the construction sector and excluded those in areas such as tourism, power sector, or agriculture. To include research in the shortlist, we placed particular emphasis on the presence of the keywords 'Global South', or 'developing countries', or the names of such countries. The final list included a list of 34 papers that focused on barriers to sustainable development in the Global South. These articles are listed in Section 5. We also relied on data from the International Energy Agency to present the energy use and carbon emissions of the Global South. Finally, we used the results to inform a list of conclusions and suggested transformations to enhance the sustainable construction sector in the Global South.

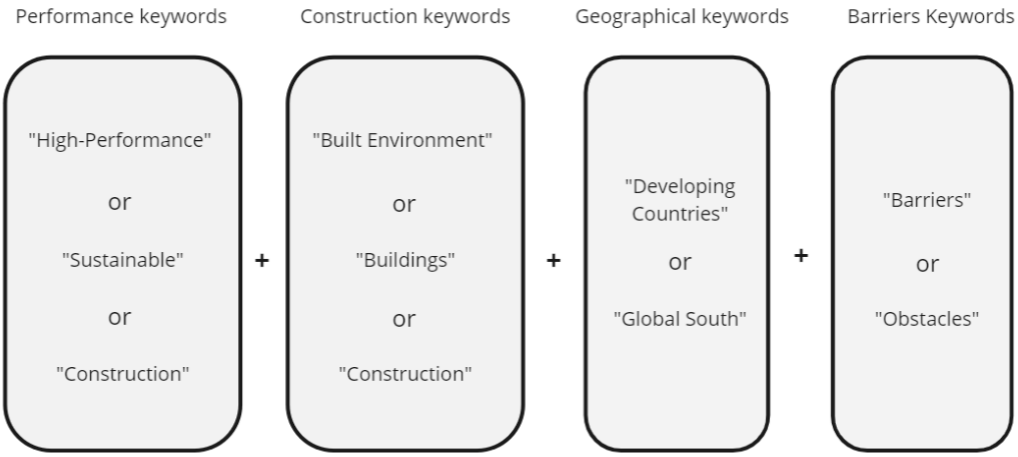



**Figure 1.** Combinations of keywords from each category used for searching.

## 3. Construction Sector in the Global South, an Overview

The global construction industry in both developing and developed countries is expected to grow and reach a Compound Annual Growth Rate (CAGR) of 9.2%, yielding USD 11,093.7 billion by 2024 [18]. With the rapid urbanization and improvement in living standards in the Global South, the need for the construction of new buildings and infrastructure is expected to grow in order to accommodate the necessary infrastructure for the expanding urban population. For example, it is estimated that India and China will need 100 million new homes in the next ten years to meet their demographic changes [19].

The construction industry is a material, resource, and carbon-intensive industry, and the projected construction demand in the Global South translates into significant quantities of material and resource consumption and GHG emissions. The rate of construction material consumption varies across the globe, with 330 tonnes of construction materials per capita consumed in the Global North and 60 tonnes per capita in the Global South [19].

The construction industry is also energy- and water-intensive. Buildings globally consume 30% of final energy use, with an additional 4% used for the production of cement, steel, and aluminum [20]. They also account for 15% of freshwater use, with the total water footprint of the construction industry in different countries ranging from 11.8 to 14.8 L/USD [21]. Additionally, the building sector is responsible for about 40% of global GHG emissions [22], caused by the construction of buildings and the consumption of electricity and energy to operate them. Due to environmental and ecological challenges associated with the construction industry, it is vital to adopt green construction paradigms that reduce the harmful impacts of buildings on the environment [13,14].

The top ten emitting countries responsible for two-thirds of global GHG emissions are China, the United States, India, the European Union collectively, Russia, Japan, Brazil, Indonesia, Iran, and Canada [23]. They, therefore, carry a substantial responsibility in the efforts to mitigate GHG emissions. Nevertheless, other countries in the Global South also possess a distinct opportunity to reduce their carbon footprint while improving the quality of life for their citizens. Table 1 and Figures 2 and 3 report and visualize the total emissions and building sector emissions of a selected number of top emitting countries in the Global North and Global South. Iran has the highest building sector emissions per capita (1.7 tons per person) in the Global South [24], which is comparable to developed countries such as Germany. Global South countries such as Saudi Arabia (26.2 MT), Brazil (12.9 MT), and Iran (12.3 MT) also demonstrate the highest total emissions per capita, which is the highest in the world, if the United States (18.4 MT) is excluded [24].

**Table 1.** Building sector emissions and total emissions for a selected number of countries in the Global South and Global North. The building sector emissions here report only the operational emissions because of energy use. Source of data: https://worldemissions.io/ [24], accessed on 15 May 2023.

| | Building Sector Emissions (mt) | Building Sector Emissions per Person (tons) | Total Emissions (mt) | Total Emissions per Person (tons) |
|---|---|---|---|---|
| Iran | 151.6 | 1.7 | 1100 | 12.3 |
| Turkey | 73.6 | 0.9 | 637.7 | 7.6 |
| India | 166.9 | 0.1 | 4000 | 2.8 |
| Indonesia | 39.7 | 0.1 | 2100 | 7.7 |
| Saudi Arabia | 6.8 | 0.2 | 953.1 | 26.2 |
| Brazil | 21.4 | 0.1 | 2800 | 12.9 |
| Kenya | 5.8 | 0.1 | 121.5 | 2.3 |
| Egypt | 22 | 0.2 | 452.7 | 4.2 |
| South Africa | 32.3 | 0.5 | 522 | 8.6 |
| China | 648.8 | 0.5 | 14,800 | 10.4 |
| United States | 512 | 1.5 | 6200 | 18.4 |
| United Kingdom | 79.1 | 1.2 | 549.2 | 8.1 |
| France | 65.7 | 1.0 | 408.9 | 6.1 |
| Germany | 138 | 1.7 | 737 | 9.1 |
| Japan | 108 | 0.9 | 1400 | 11.4 |
| Italy | 64.6 | 1.1 | 364.2 | 6.2 |
| Russia | 177.4 | 1.3 | 1900 | 13.5 |
| Canada | 76.8 | 2.0 | 896.6 | 23.5 |

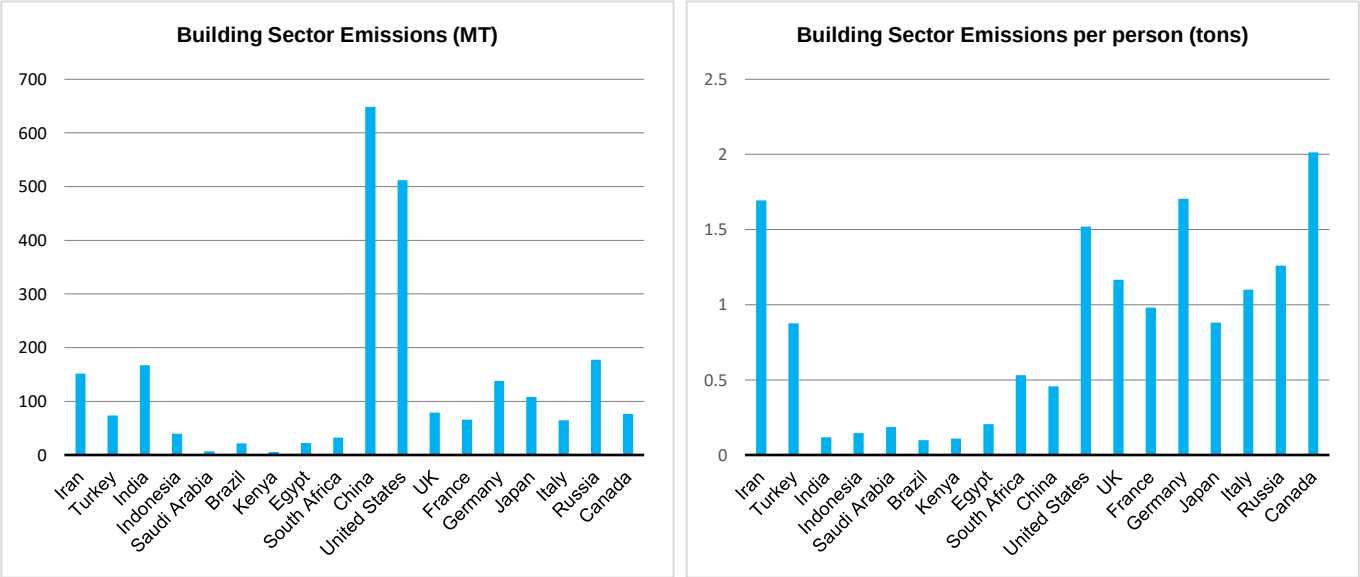



**Figure 2.** Building sector emissions in the Global South and Global North. Source of data: https://worldemissions.io/ [24], accessed on 15 May 2023.

To mitigate the diverse and significant environmental impacts of the construction sector, it is important for both developed and developing countries to adopt sustainable construction practices more aggressively and implement policies and regulations to incentivize and enforce them.

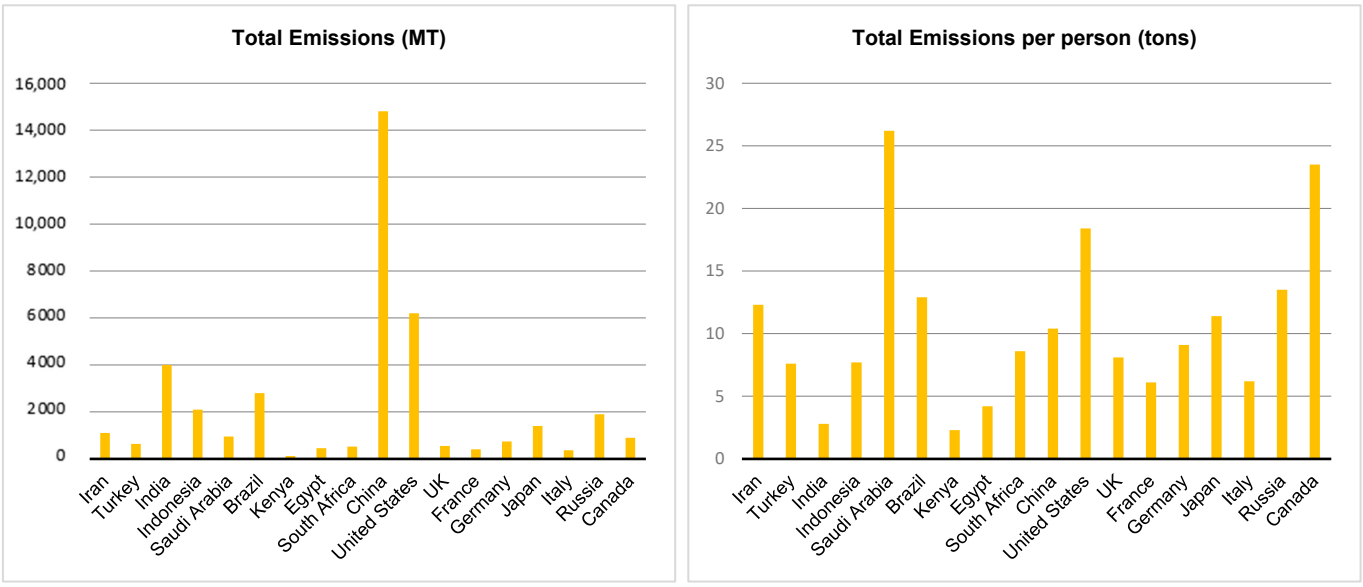



**Figure 3.** Total emissions in the Global South and Global North. Source of data: https://worldemissions.io/ [24], accessed on 15 May 2023.

## 4. Building Codes and Green Building Rating Systems for the Carbon-Neutral Building Sector in the Global South

In contrast to the building sector in the developed world, which has undergone major transformations to limit its energy use and carbon footprint, significant barriers exist in the development of environmentally friendly buildings in the Global South. In developed countries such as the United States, the United Kingdom, and Germany, there are well-established stringent building codes that regulate energy consumption in buildings by defining thresholds and mandating airtightness and thermal resistance requirements for different building skin components. These requirements vary based on building types and sizes, and climatic zones. Developed countries also take advantage of the voluntary green building rating systems such as Living Building Challenge, LEED, BREEAM, or DGNB that provide comprehensive multicriteria frameworks to ensure the design and development of energy-efficient healthy buildings.

In many developing countries, awareness of the significance of sustainable building practices is limited, and there is a lack of understanding of the benefits of high-performance, sustainable buildings [16,25]. Furthermore, green building practices in these countries often face financial constraints and a lack of incentives [26,27]. Additionally, the building codes and regulations in these countries may not be as stringent as those in developed countries [28]; therefore, creating regulatory constraints. Educational challenges also affect the availability of skilled professionals, and technical constraints limit equipment and material options.

Despite these challenges, Global South countries are experiencing a rising trend towards high-performance carbon-neutral buildings. Governments and international organizations increasingly offer assistance and funding to develop these buildings. Additionally, more sophisticated codes and green building rating systems are being developed and used in developing countries. Examples include GRIHA in India, the Three-Star system in China, ÇEDBIK in Turkey, and the Green Building Index in Malaysia.

Due to their mandatory nature, building energy codes are an effective and efficient means to improve energy efficiency and reduce the carbon footprint of buildings. According to the International Energy Agency [22], 80 countries currently have mandatory or voluntary building energy codes in place to regulate building energy efficiency through performance- or prescriptive-based compliance paths. While Global South countries, such as India, Turkey, Iran, Malaysia, and Pakistan, have adopted such energy codes, limited information exists as to the status of the energy codes in Sub-Saharan Africa, and South and

Central America [22]. Therefore, despite progress, these regions still lag behind developed countries in terms of building energy regulation development, implementation, and compliance [29]. For example, Iran has adopted a governmental building energy code titled "Code 19", approved by its Ministry of Housing and Urbanism in 1991. The code follows a prescriptive compliance approach and includes mandatory requirements for building skin insulation and airtightness [30].

## 5. Barriers to Carbon-Neutral Building Sector in the Global South

A survey of literature demonstrates that there is a wide range of barriers hindering the implementation of carbon-neutral buildings in the Global South. These barriers can be classified into economic, political, sociocultural, and technical barriers, and are listed in Table 2.

### *5.1. Economic Barriers*

Economic barriers to achieving carbon neutrality in the Global South include inadequate investment, incentives, and resource allocation in the sustainable construction sector, the high cost of implementing such practices, and financial risks and uncertainties. Additionally, the development of carbon-neutral buildings may not lead to immediate returns on investment, leading developers to prioritize short-term gains over considering the lifecycle costs of sustainable options [31]. Carbon neutrality, therefore, must be incentivized to create financially justifiable plans in both the short- and long-run. Relatively low energy prices in some Global South countries can additionally hinder the development of more energy-efficient buildings by reducing the owners' motivation to invest in this sector. Figure 4 shows that Iran has the lowest electricity price of 0.001 USD per kWh of electricity, while Italy has the highest global electricity price of 0.781 USD/kWh [32]. Higher electricity costs to heat and cool buildings, along with mandatory and voluntary building codes and standards can motivate building owners to invest in building skin insulation and airtightness to reduce the costs of building operation.

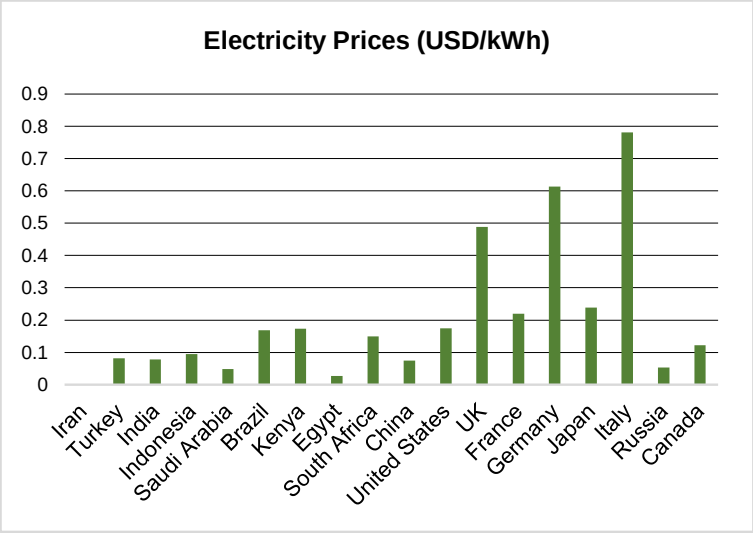



**Figure 4.** Electricity prices in different countries. The price of electricity in Iran is not visible on the diagram due to a low value of 0.001 USD/kWh. Source of data: https://www.globalpetrolprices.com/electricity_prices/ [32], accessed on 15 May 2023.

### *5.2. Political Barriers*

Some countries in the Global South face political and policy-related barriers such as corruption, political instability, nepotism, favoritism, lack of information and decision-making power, or lack of political will in the development and implementation of carbon-neutral policies, regulations, and initiatives [33]. Ineffective existing regulations for carbon-neutral

buildings, lack of political will and motivation to create new regulations that address carbon neutrality, or conflicting regulations can hinder the ability of governments and the public to effectively address national and regional environmental challenges. Additionally, a lack of public participation in political processes or conflicting interests among political actors can also limit progress toward the development of effective regulation [14]. Even where effective regulations exist, there remain challenges to fully and effectively implementing and enforcing regulations [16,27,28] due to factors such as lack of knowledge and skills, limited training of professionals, and corruption.

### *5.3. Sociocultural Barriers*

Tied with economic and political barriers are sociocultural barriers, such as beliefs, norms, attitudes, values, and lack of education and awareness that create resistance to change and affect the willingness of individuals and organizations to adopt carbon-neutral practices. Lack of awareness is a particularly important barrier for various stakeholders involved in the construction process, leading to a lack of understanding about the potential benefits of proactive measures and the higher economic risks associated with an unsustainable approach [14,33,34]. One example is user behavior, which is an important determinant of the energy consumption of buildings; hence, enhanced public awareness of behavioral changes could lead to lower building energy use.

### *5.4. Technical and Technological Barriers*

The countries in the Global South must also address technical and technological barriers, such as limited access to green technologies and materials and skilled contractors and professionals needed for such practices. Due to a combination of economic, political, sociocultural, and technical barriers, demand for environmentally superior technologies and green products, such as products with high recyclable content, is relatively limited in the Global South [15,27,34,35]. This low demand might be caused by high costs [26,35], ineffective governmental programs and policies [35], and limited knowledge about new products, materials, and technologies [36]. For example, the use of novel building materials (such as lightweight EPS concrete [37–39] and new alternative cement [40,41]) and adoption of construction technologies such as additive manufacturing and digital fabrication could be associated with higher initial costs. Therefore, even where information about the benefits of these products and practices exists, their application might still be limited due to cost and other concerns. On the other hand, even where technology and materials are available at reasonable prices, the implementation might be still limited due to the lack of information and motivation.

### *5.5. Awareness and Educational Barriers*

Education and raising awareness are important tools in shaping the attitudes of the public, professional, and governmental players toward sustainability. It is, therefore, essential to bridge the gap between research and practice in the Global South and translate academic knowledge into accessible information for public and professional use. Literature suggests that knowledge, skill, and ability barriers appear frequently in sustainable development discussions [14]. Alack of education and skills across construction industry sectors could lead to architects, engineers, and developers with limited skills for creating carbon-neutral solutions. For example, architects and engineers must be able to understand the life cycle environmental impacts of their design proposals and identify solutions with the least impacts. This, in turn, requires architecture and engineering schools in the Global South to adjust their curriculum to meet industry needs. Governmental bodies and accreditation agencies can play an important role in promoting educational and training programs for various stakeholders in carbon-neutral building.

Table 2 lists some of the main barriers to creating sustainable and carbon-neutral solutions, as reported by the literature.

**Table 2.** Economic, technical, and educational barriers to a sustainable carbon-neutral buildings sector in the Global South.

| Barrier Category | Barriers | Reference |
| --- | --- | --- |
| Economic | Lack of financing incentives and schemes | [15,16,25,27,28,33,42–45] |
| | Inadequate tax policies or high tax costs | [31,35] |
| | Low economic gains in the short run or lack of proven return on investment | [14,31,46] |
| | Risks and uncertainties in green investment | [15,33–35,47] |
| | High cost of green materials, technologies, and practices | [14–17,25,33–35,44,45,48–51] |
| | An unstable economy and a high inflation rate | [14,17,44,51] |
| | Inadequate market supply/delivery of green products, materials, and services for comparison and selection | [14,25,34,35] |
| | Sustainability criteria not considered in the bid evaluation | [25] |
| Technical, technological, and educational | Inadequate sustainable practices | [14,34,42,46] |
| | Lack of professional knowledge, expertise, and skills in sustainable projects, and technologies | [14–16,25,28,33–35,42,43,45,47,49,52,53] |
| | Inadequate use of environmental management systems, certifications, and measurement tools | [15,31,34,36] |
| | Inadequate use of updated equipment and technologies | [25,31,42,49] |
| | Lack of research | [14] |
| | Lack of technology, data, and transmission of technologies | [14,17,28,42,44,50] |
| Political | Lack of governmental incentives, promotion, and support | [16,17,20,28–31,38,40,41,44] |
| | Governmental bureaucracy | [14,43] |
| | Lack of codes, regulations, and policies | [14,16,25,28,33–35,42,44,48,49,54] |
| | Lack of enforcement | [14,16,25,28,34,36] |
| | Political instability | [33] |
| | Corruption, nepotism, & favoritism | [14,33,45] |
| | Non-alignment of regulations and byelaws within the green framework | [36] |
| Sociocultural | Lack of consumer/client engagement knowledge, and awareness | [16,25,31,33,36,46,48] |
| | Lack of collaboration among construction stakeholders | [31,33,34,43] |
| | Lack of attention to the specific needs and preferences of the community | [55] |
| | Lack of public, consumer, and stakeholder awareness, acceptance, and interest | [14,16,33–36,49] |
| | Inconsistency between the goals and activities of different sectors | [15,36] |
| | Unwillingness or fear to change from conventional practices | [15,25,34,35] |
| | Lower priority for environmental or social equity issues | [14,27] |
| | Poor market demand for sustainable options and green, recyclable construction materials | [14,15,33,34] |
| | Preferences for modernization rather than energy efficiency projects | [49] |
| | Unfamiliarity with green business practices | [45,49] |

## 6. Conclusions and Suggested Transformations to Achieve Carbon-Neutral Building Sectors in the Global South

The barriers to achieve building carbon neutrality in the Global South are complex, interconnected, and sensitive to various economic, political, social, cultural, and geographical drivers. Therefore, comprehensive approaches are needed to address these barriers and resolve some of the critical urban challenges of the Global South. These challenges include population growth, slum development, congestion, poverty, social injustice, excessive material use and solid waste generation, water scarcity and treatment, GHG emissions, pollution, and other environmental challenges. Frameworks must be developed through participatory mechanisms involving various stakeholders (e.g., governments, investors, academia, educational and accreditation bodies, professional entities, developers, owners, and users) to address these barriers across political, sociocultural, and economic categories. Specifically, the following transformations are proposed to create a carbon-neutral building sector in the Global South.

### *6.1. Environmental Data Collection*

Despite progress towards more sustainable buildings in the Global South, there is limited nationally representative data and insight on the size and significance of the diverse environmental impacts of the building sector in the Global South countries. These countries must take more aggressive steps towards the development of national benchmarking databases that establish norms and goals for building energy use, embodied carbon, and other life cycle environmental impacts of buildings. Insights from these data increase the awareness of governments, policymakers, the public, and professional communities, and can be used to inform environmental regulations in the building sector.

### *6.2. Stringent Building Energy Codes and Green Building System Certifications*

Countries in both the Global South and Global North need to work together to develop and adopt more stringent building energy codes that help achieve net-zero emission status. Because implementation and enforcement of such codes remain a challenge in some countries, governments and regulatory bodies need to identify and resolve critical barriers. Additionally, aside from a limited number of countries such as India, Malaysia, and Turkey, multi-criteria green building certification systems are currently missing in the building sector of many Global South countries. Development and adoption of such systems not only enable more sustainable buildings, but can also create economic opportunities in these countries.

### *6.3. Life Cycle-Based Thinking and Circular Design*

The dominant paradigms in building performance assessment in both developing and developed worlds rightly focus on building energy use due to significant quantities of carbon emissions associated with it. Achieving net-zero emission status, however, requires lifecycle-based whole-system thinking that considers the entire life cycle of a building from material extraction to production, use, demolition, and beyond life. Therefore, it is important that the countries in the Global South join the trends in the developed world to assess and mitigate embodied carbon, i.e., construction-related carbon emissions. Additionally, it is vital to adopt the principles of circular economy in order to conserve materials and resources, reduce waste, minimize GHG emissions, and create resilient built environments.

### *6.4. Education Enhancement and Workforce Development*

Addressing the unique urban challenges of countries in the Global South requires trained professionals. Transformations in the education, government, and professional sectors in the Global South are needed to enable the enhanced education and training of high school and university students and professionals. Universities, in particular, are

important players in the development of a workforce with the necessary knowledge to acknowledge the severity of the challenges and skills to assess and address them.

### *6.5. Net-Zero Emission Business Practices*

Achieving net zero and carbon neutrality is not possible without business and economic practices that support them. For example, transformations are needed to encourage and/or require firms, manufacturers, owners, and other entities in Global South countries to assess and report their Scope 1 (i.e., direct GHG emissions from owned and controlled sources), Scope 2 (i.e., indirect emissions caused by the purchased energy), and Scope 3 emissions (i.e., indirect emissions from sources not owned or controlled). Additionally, incentives and business models can be developed and implemented by these countries to promote manufacturers that produce locally produced low-embodied carbon materials and report their environmental impacts through the Environmental Product Declaration (EPD) reports.

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