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Exploring Energy - Efficient Architecture: Comparative Insights from Pakistan, India, and Bangladesh

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Abstract- Architecture represents one sector where energy-efficient design techniques are becoming of paramount importance; it touches upon the critical issues, renewable energy sources, water conservation, occupant comfort, and natural illumination. This paper compares the development and application of energy-efficient design strategies between India, Bangladesh, and Pakistan over the last two decades. The work sections also analyze respective policy frameworks to find best practices and areas for knowledge sharing between countries across the South Asian region.

Although tremendous strides have been made in sustainable architecture and the mitigation of environmental impact, there remains a notable absence of comparative studies that would fill in the gaps in this current literature. This research critically examines these issues about the role of green building certification standards in India, particularly GRIHA, the Pakistan Green Building Council (PGBC), LEED in Bangladesh, and Pakistan. The study reveals significant progress in green building developments, such as installing solar panels, rainwater harvesting systems, and water-efficient fixtures. It strongly needs continuous efforts with the help of tighter regulations and increased collaboration toward sustainable development to be made in this direction. Promotion of regional cooperation and examination of environmental issues that will enhance knowledge toward sustainable architecture and a resilient firm in South Asia are the emphases of this study.

Thus, this study seeks to inform and guide architects, policymakers, and construction industry stakeholders toward much-needed sustainable improvements in South Asia.

Keywords- Energy-efficient design, Green building certification, Renewable energy, Sustainable development.

I. INTRODUCTION

The demand for energy across the globe has been growing at an exponential pace of 2.2% per annum, on average, since 1965. The world's total energy need is projected to grow by another thirty percent by 2040 (Energy Information, 2017; IEA, 2015). South Asia is a place for modern emerging and developing countries. The region comprises Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, India, Pakistan, and Sri Lanka. This demographic shift has led to significant increases in energy consumption due to improved economic conditions and rising per capita income. In 2017, SAARC, formed by these eight countries, accounted for 4% of the world GDP, equivalent to about $79.86 trillion, and registered a total GDP of about $3.31 trillion (Abbas, 2018; Roy, 2017). This paper focuses on the three major economies of South Asia: India, Bangladesh, and Pakistan. The reasons for selecting these countries are as follows (The World Bank, 2020; IEA, 2018):

- They together represent over 94% of the region's whole population and, consequently, energy consumption
- The term "Indian subcontinent" is interchangeable with "South Asia" in referring to these three countries.
- They are at the crossroads of world trade because of their large populations and their enormous economic growth forecasts.

Energy efficiency improvement is recognized as one of the most critical measures for climate change mitigation regimes worldwide. Highly developed countries have developed comprehensive energy management and auditing practices to improve energy efficiency; however, the developing countries are far behind in this race" (Hasan, 2019). On the same matter, in-depth, comprehensive comparative studies are lacking to

analyze energy-efficient practices in South Asian countries that might help contribute toward their sustainable architectural practice. This paper studies the development and implementation of energy-efficient design strategies in India, Bangladesh, and Pakistan from the date of compliance and enforcement of energy conservation rules. Policies and regulations are important in determining the deployment of these practices, setting parameters for sustainable implementation, and framing the use of energy-efficient technologies (Chel & Kaushik, 2018; Wilkinson, 2009; Zuniga-Teran, 2019; Mukherjee, 2022). Important initiatives such as India's National Action Plan on Climate Change (NAPCC), the adoption of green buildings in Pakistan, and Bangladesh's Green Building Guidelines are necessary to facilitate sustainability (Nainwal & Sharma, 2023; Shafique, 2022; Asia, 2022).

South Asia, with countries inclusive of Pakistan, India, and Bangladesh, is facing grave environmental challenges from fast urbanization, an increase in population, and altered weather patterns. Sustainable architecture is a method of building that attempts to find ways to limit waste and negative influence on the environment by a building, maximizing all uses of available resources, leading to improvements in the quality of life for the occupants. It retains its long-term sustainability through not only the considerations of energy and water consumption but also material selection and waste management. Thus, sustainable design encourages practices that execute strategies designed to reduce the damage a building can cause to the environment through resource use that is efficient and sparing a building's resources, which include materials, energy, and floor area. According to this study, the systems-thinking integration of ecosystem and energy puts multiple management practices into the architecture of artificial spaces (Emmanuel, 2020).

The already existing National Energy Efficiency and Conservation Authority was mandated in the Pakistan Energy Efficiency and Conservation Act, 2016 to lay down policies, regulations, standards, and guidelines for energy efficiency that include the Energy Conservation Building Codes and the legal provision of financial incentives, i.e., tax rebates and grants (Government of Pakistan, 2016). NEECA also engages in public awareness programs and capacity-building, supported by findings of studies on the potential of energy conservation in commercial buildings, sponsored by the Pakistan Green Building Council (PGBC) (Rafique & Rehman, 2017). In this regard, the development of the Energy Conservation Building Code in India by the Bureau of Energy Efficiency prescribing minimum energy performance standards for all buildings, accompanied by certification in the form of IGBC and GRIHA, incentives in the form of tax benefits, and low-interest loans, and initiatives such as the Smart Cities Mission (Shrestha, 2021).

The Ministry of Power, Energy, and Mineral Resources (MPEMR) in Bangladesh is the essential governmental body entrusted to work for all registers of planning, development, and implementation in the country's energy sector. SREDA was formed as a nodal agency with the mandate of promoting, facilitating, and disseminating renewable sources of energy and energy efficiency to ensure the country's energy security. Further, it highlights those programs on enhancing energy efficiency, green building guidelines with the help of LEED, financial incentives, and capacity-building programs are underway, with adversities such as low awareness and economic constraints (Shrestha, 2021; Hasan, 2022).

Energy-efficient and innovative technologies could play a significant role in mitigating negative environmental effects and improving the energy efficiency of buildings. Reducing energy consumption and carbon emissions, energy-efficient technologies play an essential role in sustainable architecture. These technologies include passive design strategies, renewable energy systems, efficient building envelope materials, and intelligent building management systems, among others (Wilkinson, 2009; Potbhare, 2009). By incorporating energy-efficient technologies into design practices, architects can create environmentally favorable, economically viable, and occupant-friendly buildings.

II. Literature Review

As shown in figure 1, sustainable design is a design concept that considerably lowers the negative impact of building construction and operation on the environment, economy, and human health, consequently increasing the overall performance of the structure throughout its Life Cycle. To increase a building's service life, sustainable structures must be resistant to climate change and flexible, non-rigid, and durable (Grierson & Moultrie, 2011).

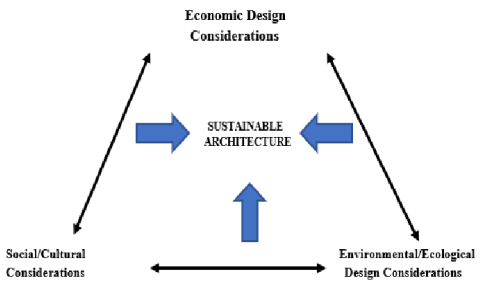

Fig 1. Sustainable Design Concept. Source: Emmanuel, 2020

Green building requires both architecture and environmental sustainability. "Green" architecture, according to Madhumita, is a purposeful effort to safeguard the air, water, and soil using eco-friendly building materials and construction practices. Green Architecture, often known as "sustainable architectural design" or "green building," is the concept, science, and construction of buildings that adhere to environmentally responsible principles (Ragheb 2015). Green architecture's fundamental goal is to reduce the amount of resources consumed during building construction, use, and operation, as well as to offset the damage caused by carbon emissions, pollution, and waste to the environment and sociocultural life. Energy efficiency, renewable energy, zero carbon emissions, and the implementation of the 3R rule are the primary goals of sustainable design. Emmanuel (2020) recommends reducing, recycling, and reusing.

In terms of energy availability, environmental degradation, and rapid urbanization, Pakistan confronts numerous obstacles (Sohail and Qureshi, 2010). Over the few decades, the failure of energy policies in Pakistan, buried the country into severe economic crisis (Usman, 2019). As per reports recorded till 2019, almost 55.2% of energy supply is based on cheap energy production methods using fossil fuel and 31.9% on hydro electrical resources which is major cause of energy shortage and insufficient production (Energy Consumption in Pakistan, n.d.). Pakistan is among those nations that rely primarily on thermal sources and generate the majority of their electricity from nonrenewable sources. This practice is causing severe environmental issues and the rapid depletion of scarce energy sources (Sohail and Qureshi, 2010).

Like other countries, the increase in energy supply demand in Pakistan depends on its rapid increase of population, extended use of electricity and economic growth. Also, there are other problems like mismanagement in supply, corruption, stealing of electricity and political agendas behind large scale energy projects. The increase in energy supply demand is recorded as 3% per year due to increase in population. Since Pakistan is struggling with an imbalance between demand and supply, reducing energy consumption is of utmost importance. Pakistan is experiencing its worst energy crisis in decades, as the country's energy production cannot satisfy its energy demand. Distribution and transmission losses are significantly greater than in other Asian nations due to the extremely unreliable and antiquated nature of the electricity distribution system (Malik, 2012). Rehman and Deyuan (2018) analyzed the current situation in Pakistan, performed calculations, and then made forecasts regarding the condition of energy demand and supply derived from a variety of sources through the year 2030. They concluded that to solve the severe energy crisis in Pakistan, government needs to develop new policies for energy consumption and supply not only to fulfil energy demands but also improve the economic condition of country. The findings of their research show how much energy being consumed in residential, commercial and industrial sector, which can also be reduced by developing and adopting energy efficiency techniques in architecture design to cut short the supply needs to some extent.

In Pakistan, the domestic sector's share in total energy consumption is a remarkable 46%, much higher than other countries. The government of Pakistan has targeted an energy-saving measure of 3 million toes from the efficiency and conservation practices by 2025. USPCAS-E at UET Peshawar is an example of the development of modern infrastructure. The need for policy propositions that target HVAC and lighting systems in such buildings is required to improve energy efficiency (Khalid & Sunikka-Blank, 2020). In residential buildings, significant energy savings can be achieved by putting into place effective practices to reduce the energy demand. These practices pertain to the adoption of solar power and green building techniques and might even reduce the demand for energy by as much as eight times (Ponsangari, 2019).

The other two major contributors to pollution and climate change are excessive energy demand and an overreliance on fossil fuels. On this note, Salam (2020) assert that sustainable design and energy-efficient technology may go a long way in resolving these challenges by helping in the reduction of the consumed amount of energy and improving the use of renewable energy while at the same time bettering the quality of the built environment. With a growing and urbanizing population, Pakistan would have to put sustainable architecture at the forefront; otherwise, it will be challenging to secure a sustainable and resilient future. Passive architectural measures and equipment upgrades are the most feasible and cost-effective measures for energy-efficient retrofits in India (Dandia, 2021). In such a scenario, integrating green building practices and eco-friendly design associated with solar passive techniques and renewable energy technologies increases the energy efficiency profile of a building (Mishra, 2013). This may encourage energy efficiency by promoting the inclusion of comprehensive energy management practices and energy audits and removing barriers to capital expenditure.

Energy-efficient design addresses global environmental issues and promotes sustainable architecture. Buildings use a large part of world energy and greenhouse gas emissions (Chan, 2017). Energy-efficient buildings reduce energy use, carbon footprint, and environmental impact. Energy-efficient design saves resources, fights

climate change, and protects ecosystems by maximizing building efficiency, using renewable energy, and using sustainable materials (Chan, 2004). Buildings that are energy efficient consume less energy for heating, cooling, lighting, and systems. Architects may conserve energy by improving insulation, daylighting, ventilation, and equipment efficiency (Feria & Amado, 2019). Energy-efficient buildings have lower operational expenses due to lower energy use. Energy-efficient HVAC, insulation, and lighting save building owners and occupiers money in the long run. Energy-efficient buildings are also more valuable, enticing purchasers and tenants (Iqbal, 2021; Saqib, 2022).

The practice of energy management in Bangladesh could boost the energy efficiency of iron and steel mills by 6%–8%. However, uncertainty relating to future energy prices, a scarcity of cost-effective implementation of technical measures, and a lack of information are some essential significant causes (Hasan, 2019). Consequently, interventions in house design and household practices are to be undertaken to promote housing practices that are less energy-intensive for sustainable development. Good example of one such house is the Sethi Haveli in Peshawar, Pakistan, which is an excellent example of green architecture being practiced at an indigenous level by, for instance, the use of courtyards in ensuring thermal comfort and daylighting, especially significant in reduction of environmental impacts and dependence on fossil fuels (Khan, 2010).

Insulation, lighting optimization, and ventilation increase air quality, thermal comfort, and acoustics. Energy-efficient buildings improve human well-being, productivity, and happiness by creating healthier, more comfortable interior environments. Many countries have adopted these to promote sustainable construction (Chel & Kaushik, 2018). These standards and certifications are increasingly required for new building and remodeling projects. Energy-efficient architects can exceed regulatory standards, get project approvals, and get green building certifications, boosting their professional standing. Table 1 shows that the energy-efficient technology and environmentally friendly architectural design principles are crucial for a number of reasons.

Table 1: Reasons for Integrating Energy-efficient Technologies in Design Practices (Chan, 2017; Chan, 2004; Chel & Kaushik, 2018)

Reasons	Description
Environmental Impact	Buildings have a huge impact on the environment through the energy they consume and the emission of greenhouse gases, not to forget the depletion of resources. Energy-efficient technology and sustainable design principles help reduce it through minimized energy usage, using of renewable resources, and maximum resource utilization. This is essential for maintaining the ecosystem, saving resources, and slowing down climate change.
Energy Conservation	The main purpose of energy-efficient technology and design strategies is to minimize building energy consumption and therefore reduce dependency on fossil fuels whose associated environmental pollution and climate change factors, besides, will save important energy supplies.
Cost Savings	Greater energy use translates into more cost for building owners and tenants in terms of their operating expenses. Buildings are, therefore, able to lower long-term energy and operating costs by adopting energy-efficient technology—HVAC systems, lighting options, and insulation. The most important thing is that the savings these costs will generate result in improved competitiveness and stability for business and household budgets.
Health and Well-being	Incorporation of sustainable design principles puts priority on the health and well-being of building inhabitants. An energy-efficient design shall consider indoor air quality, natural daylighting, thermal comfort, and acoustics. These procedures encourage productivity, raise tenant happiness, and improve general well-being by creating a healthy and cozy interior environment.
Regulatory Compliance and Certification	With this, governments and regulatory bodies of the world do special focus on energetic efficiency and sustainable design while making building standards and regulations. Some of the established green

	building certifications, including LEED, are basically based on a commitment to sustainability.
Market Demand and Reputation	Lower operating expenses for the owner and less energy consumption for the occupants of the buildings. Buildings can lower long-term energy and operating costs by using energy-efficient technology in HVAC systems, lighting, and insulation. Lower expenditure directly affects the stability, competitiveness, and profit of businesses, as well as homeowners.
Resilience and Adaptability	This strengthens the energy-efficient technology and the features of an environmentally friendly design, which are more resilient and flexible with the changing climatic conditions. The principles of energy-efficient, well-insulated, and climate-responsive building design can help buildings withstand changes in the climate and be less susceptible to changes in energy prices without any loss in durability.

Energy-efficient design that may be able to allow architects to lead in sustainability: In addition, architects may emerge as leaders in sustainable design using innovation technologies, renewable energy systems, and energy-saving measures. The leadership of the architects in the built environment affects the worldwide efforts of sustainability. It's hardly imaginable that the architects, designers, and building professionals are aware of, let alone knowledgeable about it, in cases where the architects, designers, and building professionals are not even aware of or knowledgeable about the same. Professionals may not give high priority to energy efficiency in the design if they are not informed well about what options are open to them and the benefits of those solutions.

III. Research Methodology

The case studies of Pakistan, India, and Bangladesh have been selected because of essential developments in sustainable architecture and the availability of data. This ensures a strong field of comparative study that reflects the diversity intact within the different regional contexts of these countries (Chel & Kaushik, 2018; Wilkinson, 2009; Zuniga-Teran, 2019; Mukherjee, 2022; Shafique, 2022). The study used policy document analysis to gather data from each country.

The study helped in understanding the current state of knowledge and research gaps with respect to the enhancement of sustainable architecture to get complete insights toward energy-efficient technologies integrated with design practices. This formed a firm footing for the study and helped in the development of the topic for the research. Therefore, literature, academic publications, and case studies in print from past two decades on the topic of energy-efficient design in architecture have been reviewed thoroughly. This involved well known scientific databases, including Google Scholar, and journal sites that include Elsevier, Springer, Tylor, Francis, IEEE, MDPI, and Wiley. It set the ground for learning and locate the key roadblocks and successful approaches in the studies reviewed.

Design strategies, energy-efficient technologies, and policy frameworks therefore talked about the similarities and differences between the three countries. The findings of this research will provide information to improve a better understanding of the adoption of sustainable design techniques in these countries of South Asia and fruitful insights to help future sustainable architectural initiatives in the region. There has been a great deal of effort applied to promoting energy-efficient design in the construction industry. Effective strategies in this approach were, therefore, evaluated by their reach, adaptability, and replication. In this study, similarities and differences among India, Bangladesh, and Pakistan regarding sustainable architecture practices are identified and best practices and lessons learned of each country are presented after a comprehensive analysis.

IV. Energy-Efficient Design Practices in India, Bangladesh and Pakistan

To tackle the environmental issues, Pakistan, Bangladesh, and India must adopt sustainable architecture methods to foster the sustainable development. In the following section, the energy efficient design practices and their impact on sustainable design in these three countries has been discussed.

1) E.E Design Practice in India

Currently, India has emphasized on the awareness of sustainable architecture and design practices. The Indian government has implemented numerous policies, guidelines, and rating systems to promote sustainable architecture. Green Building Certification of the Indian Green Building Council (IGBC) and the Energy Conservation Building

Code (ECBC) have encouraged the construction industry to implement energy-efficient design practices (Griha, 2019; USGBC, 2021; IGBC, 2015) (Table 2).

India has made remarkable strides in green building construction. Numerous projects, including Suzlon One Earth, Infosys campuses, and Mahindra World City, feature sustainable design elements such as energy-efficient building envelope design, renewable energy integration, water conservation measures, and refuse management systems (Piparsania & Kalita, 2022). Suzlon One Earth is a LEED India Platinum and GRIHA Five Star certified initiative and campus. Other notable sustainability key performance indicators at Suzlon one earth include a 60% reduction in water consumption, 90% of day lit spaces, a 47% reduction in energy consumption, and the recycling and diversion of approximately 85% of waste from landfills (GBRI, n.d.). Increased awareness among architects, designers, and the general public regarding the benefits of sustainable architecture has contributed to its widespread adoption. Educational institutions and professional organizations have been instrumental in promoting sustainability-focused design education and capacity-building programs (Piparsania & Kalita, 2022).

According to the United States Green Building Council (USGBC), India was rated third in the world on its annual list of the Top 10 Countries and Regions for LEED in 2021 (India Ranks Third in Top 10 Countries and Regions for LEED Green Building in 2021, 2022).

2) E.E Design Practice in Bangladesh

Bangladesh is severely affected by the climatic conditions because of its geographical location in Ganges Delta. Many mitigation and low carbon development policies has become part of their national agenda but to incorporate them, architects need extensive capabilities and knowledge. Sustainable design practices in architecture have also become a part of curriculum but it will take time to spread awareness (Afroz, 2020).

Due to various factors, Bangladesh has also witnessed an increase in the adoption of sustainable architecture practices. Many new buildings in recent years have been developed, especially industrial buildings with LEED certification. Bangladesh has 230 LEED Certified buildings (Bangladesh: GBIG, n.d.) (Table 2). Bangladesh garments industry is ruling the top positions in LEED certified buildings. It holds the number nine spot in the world's top 10 LEED-certified factory units and the 52nd spot overall in the top 100. The United States Green Building Council (USGBC) presented a platinum category Leeds certificate to the Green Textile Limited (GTL) unit-4 factory in Mymensingh on February 21, 2023 (Fw, n.d.). This manufacturing facility was awarded a score of 104, making it the winner of the industrial category project with the highest score ever recorded anywhere in the globe (Dhaka Tribune, 2023).

The manufacturing facility known as Green Textile Limited (GTL) unit-4 is very good at conserving energy. In addition to that, the roof is outfitted with a 733-kilowatt solar panel system, which satisfies sixty percent of the factory's demand for electrical power. In addition to that, it has water faucets that consume less water and a rainwater collection system. Occupants benefit from a high level of comfort, air purity, thermal comfort, and natural light thanks to the architecture of this manufacturing facility. During the construction process, environmentally responsible building practices and eco-friendly materials are utilized. According to EPIC Group (2023), the score for the site's sustainability and water efficiency was 32 out of a possible 33 points for energy and emissions management.

3) E.E Design Practice in Pakistan

Rapid urbanization and growth are taking place in Pakistan, even though this pattern is not environmentally sustainable. The absence of a green building grading system is the primary factor contributing to this phenomenon (Adoption of Green Buildings in Pakistan to Achieve Pakistan's NDC, 2022).

In recent years, a limited number of green buildings that have been certified by LEED and the US Green Building Council have been built in Pakistan. These structures include the British Council Library in Lahore, the NCC Karachi, the Mega Corporate Office - Karachi, Karachi Citiplan, and the World Bank Country Office – Islamabad. In Pakistan, the Pakistan Green Building Council (PGBC) is now also working to promote the construction of environmentally friendly structures. It is a non-profit organization which is the only organization which represents Pakistan in World Green Building Council (Rana, n.d.) (Table 2). TAIGA APPAREL PVT LTD and Crescent Bahuman Limited are two highest LEED scorer with 89 points each and have platinum rating category. Both are industrial manufacturing units. TAIGA APPAREL PVT LTD has full points in energy and atmosphere, 6 out of 14 for material resource, 7 out of 15 for indoor environment quality, 21 out of 26 for sustainable site, full points in innovation & design and 13 in water efficiency (*Pakistan: GBIG*, n.d.). While Crescent Bahuman Limited has 32 out of 3 in energy and atmosphere, full points in materials and resources, nine out of 17 in indoor environment quality, full points in sustainable site and water efficiency (*Pakistan: BIG*, n.d.).

Table 2: Green building Rating systems and Green Buildings Count in India, Bangladesh and Pakistan (Piparsania & Kalita, 2022; Pakistan: GBIG, n.d.; Bangladesh: GBIG, n.d.; Green Buildings Gain Momentum in Bangladesh, n.d.)

Countries	Green building rating systems	LEED certified buildings
India	Three green building rating systems in India are LEED India, GRIHA and IGBC	India has 1,649 buildings LEED Certified buildings
Bangladesh	Only LEED building rating system. There is no designated green building rating system	Bangladesh has 230 LEED Certified buildings
Pakistan	In Pakistan, Green Building Council (PGBC) and LEED are green building rating systems.	57 projects are currently LEED certified, 24% are in platinum rating category, 58% in gold and 17% in silver category

Energy efficiency design practices in India, Bangladesh, and Pakistan is influenced by a few factors, including government initiatives, awareness, education, and local context. While each nation has made strides in promoting sustainable architecture, obstacles such as limited awareness, financial constraints, and policy gaps still exist. To overcome these challenges, develop stakeholder engagement, and expedite the adoption of energy-efficient technologies and sustainable design principles, continued efforts are required.

V. Comparative Analysis

Implementation of green buildings codes is very important to attain sustainable environments in near future. Many green building rating systems are under development, and many are being successfully incorporated world over. But target to implement these buildings codes is hard to meet. Various strategies are highlighted in Table 2 that includes local and international funding and government benefits for the building following green codes. Also, making it mandatory to follow green building codes also proved to be beneficial in India (Table 3). Considering the stakeholders behavior towards utilizing the maximum possible covered space for their buildings, Indian state government took initiative of allowing more floor to area ratio for green buildings. In Pakistan and Bangladesh, mostly strategies are funding based and promote energy efficiency and green building rating systems by providing loans on different scales.

Table 3: Implementation Strategies in India, Bangladesh, and Pakistan (Null, 2023; Hossain, 2018; Focus, 2017; Khan, 2023; Solar Panel | Financing | Renewable Energy | Meezan Bank, n.d.; SWITCH-Asia, 2022)

Countries	Strategies
India	To promote green structures, the government of India implemented Green Rating for Integrated Habitat Assessment (GRIHA), which restricts the use of resources by 30%. Government has mandated that all central government agencies receive at least a 3-star GRIHA rating. Multiple state administrations have committed to increasing the floor-to-area ratio (FAR) for GRIHA projects.
Bangladesh	In 2016, the Bank established a mandatory green finance credit quota of 5% of total bank and financial institution loan disbursements. Development Company Limited (IDCOL) provides renewable energy initiatives with lenient loans and grants. Its goal is to finance 6 million SHS by 2021, with an estimated 220 MW of electricity generation capacity. Mujib Climate Prosperity Plan up to 2030 to mobilize funding for the implementation of renewable energy and climate resilience initiatives, including future training and skill development. The Bangladesh Climate Change Trust Fund (BCCTF) aims to increase adaptation capacity; 66% of the funds are designated for many small-scale initiatives throughout the country. In the budget for fiscal year 2017-18, the corporate tax rate for garment manufacturers with internationally recognized green building certifications was reduced from 20% to 14%.
Pakistan	Green financing/ green banking for promoting green buildings in construction industries. State

	Bank of Pakistan and even private banks are offering green financing. Islamic banking systems like Meezan Bank also offers loans for use of solar energy promotion.

Based on the energy efficient design practices in India, Bangladesh, and Pakistan, some best practices and lessons learned regarding energy-efficient design are discussed in this section of study. In India, green building certification systems like LEED India and GRIHA have partly drawn the country towards adopting strategies in design that are energy efficient.

The structure should consider using alternative sources of renewable energy, such as solar panels, to lower the dependence on traditional sources. It should lay special focus on water-saving by installing efficient plumbing fixtures and rainwater harvesting systems. The LEED certification, followed with full zeal in Bangladesh, especially in the garment industry, has emerged as an attractive tool toward enabling practices that lead to energy-efficient and sustainable building systems. Rooftop solar facilities can easily meet the electricity needs of the facility and reduce dependence on the usual sources of power.

This may encourage people to adopt energy-efficient practices and green building grading systems by lending them loans and monetary incentives for the adoption of such strategies. Moreover, rainwater collection systems and low water fixtures for better water management could also be facilitated in the building. Growing more awareness and knowledge in the area, through education, there are more cases of energy-efficient design approaches relating to sustainable architecture in the construction industry. Utilizing sustainable design principles to prioritize occupant comfort, air quality, thermal comfort, and natural light is highly important. These factors should all be given precedence in the design process.

There are few green building certification systems in Pakistan, but organizations like the Pakistan Green Building Council (PGBC) are working to promote sustainable building practices. Implementation of LEED certification in selected projects, highlighting energy-efficient design and conservation of resources is also very important in Pakistan. Energy and atmosphere management, materials and resources, interior environment quality, sustainable site design, and water efficiency should all be prioritized in certified buildings. Additional awareness and acceptance of green construction principles are required to achieve sustainable development. The installation of mandated green building codes has effectively hastened the adoption of sustainable building methods. Providing incentives and benefits, such as an increase in the floor area ratio for green buildings, encourages stakeholders to implement green design elements.

Green building initiatives can be supported by the availability of local and international funding options. It is necessary to develop and implement building codes and regulations to assure compliance with sustainable building practices. Awareness and education programs can help disseminate information about the benefits of green building and increase its adoption. Collaboration with international organizations and initiatives can facilitate the development of capacities and the dissemination of knowledge.

VI. CONCLUSION

Significant success has been made in the execution of perforated façades in the built environments of India, Pakistan, and Bangladesh. Notably, in India, increased incorporation has been there for green building standards like LEED India and GRIHA, which focus on renewable energy sources, the ability to save water, and occupant comfort. Monetary inducement via loans and subsidies provides an effective way for environmentally responsible building practices. The garment sector in Bangladesh has come alive with energy-efficient and ecologically sound building methods being used based on its widespread use of LEED certification. Initiatives taken include the changeover to more efficiency-oriented fixtures, the installation of solar panels, rainwater collection systems, and other water-efficient fixtures. All in all, the use of green building certification within construction in Pakistan remains relatively low, although organizations such as the Pakistan Green Building Council are making strides toward this. LEED is one of those initiatives that it has taken for specific projects, including a general focus on energy management, material resource management, and water efficiency.

It has been established, again in India, that mandating green building codes speaks volumes of the importance and success of taking some steps through regulatory frameworks to achieve higher sustainability in design practice. Incentives, such as enhanced floor area ratios on green constructions, are the way for stakeholders to popularize environmentally friendly practices. Promoting energy-efficient design would be better achieved with financial opportunities at both local and international levels, as well as awareness and education programs.

1). Policy Implications

As green building and energy efficiency is still a new concept for many stakeholders in developing

countries, it is very challenging to implement green building codes in construction and design policies (Shafique, 2022). These challenging factors include inadequate knowledge, lack of awareness of benefits of green buildings and depleting energy resources, architects' negligence in making the clients aware of these benefits and the old conservative thinking of typical stakeholders which are not literate enough to understand the problems of energy and benefits of going green (Table 4).

Table 4: Limitations in Implementation of Green Building Rating System in Design and Construction (Abraham & Gundimeda, 2017; Shafique, 2022; Asia, 2022)

Countries	**Strategies**
India	Energy cost: Investors find it more expensive to invest for energy saving. Fee structures of architects become heavy on clients. Especially when fees of architects and engineers are percentage of capital cost of building. Lack of knowledge: Occupants of buildings does not understand how it is benefiting them. Implementation of building codes and compliance with other laws and regulations. Its very difficult to educate stakeholder about green buildings and its benefits
Bangladesh	Limitation of use of resources**:** Technologies available for green building are not being fully used. Lack of awareness: Misconceptions that GB cost more. Acceptance of sustainability in market: The market is not yet prepared for sustainable building materials. Lack of knowledge: Hindrances in using technologies like BIM and 3D printing due to lack of knowledge and awareness.
Pakistan	Absence of green construction standards or guidelines: In the building and construction industry, there are neither quantitative targets nor a legislative force, resulting in a lack of motivation and incentives for the design and implementation of energy-efficient buildings. Insufficient funds and disincentives to develop ecological building: Stakeholders' perception of a high capital cost and minimal return on investment. Major obstacles to enforcing energy efficiency standards in buildings include the absence of financial instruments such as subsidies, tax rebates, or a dedicated revolving fund. Lack of availability of sustainably produced materials: Lack of local development and availability of energy-saving, emission-reducing, secure, convenient, and recyclable sustainable building materials, and products. Unavailability of professional expertise, skilled personnel, and technical know-how; absence of the government's capacity and limited government knowledge in developing and administering green building codes. People are still very unaware and not educated about all the benefits and the essential necessity of green buildings.

The purpose of the research is to provide architects and designers the necessary information, resources, and support to address such concerns. This would provide those architects and designers who attend workshops, seminars, and other formats of continuing education with an understanding of what ideas were being disseminated at the time and to what technologies were thought applicable in relation to energy-efficient design. To better serve architects in their pursuit of energy efficiency, there is a need to supply them with a wide range of materials: from case study databases and design guidelines to energy modeling and simulation tools. Most importantly, communication and sharing of design recommendations that save energy amongst architects, engineers, legislators, and industry experts through collaborative networks and collaboration may reduce these barriers.

Policymakers need to consider tax rebates and subsidies for green building practices to elevate or increase the green building codes in terms of enhancement and floor area ratios for green constructions. Public-private partnerships could also be improved to remove financial or technical barriers that have hindered the spread of these sustainable technologies.

2). Limitations

The design of energy-efficient practices in this study focuses mainly on a comparative analysis based on India, Pakistan, and Bangladesh during the last two decades. The scope of the study is strictly limited to these three countries and does not

go further to include other countries from the South Asian region. Besides, with available data, there is always a question of updating or including a development that may have occurred after data collection. trends over the last two decades.

3). Recommendations

- *Policy Enhancement:* Governments should adopt greener building codes with financial incentives for green projects to enhance sustainable practices.
- *Collaboration Efforts:* Encouraging collaboration efforts between the public and private sectors can help overcome critical barriers to finance and technology.
- *Education and Awareness:* Wide-ranging implementation of educational programs to raise awareness among all stakeholders about the benefits of sustainable practices.
- *Monitoring and Evaluation:* Develop robust frameworks to ensure and measure compliance.

4). Future Research Directions

Future research studies should include a broader array of countries in South Asia and the longer-term impacts of sustainable practices. Further, more significant insights could be realized with larger sample sizes and more diversified case studies. This will also provide more insight into the effectiveness and implementation of sustainable design for practitioners and critical stakeholders, including the local community and industry experts. South Asian countries, thus, shall reduce their environmental footprints and accelerate sustainable urban development through policy improvement, public awareness enhancement, and investment in sustainable technologies.

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