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Analysis for the economic revitalization and training of related experts

ESTABLISHMENT OF THE PAKISTAN GREEN BUILDING CERTIFICATION SYSTEM

GREEN GROWTH. CONSULTANTS (PVT) LTD.

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TABLE OF CONTENTS

1. INTRODUCTION

The amount of built-up area in Pakistan varies widely by region and is influenced by factors such as population density, economic development, and land use policies. The Building Sector is responsible for a significant amount of greenhouse gas (GHG) emissions. According to the International Energy Agency (IEA), it is responsible for approximately 28% of global and energy-related GHG emissions and almost 25% of the total emissions in Pakistan.[1,2] Reducing the GHG emissions of buildings is an important part of the efforts of the United Nations (UN) to mitigate climate change and achieve global emissions reduction targets. This can be attained through a combination of energy efficiency measures, the use of renewable energy sources, and the adoption of low-carbon building materials and design methods.

The building sector is responsible for most of the energy consumption in Pakistan, with the residential sector currently being the largest in energy consumption consuming about 49.2%, and the commercial sector consuming about 7% of the total electricity produced in the country. Thus, it can be a major energy and cost savings opportunity if a building is developed with the use of sustainable construction materials, design features, and energy-efficient appliances.[3] Green building through the use of sustainable structure, design, and energy-efficient appliances offers a major saving potential of up to 30% but an economic analysis is important to understand the complexities involved in using these materials, design features, and appliances.[4]

Furthermore, green buildings typically have a higher upfront cost compared to conventional buildings but they offer benefits that built-to-code projects lack. These benefits include cost savings from reduced energy and water use, less waste production, diminished environmental and emissions costs, lower operations and maintenance costs, and enhanced occupant productivity and health. These values range from being predictable (energy and water savings can be recorded over time) to relatively uncertain (productivity/health benefits are somewhat subjective.

This report encompasses a comprehensive cost-benefit analysis and human resource analysis of green buildings in Pakistan, concurrently addressing identified gaps to provide mitigation measures and training modules for economic revitalization.

2. COST-BENEFIT ANALYSIS

The adoption of green materials, design features, and energy-efficient appliances is uncommon in construction practices in Pakistan. This situation is due to a lack of awareness among professionals and the general public, limited access to requisite technology and materials, and higher associated costs. The following section presents a cost-benefit analysis for evaluating the suitability of green

1 https://iea.blob.core.windows.net/assets/026bff1b-821d-48bc-8a0e-7c10280c62bc/Perspectives_for_the_Clean_Energy_Transition_2019.pdf

2 https://www.climate-transparency.org/wp-content/uploads/2021/11/Pakistan-CP-2020.pdf

3 https://unfccc.int/documents/470405 (BUR1)

4 Baig, A. (2018). *Green Buildings as a Solution for Sustainable Housing: Role of Private Housing Schemes, Lahore, Pakistan*. Research Gate. https://www.researchgate.net/publication/327267222_Green_Buildings_as_solution_for_Sustainable_Housing_Role_of_Private_Housing_Schemes_Lahore_Pakistan

buildings. This assessment will help determine whether green buildings represent an advantageous and practical choice for adoption in Pakistan's construction industry.

COST-BENEFIT ANALYSIS OF GREEN BUILDING MATERIALS, DESIGN, AND ENERGY-EFFICIENT APPLIANCES

Cost-benefit analysis of green buildings in Pakistan is carried out for domestic, commercial and industrial buildings. In addition, savings for building materials, design features, and energy-efficient appliances are calculated for these buildings separately.

DOMESTIC SECTOR

In Pakistan, the per capita annual consumption of electricity is 399 kWh in domestic sector.[5] Keeping an average household of 7 persons, give the aggregate consumption as 2793 kWh/Annum. So, the monthly consumption of a house having 7 persons is 233 kWh. Keeping given NEECA electricity rates following calculations have been done.

Table 1 - Electricity Cost in Absence of Green Building Practices

S. No	Units consumed (kWh)	Unit Price	With a 17% tax	Unit consumed by household	Household Monthly Bill (RS)	Yearly bill (Rs)
1	201-300	22.14	25.9038	232.75	6,029.109	72,349.31
2	301-400	25.33	29.6361	360	10,668.996	128,028
3	401-500	27.74	32.4558	420	13,631.436	163,577.2
4	501-600	29.16	34.1172	580	19,787.976	237,455.7
5	601-700	30.3	35.451	650	23,043.15	276,517.8
6	Above 700 units	35.22	41.2074	750	30,905.55	370,866.6

Economic analysis was conducted comparing electricity consumption between conventional and green building approaches using Table 1 as baseline data for residential buildings. For this purpose, a residential building of the area of construction; 25` X 50` (5.5 Marlas) was used. The cost-benefit analysis was conducted in terms of the use of:

i. Building Materials

5 https://www.pbs.gov.pk/sites/default/files/industry_mining_and_energy/publications/cee/report.pdf

ii. Building Design features
iii. Energy-efficient appliances

COST-BENEFIT ANALYSIS OF GREEN BUILDING MATERIALS

Green building materials such as fly ash bricks, low VOC (Volatile Organic Compound) paint, low-e windows, rammed earth, and bamboo was analyzed in the structural review document which showed that sustainable building materials such as the use of Fly Ash Bricks instead of conventional bricks can **save up to 40%,** bamboo can offer **savings up to 3-5%**, and cellulose insulation can **save up to 28%** of the energy cost of the building. Also, it showed an increase in the overall cost by 18% but reduced CO_2 emissions by 63%. Additionally, it led to energy-cost savings of $113,710 which **equals 30% of the total energy-cost savings.** The payback period for building using green construction materials was calculated to be almost 2 years.[6]

Below (Table 2) is the analysis of the example residential building in terms of the use of green building materials. The costs are taken based on the local market price in Pakistan, and calculations are done where direct cost for green materials is not available.[7,8] Their average electricity units consumed are taken based on the Table 1 calculations.

Table 2 - Use of Energy-Efficient Building Material

	Use of Fly Ash Bricks	Use of Cellulose Insulation in Roof	Combined Use of both Materials (Fly Ash Bricks, Cellulose Insulation)
Electricity Units Range	**201-300**		
No. of Electricity Units Consumed/Month	**232.75**		
Yearly Bill	**72,349.31**		
Percentage Savings (Avg.)	40	28	68
Yearly Benefit of Building Material	28,939.6	20,257.80	49,197.4
Cost of Installation/Retrofitting	3,50,000	36,354	386,354
BCR (Ratio)	4.13	13.9	2.54

6 https://ijcrt.org/papers/IJCRT22A6552.pdf

7 https://www.zameen.com/blog/construction-cost-5-marla-house.html

8 https://jbms.pk/fly-ash-brick-price/

ROI (%)	8.2	55	12.73
Payback Period (years)	12.09	1.79	7.8
Life Span	50 years	25 years	20 years

The benefit-cost ratio (BCR) is 4.13, 13.9, and 2.54 for using fly-ash bricks, cellulose insulation, and using the two together, respectively, showing a highly beneficial investment. Moreover, the return on investment and payback period are showing satisfactory results. As a rule of thumb, if the ROI value is greater than 7%, it's considered a good investment. It is thus concluded that the use of energy-efficient materials is a good option in monetary as well as energy-saving terms. The payback period is 12.09, 1.79, and 7.8 years for the use of fly ash bricks, cellulose insulation, and a combination of the two.

COST-BENEFIT ANALYSIS OF BUILDING DESIGN FEATURES

The cost of green building design features such as WWR, building orientation, green roofing systems, and renewable energy systems, was analyzed in the architectural review document and it showed that WWR can offer up to **12-39% savings** in different climates, Building Orientation can save up to **15-30% of energy cost**, and the case study of several building design parameters such as WWR, Glazing, Insulation, Biophilic design, and building orientation in building design offered a cost saving of up to $113,999 which equals to almost **30% of the building energy consumption**. It showed a payback period of 3 years and 2 months.[9]

Below (Table 3) is the analysis of the example residential building (25' x 50') in terms of the use of green building design features. The cost of installation is calculated by using the local market price of Windows, glazing, and insulation in Pakistan, and calculations are done where direct costs are not given.[10] Their average electricity units consumed are taken based on the Table 1 calculations. The details of the analysis are given in the table 3 below:

Table 3 - Use of Energy-Efficient Building Design Features

	Building with Optimum WWR	**Overall saving through Green Design (WWR, Glazing, Orientation, Insulation)**
Electricity Units Range	**201-300**	
No. of Electricity Units Consumed	**232.75**	

9 https://ijcrt.org/papers/IJCRT22A6552.pdf

10 https://wallrealestate.pk/guide/5-marla-house-construction-cost-pakistan-complete-guide/

Yearly Bill	72,349.31	
Percentage Savings (Avg) %	25	45
Yearly Benefit of Building Design Features	18,087.32	32,556
Cost of Installation/Retrofitting	1,80,000	2,20,000
BCR (Ratio)	1.51	2.96
ROI (%)	10	15
Payback Period (years)	9.9	6.7
Life Span	15 years	20 years

The benefit-cost ratio (BCR) is 1.51, and 2.96 for using installing optimum WWR and integrating other factors alongside also, respectively, which shows a beneficial investment. Moreover, the Return on investment and Payback periods are showing satisfactory results. As a rule of thumb, if the ROI value is greater than 7%, it's considered a good investment. It is thus concluded that the use of energy-efficient design features is a good option in monetary and energy-saving terms. The payback period for the use of WWR is 9.9 years, and for multiple energy-efficient building design features is approximately 6.7 years, which has differed from the architectural review document due to the difference in size of the buildings.

COST-BENEFIT ANALYSIS OF ENERGY-EFFICIENT APPLIANCES

The energy expert analysis on green buildings shows the use of insulated walls, roofs, and energy-efficient appliances i.e., LED bulbs, inverter AC, energy-saving fans, etc., save 29% of the energy consumption of a building. Also, the solar PV system delivers annual savings of approximately US$ **16,096.50 or PKR 4,819,950** by reducing the consumption of grid electricity. The payback period for **Solar PV systems is about 3 years**, and for **energy-efficient appliances, it is about 1-2 years**.

Below (Table 4) is the analysis of the example residential building (25’ x 50’) in terms of the use of energy-efficient appliances. The cost of installation is calculated by using the local market price of LEDs, and fluorescent bulbs in Pakistan, and calculations are done where direct costs are not given.[11,12] The details of the analysis are given below in the Table 4.

11 https://www.mdpi.com/2673-4591/23/1/10

12 https://www.shineretrofits.com/knowledge-base/lighting-learning-center/pros-and-cons-of-fluorescent-lighting.html

Table 4 - Use of Energy-Efficient Appliances

	Savings by LEDs	Savings by Fluorescent
Electricity Units Range	**201-300**	
No. of Electricity Units Consumed/Month	**232.75**	
Yearly Bill	72,349.3	
Percentage Savings (%)	50	75
Yearly benefit of appliances	36,174	54,261
Cost of Installation/ Retrofitting	185,000	196,655
BCR (Ratio)	1.11	0.8
ROI (%)	19.5	27
Pay Back Period (years)	5.11	3.62
Life Span of bulbs/tubes	5.7 years (50,000 hours)	2.5 Years (24,000 - 36,000 hours)

The benefit-cost ratio (BCR) of LEDs is 1.1, which is higher than the 0.8 value for fluorescent tubes, showing that despite the higher savings of fluorescent tubes they are a slightly costly investment when compared to LEDs. However, the return on investment and payback period are showing satisfactory results. As a rule of thumb, if the ROI value is greater than 7%, it's considered a good investment. It is thus concluded that the use of the energy-efficient appliance is a good option in monetary as well as energy-saving terms. The payback period for the use of LEDs is 5.11 years, and for fluorescent tubes is 3.62 years.

The cost-benefit analysis of building materials, design features, and energy-efficient appliances shows that green buildings have more benefits outweigh the associated costs. All these aspects can lead to an overall 30% decrease in the energy consumption of the building, which can help in utilizing the 30% energy-saving potential that the building sector of Pakistan has to offer.[13]

COMMERCIAL SECTOR

13 Baig, A. (2018). *Green Buildings as a Solution for Sustainable Housing: Role of Private Housing Schemes, Lahore, Pakistan*. Research Gate. https://www.researchgate.net/publication/327267222_Green_Buildings_as_solution_for_Sustainable_Housing_Role_of_Private_Housing_Schemes_Lahore_Pakistan

In Pakistan, residential buildings electricity unit is usually charged on the basis on units consumed by a household, while on the other hand for the commercial sector NEPRA has defined a load range based on which price of a unit will be charged.

Table 5 - Electricity Cost for Commercial Units in Pakistan 2023[14]

S. No	Load Type	Rate per Unit (kWh)	With 17% tax
1	Less than 5kW load	Rs. 38.80	45.39
2	More than 5kW load	Rs. 40.26	46.84

The cost-benefit analysis was conducted in terms of the use of:

i. Building Materials
ii. Building Design features
iii. Energy-efficient appliances

COST-BENEFIT ANALYSIS OF GREEN BUILDING MATERIALS

The structural review document analyzed the use of green building materials, finding that they could result in significant energy savings, with fly ash bricks saving up to 40% and bamboo offering savings of 3-5%. However, this green approach increased the overall construction cost by 18% while reducing CO2 emissions by 63%.

Below (Table 6) is the analysis of the example commercial building in terms of the use of green building materials. The costs are taken based on the local market price in Pakistan, and calculations are done where direct cost for green materials is not available. [15,16] Their average electricity units consumed are assumed because of the fact that commercial sector has high variance in number of units consumed by a tall building vs a small commercial shop and similarly for other buildings residing in a commercial sector. For the price of a unit charge building under consideration Is assumed to have load greater than 5 kw.

Table 6 - Use of Energy-Efficient Building Material

	Use of Fly Ash Bricks	**Use of Cellulose Insulation in Roof**	**Combined Use of both Materials (Fly Ash Bricks, Cellulose Insulation)**

14 https://ehsaas8171.com/electricity-price-per-unit-in-pakistan/

15 https://www.zameen.com/blog/construction-cost-5-marla-house.html

16 https://jbms.pk/fly-ash-brick-price/

Load Type	Less than 5 kW		
No. of Electricity Units Consumed/Month	**400**		
Yearly Bill	**224,832**		
Percentage Savings (Avg.)	40	28	68
Yearly Benefit of Building Material	89,932	62,952.96	152,884
Cost of Installation/Retrofitting	3,50,000	36,354	386,354
BCR (Ratio)	12.84	43.29	7.91
ROI (%)	25.69	17.36	39.5
Payback Period (years)	3.89	0.57	2.52
Life Span	50 years	25 years	20 years

The benefit-cost ratio (BCR) is 12.84, 43.29, and 7.91 for using fly-ash bricks, cellulose insulation, and using the two together, respectively, showing a highly beneficial investment. Moreover, the return on investment and payback period are showing satisfactory results. As a rule of thumb, if the ROI value is greater than 7%, it's considered a good investment. It is thus concluded that the use of energy-efficient materials is a good option in monetary as well as energy-saving terms. The payback period is 3.89, 0.57, and 2.52 years for the use of fly ash bricks, cellulose insulation, and a combination of the two.

COST-BENEFIT ANALYSIS OF BUILDING DESIGN FEATURES

The analysis in the architectural review document found that incorporating green building design features like WWR and building orientation can result in significant energy savings of up to 12-39% and 15-30%, respectively. The study also demonstrated that these features, along with others, could lead to cost savings of approximately $113,999, equivalent to nearly 30% of the building's energy consumption, with a payback period of 3 years and 2 months.

Below (Table 7) is the analysis of the example commercial building in terms of the use of energy efficient design. The costs are taken based on the local market price in Pakistan, and calculations are done where direct cost for green materials is not available.[17,18] Their average electricity units

17 https://www.zameen.com/blog/construction-cost-5-marla-house.html

18 https://jbms.pk/fly-ash-brick-price/

consumed are assumed because of the fact that commercial sector has high variance in number of units consumed by a tall building vs a small commercial shop and similarly for other buildings residing in a commercial sector. For the price of a unit charge building under consideration Is assumed to have load greater than 5 kw.

Table 7 - Use of Energy-Efficient Building Design Features

	Building with Optimum WWR	**Overall saving through Green Design (WWR, Glazing, Orientation, Insulation)**
Load Type	**> 5kw**	
No. of Electricity Units Consumed/Month	**400**	
Yearly Bill	**224,832**	
Percentage Savings (Avg) %	25	45
Yearly Benefit of Building Design Features	56,208	101,174
Cost of Installation/Retrofitting	1,80,000	2,20,000
BCR (Ratio)	4.684	11.49
ROI (%)	31.22	45.98
Payback Period (years)	3.2	2.17
Life Span	15 years	20 years

BCR for installing optimal WWR is 4.684, and when combined with other factors, it reaches 11.49, indicating a highly advantageous investment. Additionally, the ROI and Payback periods are delivering favorable results, with an ROI exceeding 7%, signifying a sound investment choice. In conclusion, incorporating energy-efficient design features proves to be a prudent decision both in terms of financial and energy savings. The payback period for optimal WWR utilization is 3.2 years, while the use of multiple energy-efficient building design features results in an approximate payback period of 2.17 years, with variations due to differences in building sizes.

COST-BENEFIT ANALYSIS OF ENERGY-EFFICIENT APPLIANCES

The energy expert's analysis of green buildings highlights that the incorporation of insulated walls, roofs, and energy-efficient appliances such as LED bulbs, inverter ACs, and energy-saving fans can lead to a 29% reduction in a building's energy consumption. Additionally, the installation of a solar PV system can yield annual savings of approximately US$ 16,096.50 or PKR 4,819,950 by decreasing reliance on grid electricity, with a payback period of around 3 years for the solar PV system and 1-2 years for energy-efficient appliances. Table 8 provides a detailed analysis of an example commercial building (load >5kw) in terms of the use of energy-efficient appliances, considering local market prices in Pakistan.

Table 8 - Use of Energy-Efficient Appliances

	Savings by LEDs	**Savings by Fluorescent**
Load Type	**> 5 kw**	
No. of Electricity Units Consumed/Month	**400**	
Yearly Bill	**224,832**	
Percentage Savings (%)	50	75
Yearly benefit of appliances	112,416	168,624
Cost of Installation/ Retrofitting	185,000	196,655
BCR (Ratio)	3.46	2.14
ROI (%)	60.7	85.74
Pay Back Period (years)	1.64	1.16
Life Span of bulbs/tubes	5.7 years (50,000 hours)	2.5 Years (24,000 - 36,000 hours)

BCR of LEDs stands at 3.46, surpassing the 2.14 BCR value for fluorescent tubes, indicating that while fluorescent tubes provide higher savings, they represent a slightly more expensive investment compared to LEDs. Nevertheless, both the return on investment and payback period show positive results with an ROI value exceeding 7% which is generally considered a good investment. Therefore, using energy-efficient appliances is a favorable choice in terms of both financial and energy savings. The payback period for LEDs is 1.64 years, and for fluorescent tubes, it is 1.16 years.

The cost-benefit analysis of building materials, design features, and energy-efficient appliances underscores that green buildings offer more advantages than their associated costs. The combination of these factors can result in an overall 30% reduction in a building's energy

consumption, contributing to the realization of the 30% energy-saving potential within the building sector of Pakistan.[19]

INDUSTRIAL SECTOR

Like commercial sector, unit price of electricity and tariff for industrial area is determined based on load they consume.

Table 9 - Electricity Cost For Industrial Units in Pakistan 2023[20]

S NO.	Load Type	Per Unit Price (Peak time)	Per Unit Price(Off Peak)
1	Up To 25 kW (at 400/230 Volts)	-	34.33
2	Exceeding 25-500 kW (at 400 Volts)	-	33.83
3	Up to 25 kW	37.89	32.33
4	Exceeding 25-500 kW (at 400 Volts)	37.83	32.12
5	For All Loads up to 5000 kW (at 11,33 kV)	37.83	32.03
5	For All Loads (at 66,132 kV & above)	37.83	31.93

The cost-benefit analysis was conducted in terms of the use of:

i. Building Materials
ii. Building Design features
iii. Energy-efficient appliances

COST-BENEFIT ANALYSIS OF GREEN BUILDING MATERIALS

The structural review document examined green building materials like fly ash bricks, low VOC paint, low-e windows, rammed earth, and bamboo. The findings revealed significant energy savings potential, with fly ash bricks potentially saving up to 40%, bamboo offering 3-5% savings, and cellulose insulation potentially reducing energy costs by 28%. Despite an 18% increase in overall costs, these materials reduced CO_2 emissions by 63% and led to energy cost savings of $113,710, equivalent to 30% of total energy cost savings.

19 Baig, A. (2018). *Green Buildings as a Solution for Sustainable Housing: Role of Private Housing Schemes, Lahore, Pakistan*. Research Gate. https://www.researchgate.net/publication/327267222_Green_Buildings_as_solution_for_Sustainable_Housing_Role_of_Private_Housing_Schemes_Lahore_Pakistan

20 https://iesco.com.pk/index.php/customer-services/tariff-guide

Below (Table 10) is the analysis of the example Industrial vicinity in terms of the use of green building materials. The costs are taken based on the local market price in Pakistan, and calculations are done where direct cost for green materials is not available. [21,22] Their average electricity units consumed are assumed because of the fact that industrial sector has high variance in number of units consumed based on the apparatus, technology and machinery used by a particular industrial unit. For the price of a unit charge building under consideration Is assumed as a small factory having load between 25-500 kw.

Table 10 - Use of Energy-Efficient Building Material

	Use of Fly Ash Bricks	**Use of Cellulose Insulation in Roof**	**Combined Use of both Materials (Fly Ash Bricks, Cellulose Insulation)**
Load Type	**25-500 kw**		
No. of Electricity Units Consumed/Month	**15000**		
Yearly Bill	**63,00000**		
Percentage Savings (Avg.)	40	28	68
Yearly Benefit of Building Material	2520,000	1764,000	4284000
Cost of Installation/Retrofitting	3,50,00000	3635400	386,35400.00
BCR (Ratio)	3.6	12.13	2.21
ROI (%)	72	48.5	11.08
Payback Period (years)	13.8	2.06	9.01
Life Span	50 years	25 years	20 years

The benefit-cost ratio (BCR) is 3.6 for fly-ash bricks, 12.13 for cellulose insulation, and 2.21 when using both materials together, signifying a highly advantageous investment. Additionally, the return on investment (ROI) and payback periods yield favorable results, with an ROI exceeding 7%, indicating a sound investment choice. In conclusion, the use of energy-efficient materials proves to

21 https://www.zameen.com/blog/construction-cost-5-marla-house.html

22 https://jbms.pk/fly-ash-brick-price/

be a prudent decision both in terms of financial and energy savings, with payback periods of 13.8 years for fly ash bricks, 2.06 years for cellulose insulation, and 9.01 years for their combined use.

COST-BENEFIT ANALYSIS OF BUILDING DESIGN FEATURES

The architectural review document analyzed green building design features, finding that WWR can save 12-39% in different climates, building orientation can cut energy costs by 15-30%, and a combination of design parameters could result in $113,999 savings, equivalent to 30% of energy consumption.

Below (Table 11) is the analysis of the industrial vicinity (25-500 kw) in terms of the use of green building design features. The cost of installation is calculated by using the local market price of Windows, glazing, and insulation in Pakistan, and calculations are done where direct costs are not given.[23] Their average electricity units consumed are assumed because of the fact that industrial sector has high variance in number of units consumed based on the apparatus, technology and machinery used by a particular industrial unit. For the price of a unit charge building under consideration Is assumed as a small factory having load between 25-500kw

Table 11 - Use of Energy-Efficient Building Design Features

	Building with Optimum WWR	**Overall saving through Green Design (WWR, Glazing, Orientation, Insulation)**
Load Type	**25-500 kw**	
No. of Electricity Units Consumed/Month	**15000**	
Yearly Bill	**63,00000**	
Percentage Savings (Avg) %	25	45
Yearly Benefit of Building Design Features	157,5000	2835,000
Cost of Installation/Retrofitting	1,80,0000	2,20,0000
BCR (Ratio)	13.1	25.7
ROI (%)	8.75	12.8
Payback Period (years)	1.14	0.77

23 https://wallrealestate.pk/guide/5-marla-house-construction-cost-pakistan-complete-guide/

Life Span	15 years	20 years

BCR is 13.1 for optimal WWR and 25.7 when combined with other factors, indicating a beneficial investment. The Return on Investment (ROI) is satisfactory with an ROI above 7%, making energy-efficient design features a financially and energy-saving option. Payback periods are 1.14 years for WWR and approximately 0.77 years for multiple energy-efficient design features.

COST-BENEFIT ANALYSIS OF ENERGY-EFFICIENT APPLIANCES

The energy expert's analysis indicates that utilizing insulated walls, roofs, and energy-efficient appliances can save 29% of a building's energy consumption. Furthermore, a solar PV system can provide annual savings of around US$ 16,096.50 or PKR 4,819,950 by reducing grid electricity consumption.

Below (Table 12) is the analysis of the example of industrial building (25-500 kw) in terms of the use of energy-efficient appliances. The cost of installation is calculated by using the local market price of LEDs, and fluorescent bulbs in Pakistan, and calculations are done where direct costs are not given.[24,25] The details of the analysis are given below in the Table 4.

Table 12 - Use of Energy-Efficient Appliances

	Savings by LEDs	**Savings by Fluorescent**
Load Type	**25-500 kW**	
No. of Electricity Units Consumed/Month	**15000**	
Yearly Bill	**63,00000**	
Percentage Savings (%)	50	75
Yearly benefit of appliances	3150,000	4725,000
Cost of Installation/ Retrofitting	185,0000	196,6550
BCR (Ratio)	9.7	6.006
ROI (%)	11.7	22.4
Pay Back Period (years)	0.58	0.416

24 https://www.mdpi.com/2673-4591/23/1/10

25 https://www.shineretrofits.com/knowledge-base/lighting-learning-center/pros-and-cons-of-fluorescent-lighting.html

Life Span of bulbs/tubes	5.7 years (50,000 hours)	2.5 Years (24,000 - 36,000 hours)

BCR for LEDs is 9.7, surpassing the 6.006 value for fluorescent tubes, indicating that although fluorescent tubes offer higher savings, they represent a slightly more costly investment compared to LEDs. Nevertheless, the return on investment and payback periods show positive results, with an ROI exceeding 7%, signifying a sound investment choice. In conclusion, the use of energy-efficient appliances proves to be a beneficial choice in both financial and energy-saving terms, with a payback period of 0.58 years for LEDs and 0.416 years for fluorescent tubes. The cost-benefit analysis of building materials, design features, and energy-efficient appliances highlights that green buildings provide more benefits than their associated costs, potentially leading to an overall 30% reduction in a building's energy consumption, contributing to the utilization of Pakistan's 30% energy-saving potential in the building sector.

FACTORS INFLUENCING BUILDING STRUCTURE, DESIGN, AND ENERGY COSTS

Several factors exert influence on building structure, design, and energy costs. These factors are critical in shaping the sustainability and efficiency of structures within the construction industry. The following factors are critical in determining the factors that can introduce a change in the overall energy performance, construction, and energy cost of a building.

ECONOMIC FACTORS

The economic sustainability of construction ensures high economic growth and employment in the construction industry but it is also intrinsically linked to improved project delivery. While there is a perception of high initial costs it is important to consider the concept of whole life value. Whole life value takes into consideration the initial cost; design and procurement cost, cost in use; maintenance operation and dismantling cost, and residual value of the construction material. In the long run, the whole life value of the sustainable construction material should resort to profitability without compromising their positive environmental impact.

The **construction industry in Pakistan** is influenced by a lack of funding availability, high material costs, and high housing demand. Moreover, the shortages in foreign investment, volatile material prices, and increased housing demand in urban areas affect the construction industry. Although government policies encourage energy-efficient practices and safety standards, their implementation remains a concern. Despite these challenges, the industry has grown due to government initiatives and rising real estate demand, contributing significantly to the country's economy. [26]

ENVIRONMENTAL FACTORS

26 https://zarea.pk/economys-impact-on-pakistans-construction-industry/

The environmental factors are geared towards preventing harmful effects on the environment. These are realized by minimizing the production of waste, appropriate usage of natural resources, and protecting the environment. Local and recycled building materials have been touted to reduce CO_2 emissions leading to the production of healthier buildings which concomitantly strengthen the economy. [27] Literature has provided evidence that the promotion of prioritization of the use of local and recycled building materials has been advanced in research and development due to the evolution of the low-carbon building movement. Szydlik (2014) added in a study that sustainable buildings maximize resource efficiency, energy efficiency, water conservation systems, and grey water use, enhance indoor environment and quality, and usage of non-toxic materials. [28] This agrees with Reddy (2016)[29] who asserted that selecting sustainable materials is keen to the reduction or minimization of the economic (pricing) of buildings. Energy efficiency reductions in the construction and operation of buildings lead to reduced financial burdens for owners.

Environmental concerns are increasingly significant in **Pakistan's real estate** market, with demand for energy-efficient and eco-friendly properties.[30] Extreme weather conditions, such as hurricanes and earthquakes, can necessitate costly structural reinforcements. To accurately estimate costs, understanding local climate and conditions is vital. To optimize construction expenses in Pakistan, it's essential to consider factors like accessibility, resource availability, and local regulations, and collaborate with local experts and experienced construction companies.[31]

SOCIAL FACTORS

The social factor addresses the needs (culture, living conditions) of people involved in construction activities. According to Patil and Patil (2017), social factors highlight improvements in the quality of human life and the human living environment encompassing intergenerational equity, culture, education, and health. According to Jamilus et al. (2013)[32], social factors provide high customer satisfaction. It stated that the social aspect of sustainability undergoes degradation in the same way as the natural environment. The need for a comfortable housing system is to be met by the usage of sustainable construction materials/products. Social sustainability is to improve the quality of life of individuals. Patil and Patil (2017) [33] asserted that sustainable building materials provide the opportunity for living inhabitants to live in healthy, comfortable conditions throughout the building's full life cycle. The emissions from the various construction materials could end up in health risks such as cancer, asthma, and so on. Othman et al. (2018)[34] in a study posited that long-term exposure to specific building materials may be harmful to the overall health of building occupants. Materials can contain hazardous, irritating, toxic, or odorous elements that can adversely impact human overall health either directly or indirectly.

27 Kibert CJ. 2016. Sustainable construction: green building design and delivery. Hoboken, New Jersey: John Wiley & Sons.

28 Szydlik C. 2014. Identifying and overcoming the barriers to sustainable construction. [Doctoral dissertations] 2330. https://scholarsmine.mst.edu/doctoral_dissertations/2330.

29 Reddy V. S. 2016. Sustainable construction: analysis of its costs and financial benefits. IJIREM. 3(6):522–525.

30 https://www.agency21.com.pk/blog/factors-affecting-pakistans-real-estate-market/

31 https://syed-brothers.com/construction/factors-affecting-commercial-building-construction-cost/

32 Jamilus MH, Ismail AR, Aftab HM. 2013. The way forward in sustainable construction: Issues and challenges. Int J Adv Appl Sci. 2(1):15–24.

33 Patil AK, Patil EM. 2017. Sustainable construction materials & technology in context with sustainable development. Int J Eng Res Technol. 10(1): 112–117.

34 Othman M, Mohamed AF, Othman M. 2015. Review of carbon emission and LCA application towards sustainable building. Malays Constr Res J. 16(1): 77–96.

In **Pakistan**, social factors significantly influence construction projects. These factors encompass accidents, shopping, tourism, and traffic, impacting project schedules, costs, and quality. Transportation efficiency, health, safety, migration, land value, and several other factors also play vital roles in project performance, making it crucial to address these considerations in the context of Pakistani construction.[35]

SOLUTIONS/STRATEGIES

To address the financial aspects and gaps identified in green buildings in Pakistan, the following strategies and solutions can be considered. Below (Figure 1) is the graphical representation of financial solutions for different stages of the value chain of buildings in Pakistan.

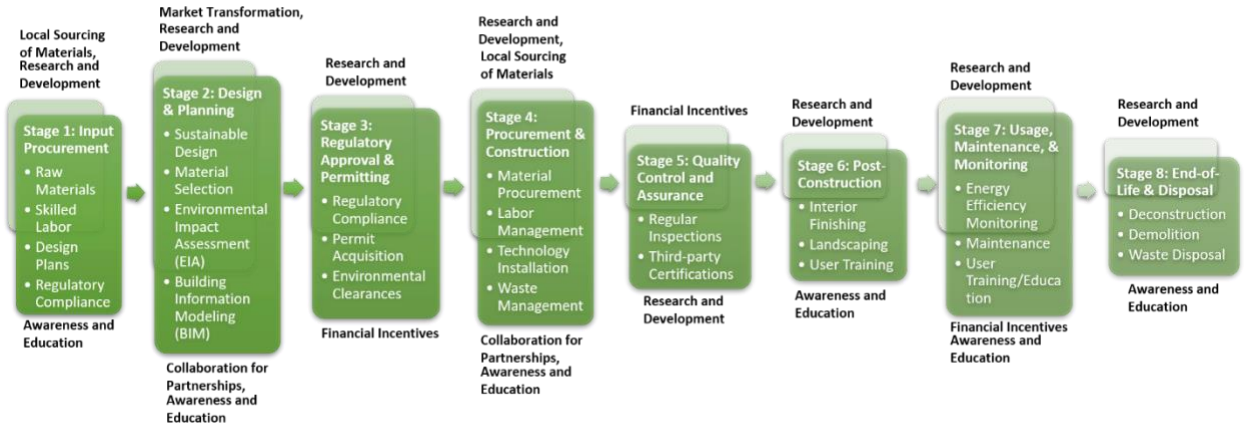

Figure 1 - Financial Solutions of the Design and Construction Phases of Green Buildings in Pakistan

FINANCIAL INCENTIVES AND SUBSIDIES

The government of Pakistan can offer **subsidies or tax incentives** to encourage the use of green building materials and practices. This can help offset the initial higher costs. Also, financial institutions can provide specific **green financing** options, such as lower interest rates or longer repayment terms, for individuals and companies investing in green buildings. Further, the Government can establish a system of **grants or rebates** for green building projects that meet certain sustainability criteria. These incentives can help reduce the upfront costs.

AWARENESS AND EDUCATION OF GOVERNMENT, PROFESSIONALS, AND PUBLIC

Awareness of the Government can ensure investments in sustainable buildings and technology. **Training programs and workshops** for architects, engineers, and builders can be offered to educate them about the benefits and techniques of green construction, which can lead to increased adoption

35 Khahro SH, Memon AH, Memon NA, Memon ZA, Naresh R. Influence of Social and Economic Factors on Construction Project Performance in Pakistan. *Sustainability*. 2023; 15(3):2469. https://doi.org/10.3390/su15032469

and reduced costs as skilled labor becomes more readily available. Also, doing **public awareness campaigns** to educate homeowners and businesses about the long-term cost savings associated with green buildings can drive demand for such changes in the building sector of Pakistan.

LOCAL SOURCING AND RECYCLING OF MATERIALS

Encouraging the use of **locally sourced building materials**, **design technology,** and **energy-efficient appliances** can reduce transportation costs and support the local economy. Also, promoting the **recycling** of construction waste and the use of recycled materials can reduce costs and minimize environmental impact.

FUNDING FOR RESEARCH AND DEVELOPMENT

The Government should allocate **funding for research and development** in the green building sector to develop innovative and cost-effective green materials and technologies and also, establish a **platform for sharing research findings** and best practices within the industry to facilitate knowledge transfer and cost reduction.

COLLABORATION AND PARTNERSHIPS

Foster **partnerships** between **government agencies, private sector entities,** and **NGOs** to jointly promote and invest in green building initiatives and encourage **collaboration among different sectors** of the construction industry to share resources and knowledge, leading to cost reduction.

MARKET TRANSFORMATION BY PROFESSIONALS

Encourage architects, real estate developers, and homeowners to **create a market demand** for green buildings, which can drive competition and lower prices. This can be achieved if infrastructure professionals promote the use of green materials, design technology, and efficient appliances.

By implementing these strategies and solutions, Pakistan can address the financial aspects and gaps in green buildings, making them more accessible and affordable while reaping long-term economic and environmental benefits.

3. HUMAN RESOURCE ANALYSIS

The construction industry in Pakistan is a significant contributor to the country's economy, and there is a wide range of skills and expertise available among the labor force in the construction sector. Pakistan boasts a substantial labor force of 68.75 million individuals.[36] However, it is difficult to gauge the percentage of labor, who have green building construction knowledge. This concept is relatively new in Pakistan but there is a growing interest in sustainable building practices. In the pursuit of economic revitalization in Pakistan's construction industry through the adoption of green

36 https://www.pbs.gov.pk/sites/default/files/labour_force/publications/lfs2020_21/LFS_2020-21_Report.pdf

building practices, a careful evaluation of required human resources is essential. This report includes the assessment of skills and expertise available and required in the value chain of the green building structure, design, and energy-efficient appliances in Pakistan.

ASSESSMENT OF THE VALUE CHAIN OF GREEN BUILDINGS IN PAKISTAN

The value chain of green materials involves several individuals including engineers, architects, project managers, electricians, laborers, and several other experts. Analysis of all the relevant individuals is important to identify the gaps in the value chain of green building, design, and energy-efficient appliances.

ASSESSMENT OF MATERIALS AND TECHNOLOGY

The assessment of materials and technology in the building value chain is shown below (Figure 2) and carried out as follows:

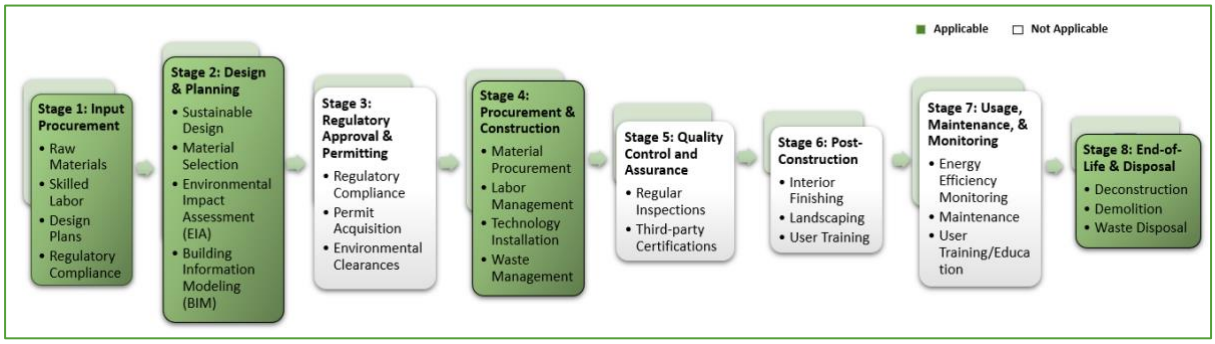

Figure 2 - Materials and Technology in Construction Value Chain

1. Sustainable Materials and Construction Techniques

Several sustainable and green building materials are produced locally in Pakistan but they are not produced in very high quantities due to the low market demand. Most of the sustainable materials to be used in green buildings are given below:

- **Fly Ash Bricks:** Fly ash bricks, made from waste materials, and produced by coal-fired power plants, are strong, durable, and environmentally friendly, as they help reduce waste and save energy. They are cheaper than traditional bricks, making them an affordable option for construction in Pakistan. **Tameerkaro Construction Company and Sitara Chemical Industries** are two of the very few suppliers of fly ash bricks in Pakistan.

- **Cellulose insulation:** Cellulose insulation is used in roofs due to the low thermal conductivity of Cellulose foam making it an excellent choice for insulation purposes. **Duracon Engineering and Lakhwa Chemical Services** are the suppliers of cellulose roof insulation in Pakistan.

- **Insulated Glass (Glazed Glass):** Insulated glass unit (IGU), more commonly known as double glazing, consists of two or three glass window panes separated by a vacuum or gas-filled space to reduce heat transfer across a part of the building envelope. **Al-Haq Glass & Aluminum, Pakistan Sunshine, and the graph** are a few firms that provide single- and double-glazed glass for windows.

- **Cool Bricks:** In Pakistan, a new material called the "cool block" that has been made using a special window called the Muscatese Evaporative cooling window is being tested. This cool block is created by putting water in a ceramic container and placing it next to a wooden screen. It is still in the experimental phase, hence there is **no supply** yet.

- **Bamboo:** Bamboo is a highly sustainable material that grows quickly and can be harvested without damaging the environment. It is strong and durable, making it an ideal construction material. Bamboo is used in building construction in Pakistan primarily for structural support in various construction applications, including scaffolding, roofing, and as a building material itself. Bamboo is grown in Pakistan on **private farms**, particularly in the Punjab region, and is also supplemented by **imports from other countries** such as China and Bangladesh to meet the demand for construction purposes. **NYJ industries** are the biggest suppliers of bamboo in Pakistan.

- **Straw Bale:** Straw bale construction is gaining popularity in Pakistan due to its affordability and sustainability. Straw bales are made from the leftover stalks of wheat, rice, and other crops, which are often burned or discarded. They are highly insulating, making them an ideal material for construction in hot climates Straw bale buildings are also earthquake-resistant, which is crucial in Pakistan, where earthquakes are common. **Zeta Traders, Shoaib Enterprises, and Syed Usman Corporation** are a few suppliers of straw bales in Pakistan.

- **Low VOC Paints:** In Pakistan, paint serves the dual purpose of protecting walls and adding decorative appeal to homes and buildings. However, some paints can release **harmful chemicals** called VOCs into the indoor air, leading to air pollution indoors, which is where the need for low-VOC paints comes in. Paint manufacturers in Pakistan such as **Brighto, Berger, and Master Paints** are now supplying low-VOC paints.

- **Rammed Earth:** Rammed Earth is made by compressing layers of earth, gravel, and other locally available materials. Rammed-earth buildings are highly durable and can withstand earthquakes, fires, and other natural disasters, while also having excellent insulation properties, which can help reduce the need for heating and cooling systems. The use of rammed earth is **very common in rural areas** of Pakistan, but not very much in urban areas.

- **Stone, Marble & Chips:** Natural stones such as granite, marble, and limestone are used in Pakistan for building purposes. They are commonly used for cladding and flooring. These materials are mostly **available in the local market**. However, imported marbles are also available in the market. Solar Chips or green chips are used, and manufactured locally, and their cost is 20% higher than regular chips. They are used on rooftops to control direct heat from the sun.

- **Energy Efficient Lights** are manufactured in Pakistan. The system of smart and energy-efficient lights, swatches, doorbells, locks, swatches, surveillance cameras, and AI-integrated technologies are **available in the market**. However, the cost is 40-50% more than the locally manufactured products.

- **Water efficient Fixtures** are manufactured in Pakistan and there are several local manufacturers available, meeting the market demand as **Faisal Sanitary, Sonex Sanitary, Master Sanitary, and Super Asia Sanitary.** Most of them are water efficient. However, some of the imported water-efficient, sensor-embedded fixtures such as sensor taps, and sensor toilet flush are available in the market, providing smart solutions to homes.

Most of the building materials are produced locally in Pakistan such as bamboo, rammed earth, and natural stones. However, some building materials such as smart glass/glazed glass, fly ash bricks, insulation, and advanced electrical equipment, are imported from other countries mainly due to the presence of only a few local suppliers. Also, there is a limited number of firms in Pakistan offering expertise in **sustainable materials and construction techniques**. These firms prioritize the use of environmentally friendly materials and practices that align with principles of sustainability and conservation. Firms such as **Banu Mukhtar-Lahore** are at the forefront of this movement, emphasizing the use of eco-friendly materials and methods that align with environmental conservation principles.

2. Sustainable Design & Renewable Energy Technology

Sustainable design, also known as green or eco-friendly design, focuses on minimizing the negative impact of buildings on the environment and maximizing their energy efficiency. It involves incorporating sustainable design features such as WWR, Building Orientation, green roofs, and renewable energy sources. In the Pakistani context, sustainable design is gaining importance due to increasing environmental concerns. There are a few firms such as **Landscape-Karachi, Amir Adnan Associates-Lahore, and Consulting and Design Consortium Pvt. Ltd**., providing sustainable building design services to this industry.

Renewable energy technology focuses on the utilization of natural resources to generate clean and sustainable energy. Few firms are working in this area, that design energy-efficient buildings that incorporate renewable energy technologies, leading to sustainable and environmentally friendly construction projects in Pakistan such as the **Pakistan Council of Renewable Energy & Technology**.

ASSESSMENT OF SKILLS

The assessment of skills in building a value chain is shown below (Figure 3), and carried out as follows:

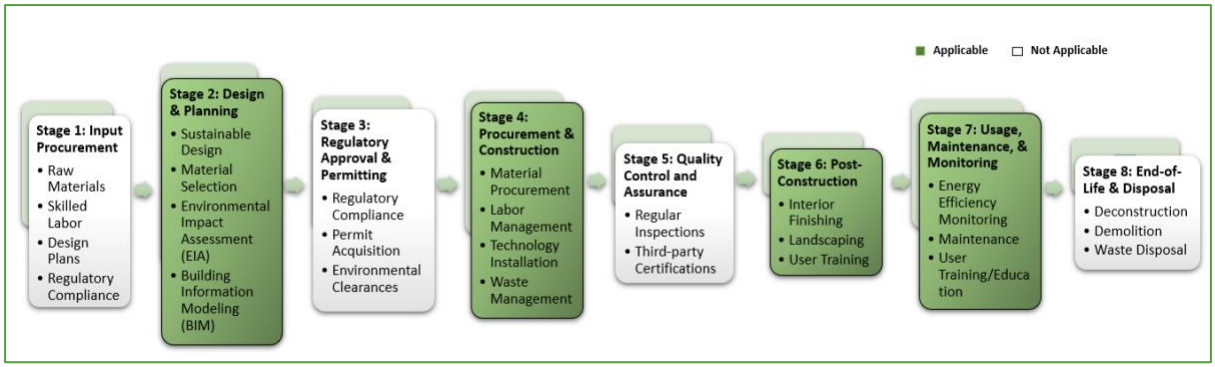

Figure 3 - Skills in Construction Value Chain

1. Architecture & Engineering

In the context of green building structures, architecture and engineering are of utmost importance. Architects and engineers are responsible for making buildings that not only look good but also have a minimal impact on the environment. They ensure that the construction uses sustainable materials and energy-efficient systems. Moreover, they strike a balance between making the building environmentally friendly while still being visually appealing and fitting into the local culture. In simple terms, architects and engineers are crucial for turning regular buildings into eco-friendly and energy-efficient green structures.

Within Pakistan's construction landscape, a multitude of architectural firms and engineers thrive, proficiently versed in various architectural styles and building engineering disciplines. Their expertise extends to the aesthetics, functionality, and cultural context of structures. However, a significant gap persists in the availability of expertise in sustainable and eco-friendly design practices. This shortage of firms dedicated to green design limits the widespread integration of sustainable principles into construction projects.

2. Construction Management

Construction management plays a crucial role in ensuring the successful execution of construction projects. Construction management is of vital importance Professionals in this field are responsible for overseeing all aspects of a project, including scheduling, budgeting, and quality control ensuring that projects are completed on time and within budget while maintaining high standards of quality. Construction management is essential for the efficient allocation of resources, preventing delays, and managing costs effectively. This expertise is vital for the construction industry's growth and success.

Pakistan exhibits self-sufficiency in construction management skills. Substantial growth in construction management services has been observed in recent years. This growth has solidified the nation's self-sufficiency in construction management skills, ensuring the timely, budgeted, and high-quality completion of construction projects.

3. Masonry, Concrete Work, Electrical, HVAC, Plumbing, and Carpentry Skills

Trades skills in masonry, concrete work, electrical, HVAC, plumbing, and carpentry are the backbone of the construction industry in Pakistan, these skills are essential for creating strong and durable structures. Masons and concrete workers lay the foundation and build the structural framework, ensuring stability. Electricians and HVAC technicians install crucial systems for power and climate control. Plumbers set up water supply and drainage systems, while carpenters add the finishing touches. These trade skills are really important to utilize green construction materials to the fullest. If expertise is not available in this domain then the availability of green materials is of no use.

A considerable labor force in Pakistan possesses a high level of proficiency in critical construction trades. These skills encompass masonry, concrete work, electrical work, HVAC installation, plumbing, and carpentry, collectively forming the foundation of construction endeavors. These skilled individuals form the backbone of construction projects, contributing significantly to the creation of sturdy foundations and structures.

ASSESSMENT OF CERTIFICATION AND REGULATORY BODIES

The assessment of certification and regulatory bodies in building the value chain is shown below (Figure 4), and carried out as follows:

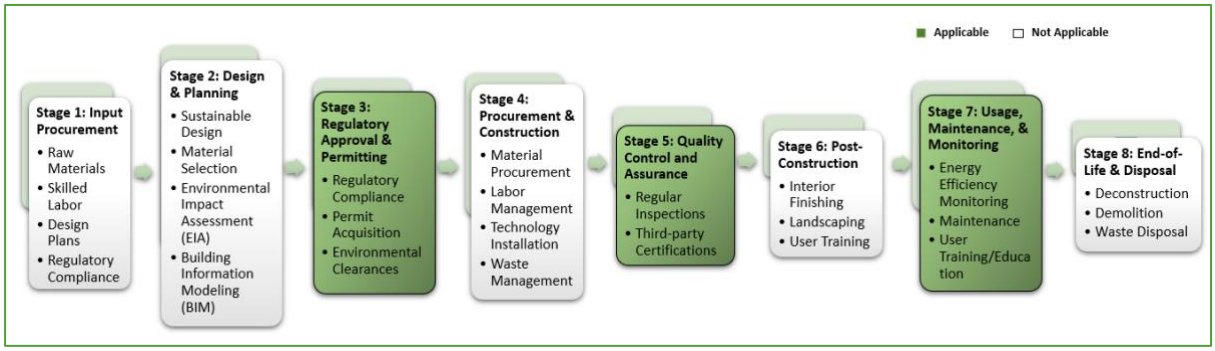

Figure 4 - Regulatory and Certification Bodies in Construction Value Chain

1. Green Building Certification System

Green building certification systems hold particular significance in Pakistan's construction industry, primarily concerning building materials. These systems play a crucial role in advancing sustainability by ensuring that construction projects utilize eco-friendly materials, thus reducing the environmental impact. Green building certification can play a crucial role in advancing sustainable development and reducing the environmental impact of the built environment in Pakistan. It is primarily driven by **LEED certification** and supplemented by local initiatives, such as the **Green Building Certification System (GBCS)** launched by the **Pakistan Green Building Council (PGBC)** and **National Green Building Standards by The Pakistan Engineering Council (PEC).** It promotes sustainable construction practices and recognizes buildings that meet specific environmental criteria. One of the few firms that provides this service to the country is **EDGE green building certification**. EDGE provides a simple and easy-to-use interface that can calculate and evaluate the environmental impact of the building design as well as energy efficiency and water conservation of the building by taking some inputs from the user.

2. Regulatory Bodies for HVAC, Safety, and Water Conservation

The importance of regulatory bodies and standards for HVAC (Heating, Ventilation, and Air Conditioning), safety, and water conservation in the construction industry, particularly in green building projects, cannot be overstated.

HVAC (Heating, Ventilation, and Air Conditioning), building safety, and water conservation standards in Pakistan are established and regulated by various authorities to ensure the well-being of occupants, prevent structural failures, and mitigate potential hazards. Here are the key organizations involved in setting building safety standards in Pakistan:

- **Pakistan Engineering Council (PEC):** The Pakistan Engineering Council is the regulatory body responsible for overseeing the engineering profession in Pakistan. PEC sets and enforces standards related to building design, construction, and safety. It develops the Pakistan Building Code (PBC), which provides guidelines for structural design, fire safety, electrical systems, water conservation, HVAC, and other aspects of building safety.
- **National Engineering Services Pakistan (NESPAK):** NESPAK is a leading engineering consultancy firm in Pakistan that provides expertise in various engineering disciplines, including building safety. NESPAK works closely with government organizations and local authorities to develop and update building codes and standards. They provide consulting services and ensure compliance with building safety regulations, water conservation, and HVAC.
- **Local Development Authorities**: Local development authorities, such as the Lahore Development Authority (LDA), Karachi Development Authority (KDA), and Capital Development Authority (CDA), oversee building and construction activities within their respective jurisdictions. These authorities enforce building codes, bylaws, and regulations to ensure compliance with given standards.
- **National Disaster Management Authority (NDMA):** The National Disaster Management Authority is responsible for disaster risk reduction and management in Pakistan. NDMA plays a role in establishing guidelines and regulations related to building safety in areas prone to natural disasters, such as earthquakes, floods, and cyclones. They provide recommendations for designing structures to withstand such hazards.

- **Punjab Emergency Service (Rescue 1122):** Rescue 1122 is an emergency service provider in Punjab province. While not primarily responsible for setting safety standards, it plays a crucial role in responding to emergencies and enforcing safety protocols during rescue operations. They provide guidelines for fire safety and emergency evacuation in buildings.

- **International Standards:** Pakistan often adopts international building safety standards and guidelines. These include standards from organizations such as the International Code Council (ICC), the International Organization for Standardization (ISO), and the American Society of Civil Engineers (ASCE). International standards provide references and best practices for various aspects of building safety.

Value chain analysis shows the presence and absence of materials, technology, design features, and energy appliances regarding green buildings. There is a lack of firms supplying green materials, features, and expertise in this area, which is discussed in the identified gaps section as follows.

IDENTIFIED GAPS

While the construction industry in Pakistan exhibits a range of skills, significant gaps and challenges remain:

- **Limited Expertise in Sustainable Practices:** Across multiple segments, there is an overall lack of expertise in sustainable and eco-friendly practices. This gap includes the knowledge and skills needed to implement sustainable design, construction, and operational practices. Addressing this gap is essential for promoting environmentally responsible economic revitalization.
- **Inadequate Specialization in Green Building Certification:** The expertise required for green building certification is not readily available in most segments. Professionals who can navigate certification systems like LEED and ensure compliance with environmental criteria are in short supply. Bridging this gap is crucial to achieving sustainable and energy-efficient construction.
- **Regulatory Compliance Expertise:** The segments generally lack sufficient human resources with expertise in regulatory compliance, particularly related to safety, HVAC standards, and water conservation. Regulatory bodies and standards play a crucial role in ensuring building safety and environmental performance. Addressing this gap is essential for maintaining compliance with building codes and environmental regulations.
- **Limited Human Resources for Sustainable Materials and Techniques:** There is a gap in the availability of human resources knowledgeable in sustainable materials and construction techniques. These professionals are needed to promote the use of eco-friendly materials and construction methods that align with sustainability and conservation principles.
- **Insufficient Skilled Workforce in Specialized Trades:** While there is a skilled labor force in trades like masonry, concrete work, electrical work, HVAC installation, plumbing, and carpentry, there may be gaps in specialized skills required for sustainable and energy-efficient construction practices. Building a skilled workforce in these specialized trades is essential for high-quality and sustainable construction.

RECOMMENDATIONS/SOLUTIONS/STRATEGIES

To address these identified gaps and facilitate economic revitalization through green building construction, a series of strategic recommendations and solutions are proposed:

HUMAN RESOURCE CAPACITY BUILDING

Building the capacity for adopting green buildings involves a comprehensive approach that encompasses both skilled and unskilled manpower. Given some strategies and training activities to consider these can be grouped based on the audience and target sector

Green Building Workshops, Seminars, and Training Initiatives Organize **workshops and seminars** to introduce the concepts of green buildings, green building materials, their benefits, and the environmental impacts of conventional construction. Also, **develop online/onsite courses** or

webinars that provide an overview of green building principles, practices, and technologies adopted**.** Further, **collaborate** with green building organizations, industry experts, and NGOs to develop and deliver training programs.

Public Awareness

Launch public awareness **campaigns** to educate homeowners, developers, and the general public about the importance of building codes, energy efficiency, and sustainable construction practices. Further, provide easily accessible online resources, guidelines, and toolkits to help stakeholders understand and comply with building codes.

Training for Professionals

Offer **training programs** and workshops for architects, engineers, builders, and local government officials to enhance their understanding of the latest building codes and green building practices and design training programs focused on specific **green building technologies**, such as energy-efficient HVAC systems, renewable energy integration, rainwater harvesting, etc. Further, introduce **certification programs** for construction and building inspection professionals to ensure they have the necessary expertise to enforce and monitor codes effectively and conduct **workshops on sustainable design** principles, energy-efficient architecture, passive design strategies, and using sustainable materials. Also, teach the design and installation of **rainwater harvesting systems** to reduce water consumption. Also, provide knowledge about reusing grey water for non-potable purposes.

Training for Labor

Educate workers on **waste segregation**, recycling practices, and proper disposal methods on construction sites and provide **practical training sessions** where individuals can work with green building technologies under supervision. Further, train construction workers in techniques for reducing construction waste, efficient resource use, and proper installation of green technologies.

The strategies and training activities proposed for human resource capacity building are essential to promote green building practices in Pakistan. By raising awareness and providing training in green building concepts, public awareness campaigns, and professional development, these initiatives can significantly contribute to the adoption of eco-friendly construction methods. The introduction of certification programs and workshops for professionals ensures the necessary expertise for enforcing green building codes effectively. Ultimately, these actions lay the foundation for a more sustainable and environmentally responsible construction industry in Pakistan.

STRENGTHENING COMPLIANCE AND ENFORCEMENT

Local Capacity

Establish **specialized teams** at the local level tasked with monitoring and enforcing building codes. These teams should consist of trained inspectors, engineers, and other relevant professionals. While also **fostering collaboration** between local authorities, professional associations, and construction industry stakeholders to enhance enforcement efforts.

Technology and Data Management

Develop **digital platforms** for submitting building plans, permit applications, and inspection requests. Implement electronic record-keeping to improve transparency and accessibility of enforcement data. Further, utilize **remote monitoring** technologies, such as drones and satellite imagery, to conduct inspections and verify compliance with building codes.

Review and Continuous Improvement

Establish a **schedule for periodic reviews and updates** of human resource capacity building to ensure they remain aligned with technological advancements, best practices, and changing environmental concerns and **solicit feedback** from industry stakeholders, professionals, and the public to identify challenges, gaps, and areas for improvement in the enforcement process. Also, develop key performance indicators (KPIs) to measure the effectiveness of building code enforcement efforts, including compliance rates, energy savings, and environmental impact.

By developing a robust policy framework, building local capacity, leveraging technology, and fostering collaboration, Pakistan can create a more effective and efficient system for enforcing building codes. Continuous review, stakeholder engagement, and data-driven decision-making will be essential for ensuring the long-term success of these efforts and promoting sustainable and resilient construction practices across the country.

PROCESS FOR IMPLEMENTATION OF GREEN BUILDING CODES AND CERTIFICATION IN PAKISTAN

The implementation and actualization of the Green Building Code can be achieved by following the steps below:

- Establish a **Green Office coordinator** and a team to plan a practical environmental program.
- The detailed plan should have a different stage **assessment strategy**. For example, dividing the building construction into three stages the base structure assessment, the grey structure assessment, and the final building assessment.
- For all chosen indicators for assessment, numeric **objectives**, benchmarks, and monitors are set to fulfill the assessment process.
- The final building assessment, specifically checks the environmental aspects of the building, including energy efficiency, ventilation, waste reduction, recycling, and water conservation aspects.
- Special attention be paid to green issues in **procurements** and the purchase of green smart building materials. Incentives be given to industries manufacturing smart building materials solar chips, ash bricks, PVC, etc.
- **Annual reports** be compiled and set to the regulatory offices for audit purposes and certification purposes.
- **Training and certification** of the Project development offices, and district offices development could be done. Thus, only certified people are allowed to perform different tasks/ jobs in the construction industry.
- Incentives for the construction of green buildings, as **tax relaxations/ subsidies** could be given to real estate contractors

- Quick and efficient **e-approval** process be implemented. File approvals or approvals from CDA could be done by adding a separate swift digital platform by the name of Green Dream/ Green Building/ Green Society etc
- For industrialists, who are producing green technology or materials, incentives be given in terms of relaxing the caps and allowing trade by increasing the production units
- Designated **certified firms** or individuals be allowed in the construction industry
- Acquiring licenses for the engineers or contractors could be made compulsory. For certified/licensed engineers and contractors, who have proven themselves by constructing green smart projects, awards and relaxation in license renewals be given
- **Clean development mechanism** (CDM) projects be initiated with the coordination of local industry and foreign partners for long-term sustainability and SDG achievement.

Figure 5 - Process for Implementation of Green Building Codes and Certification in Pakistan

RECOMMENDATIONS FOR TECHNOLOGICAL IMPLEMENTATION OR ADOPTION

The **implementation of technology**, especially in government and policy institutions, is a key focus. Some suggestions to help with this include conducting a thorough assessment of Pakistan's ecological region to determine the availability of raw materials for making **smart building materials**, as Pakistan has abundant natural resources. Additionally, it is important for **academia and research** institutions to better understand the challenges faced by industries. Instead of seeking random ideas, they should conduct research based on **industry needs**. For instance, **research grants** can focus on finding low-cost, smart bricks for construction. Providing incentives and tax exemptions to industries involved in making smart building solutions is another recommended step. Furthermore,

reducing the import of smart building equipment can support local industry growth and generate employment opportunities.

Educating people, training professionals and workers, enforcing green building rules, and supporting local industries in making materials are key recommendations for green materials in Pakistan. The report also suggests using available resources for smart building materials, promoting research that aligns with industry needs, providing incentives to local industries, and reducing imports of building equipment. These steps can help Pakistan transition to greener and more sustainable construction practices.

4. CONCLUSION AND WAY FORWARD

This report highlighted the significance of adopting green building practices in Pakistan to reduce greenhouse gas emissions, lower energy consumption, and ultimately, enhance the country's economic and environmental sustainability. Green building materials, design features, and energy-efficient appliances offer substantial cost savings, good BCR (Benefit-to-Cost Ratio), and good returns on investment with feasible payback periods. Alongside, there are long-term benefits, with a potential energy reduction of up to 30% in all aspects such as materials, design, and energy-efficient appliances. Also, various factors influence construction costs, including economic, environmental, and social aspects, making green building practices a favorable choice. To facilitate this shift, the report suggests strategies such as financial incentives, awareness and education initiatives, local sourcing, research funding, collaboration, and market transformation by professionals. By implementing these strategies, Pakistan can bridge the financial gaps in green buildings and promote sustainable construction practices, benefiting both the economy and the environment.

Furthermore, Pakistan's construction industry holds significant potential for green building practices. While it possesses a large labor force and some local sources of sustainable materials, there are notable gaps in expertise, green certification, and regulatory compliance. Addressing these gaps through capacity building, awareness programs, and enforcement measures is essential for fostering sustainable construction and economic revitalization. The adoption of technology and support for local industries can further drive progress. Transitioning towards green building practices will not only benefit the environment but also contribute to Pakistan's long-term economic growth and improved quality of life.

Moving forward, Pakistan should take action on the recommendations provided in this report. This includes creating and enforcing green building rules, offering financial incentives, and educating people about green construction. Promoting local materials, supporting research, working together, and making sure everyone follows the rules are equally important. Using technology and cooperation between the government and private sector will be crucial and periodic evaluation and adjustment of strategies will ensure the country remains on a sustainable path. By doing this, Pakistan can benefit from green building practices, leading to better economic growth, a healthier environment, and a better lifestyle for its citizens.