

Midocean University



College of Management

Master of Project Management

**The Impact of the Green Building Materials on
Sustainable Development in Riyadh**

أثر استخدام مواد البناء الخضراء في التنمية المستدامة بالرياض

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Abstract

Green building materials (GBMs) are environmentally friendly compared to their traditional counterparts. Using of green building materials (GBMs) in achieving sustainable buildings is well recognized by the global construction industry. However, the major challenges of using the GBMs are information, awareness, incentive, and hard and soft logic regulations which are still limited in Riyadh either by local authorities, investors, consultants' offices, contractors, and suppliers.

Focused studies on how green building materials contribute to sustainable development are limited for Riyadh. This paper aims to provide systematic and comprehensive insights on current trends and future potentials of green building materials research by analyzing the existing literature reviews with their research features (i.e. research backgrounds, goals, and outputs), and using a mixed-methods approach, incorporating both quantitative and qualitative methods.

Keywords: Green Building Materials, Sustainable Development, Riyadh.

Introduction

Sustainable development has recently become central to international policy discussions [1]. The Kingdom of Saudi Arabia is committed to implementing sustainable development goals, placing them as a top priority in line with its specific principles. The Kingdom's vision 2030 as a whole is consistent with the sustainable development goals [2]. This scientific research aims to explore the impact of green building materials on sustainable development in Riyadh, Saudi Arabia and will investigate for other issues. Because the impact of building materials differs based on contamination and the material's function in each stage of its life cycle production from cradle to grave. Green materials with low or no impact on humans and the environment can decrease embodied energy, energy consumption (Papadopoulos and, CO₂ emission, indoor air pollution, and recyclability. This strategy is required to achieve sus-tainability in building materials. The mainstream theory for sustainability has become the idea of three pillars (3Ps): environmental, social, and economic sustainability. These 3Ps have been drawn in a variety of ways: pillars concentric circles, or interlocking circles. Therefore, applying sustainability to materials selection requires achieving all 3Ps of sustainability [3].

Through a comprehensive literature review and collecting the data by analysis of the questionnaire (survey), and samples the research provides insights into the potential of green building materials to mitigate environmental impacts and promote sustainable development in Riyadh. The findings of this study will contribute to the existing knowledge of green building practices and inform architects, and developers in their efforts to create more sustainable urban environments.

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Chapter 1 Theoretical Framework of the Study

Research Problems

As mentioned, the focused studies on how green building materials contribute to sustainable development are limited for Riyadh, therefore the researcher has major challenges to collect, list, and discuss the previous studies combined with using a mixed-methods approach, incorporating both quantitative and qualitative, the questions are the following :

Main question

1- What is the green building materials impact on the sustainable development (economic, environmental, and social) in Riyadh?

Sub-questions

2- What are the benefits and challenges associated with the use of green building materials in the context of sustainable development in Riyadh?

3- What the existing policies and regulations related to green building materials and their effectiveness in promoting sustainable development in Riyadh?

4- What is the current level of awareness and adoption of green building materials in Riyadh?

5- What is the main criteria for green building materials selection?

6- What are the recommendations and strategies for enhancing the implementation of green building materials in Riyadh and achieving sustainable development goals?

The Importance and Objective of the Research

After Reviewing the previous studies, there is deeply lack of literature reviews (theoretical aspect) to show the impact of green building materials on sustainable development in the Arab world, especially in Riyadh city, therefore the researcher generated five objectives and he will also employ a mixed-methods approach, incorporating both quantitative and qualitative methods in order to enable the searcher to find real answers and conclusions.

A survey (practical aspect) will be conducted to collect data on the current use of green building materials in Riyadh, including their adoption rate, availability, and challenges faced by stakeholders in order to explore their perspectives on green building materials and their role in sustainable development, the objectives are the following:

Objective # 1: Evaluate the economic, environmental, and social impacts of green building materials in R i y a d h .

Objective # 2: Identify the benefits and challenges associated with the use of green building materials in the context of sustainable development and the main criteria for GBM's selection.

Objective # 3: Analyze the existing policies and regulations related to green building materials and their effectiveness in promoting sustainable development.

Objective # 4: Assess the current level of awareness and adoption of green building materials in Riyadh.

Objective # 5: Provide recommendations and strategies for enhancing the implementation of green building materials in Riyadh and achieving sustainable development goals.

Research Hypotheses Development

To achieve the objectives of the research, the researcher will be looking for facts and evidence for the following hypotheses:

Hypothesis # 1: There is a significant impact of using green building materials on the economic, environmental, and social in Riyadh.

Hypothesis # 2: There are the benefits and challenges associated with the use of green building materials in the context of sustainable development.

Hypothesis # 3: There is a significant relation between the existing policies and regulations to green building materials and their effectiveness in promoting sustainable development.

Hypothesis # 4: There is a significant impact of the current level of awareness and adoption on using of green building materials in Riyadh.

Chapter 2 Literature Review

Green Building Materials

The study of [4] linked to hyp. # 1, aim to achieve reducing carbon dioxide emissions is through **building insulation**. Thermal insulation plays a significant role in energy conservation and sustainable development in civil engineering. Older construction materials such as roof and wall units have high thermal transmittance, but this can be significantly reduced by adding insulation material. In this study, we aimed to evaluate the performance of different insulation materials on conventional buildings. We found that while U-values were low in non-insulated conventional buildings with subsequent high temperatures, insulated roofs and walls had high U-values. We measured the thermal conductivity values of different insulating materials and found that polyurethane foam had a K-value of 0.01 with a density of 35–40 kg/m³. We applied various thicknesses of insulation and non-insulation materials to achieve the recommended U-factor and R-value according to the ECBC criteria for conventional buildings. Keeping in view the above objective following conclusions were found with the application of polyurethane.

The study of [5] linked to hyp. # 1 aims to achieve **production of about 50% of renewable energy** from the total energy that Saudi Arabia needs based on solar plants. The construction projects are still not clearly considered in the policies and regulations. The construction projects contribute only 1.6% based on the official renewable energy 2020 statistic. Therefore, a holistic study as an assessment and evaluation approach for the selected case study inside a university campus as a public construction project in Saudi Arabia was conducted. The aim of this study was to provide a pioneering example for achieving a retrofitting process and a near zero energy

campus to support the Saudi Arabia 2030 Vision. The holistic study explored the quantity of contributions in improving the energy performance and updating the bidding documents to achieve advanced ranking in the construction sustainability standards. The selected case study from the campus projects was the shell envelope of the talent and research center project. This project was under construction and was registered in the LEED to obtain the golden certificate in sustainability with a total of 68 points (37 points in the design phase and potential 31 points in the construction phase). By applying the holistic approach and analysis for the entire contract documents for the shell envelope, significant goals were achieved. PVsyst V7.1.0 software was used for solar analysis to redesign and implement the steel dome covered with 30% double structured glass and 70% composite aluminum on a surface of 9500 m² to give 4750 active BIPV solar panel panels on the entire surface of the case study building. It involved two comparative analysis stages. The significant goals included the upgrading of the building energy performance by generating electricity with approx. 925 kWp and about 1,320,000 kWh/year, which covers 68% of the energy building needs, achieving an annual saving of about 436 thousand riyals annually. The significant goals also include the building's upgrading in the sustainability rating system from gold certificate to platinum certificate based on energy performance by obtaining another 20 points in credit EAc1: optimize energy performance and credit EAc2: on-site renewable energy. Other significant results include reducing 7 tons of CO₂ annually and saving oil burning consumption to about 7 Barrels/m². In addition, the cost of the proposed solar BIPV modules is less than the cost of the design bidding item, and transparency increased. Since all building roofs were designed as outdoor areas, this enhances the positive visual interaction between the outdoor and the indoor and the psychological comfort of the building's occupants.

The study of [6] linked to hyp. # 1 &3, about the **challenges and regulations** for using green building. The Saudi government's circular carbon initiative provides other solutions to the barriers to green building adoption, as these initiatives directly acting upon climate change ensure the reach of clean and cheap energy. All businesses are encouraged to take not only circular carbon initiatives to support the government's CCE program, but also offer different incentives for adopting environmentally friendly policies. Therefore, CCI may play an important role in eliminating key barriers to the adoption of green buildings. For this purpose, the government of Saudi Arabia has taken many initiatives in alliance with four key factors: reduction, recycling, reuse, and removal. Under the heading of reduction, the KSA launched an energy efficiency and conservation program in 2012 that covers key energy efficiency activities practiced across different sectors, including industry, buildings, and transportation, satisfying 90% of the energy demand of the country. Approximately 35 initiatives focus on capacity building, governance, public awareness, energy efficiency standards, benchmarks, and specifications (Shehri et al, 2022). Second, fuel is switched from oil to natural gas reserves to reduce the country's oil consumption for power generation by 2030. Third, there is an increased reliance on the use of nuclear and renewable energy to overcome environmental concerns. Although the Saudi government is looking for recycling solutions and possibilities for biofuel production, there is still no recycling potential in the country (IEA, 2020). Next, to build reuse capacity, the Saudi government is largely funded by research and development but still falls behind because the largest industrial city of Jubail is only partially eligible to reuse CO₂, following the CCE guidelines (Shehri et al, 2022). Finally, the country is still struggling to eliminate the negative effects of carbon emissions to overcome environmental problems. Therefore, based on the initiatives taken by the Kingdom of Saudi Arabia, the study concludes by integrating green initiatives with CCI initiatives

to overcome the potential barriers to the adoption of green concepts in the country, particularly green buildings. This could be the best way to encourage businesses to adopt green solutions to support the government's CCE program.

The study of [3], The development of a green material index was the prime objective of the study, and a model has been successfully applied in ranking building materials to provide the best solution for a green and sustainable project. A total of 23 criteria were identified thorough literature review and discussion with selected experts in the use of green materials for building projects. By considering a hybrid MCDM methodology, the study tried to resolve multiple incompatible and conflicting GBM criteria to align with 3Ps sustainability. Obtained results indicate that the relationship between GBMs and sustainability criteria are different based on the separate 3Ps of sustainability. The GBM criteria prioritizing and aligning with the sustainability criteria revealed that affordability is one of the important GBM criteria in the selection procedure that assembles materials with life-cycle cost specifications comparable to conventional materials. Resource efficiency was highlighted as the second most important criteria. The results suggest that natural, renewable, and recycled content are resource-efficient criteria for GBM selection. The embodied energy was weighted as the third specification for the energy efficiency term in GBM selection. Additionally, non-toxic materials with low-VOC assemblies highlight the indoor air quality characteristic in the GBM selection procedure. The final criteria ranking considering the social aspect highlights the IAQ categories for GBM selection as a health issue, particularly using natural and renewable resources and energy efficient materials during the life product of materials. Consideration of these criteria will ensure a green material selection and consequently a sustainable development in building design and construction. The present study is only a tentative beginning in this direction. This research has opened up opportunities for

further research in selecting the best green building materials. The findings in this research can be further extended and modified to accomplish the ultimate goal of promoting and improving green practices in construction. The evaluation and results can provide a valuable reference for building professionals who seek to enhance sustainable construction through green materials.

The study [22], talks about life cycle of construction and demolition waste (CDW). Large cities in the Gulf region are producing a large quantity of CDW annually. Being one of the largest cities and the capital of Saudi Arabia, Riyadh is currently producing over 8 MTPA from 15 municipalities covering all the important regions of the city. To meet the sustainable development goals of KSA Vision 2030, the entire city is going through extensive construction and demolition activities. The present study assessed the potential environmental impacts of the current (and planned) CDW management system of Riyadh City using Impact 2002+ LCIA methodology. The assessment results revealed that MSSR recycling significantly avoided the potential impacts of “non-renewable energy”, “carcinogens”, and “global warming” midpoint environmental impact categories generated by landfilling. The study also found that concrete block recycling significantly avoided the human health impacts of “non-carcinogens” and “respiratory inorganics” generated by landfilling. In addition to the direct avoided impacts of landfilling, conversion of CDW into different sized (0–50 mm) aggregates can replace 10–100% virgin aggregates in several construction activities, including backfilling applications, encasement and bedding of water mains and sanitary and storm sewers, manufacturing of internal walls and manholes, non-load bearing walls, encasement of water and sewerage linear assets, and construction of farm-to-market roads. These results encourage the 15 municipalities in Riyadh City to actively participate in source segregation, handling, and storage of CDW to enhance the effectiveness of MRF operated by SIRC in Riyadh City. With the support of the municipalities, SIRC can effectively improve the existing 45% recycling rate to 100% in next five years and finally

progress toward a zero-waste scenario in line with the KSA Vision 2030. Undoubtedly, SIRC needs to make every effort to implement its CDW management plans in the given timeframe. To attain the environmental benefits of CDW reuse and recycling, the outcomes of the present study need to be validated at each development stage (capacity enhancement, process change, and practices) of the existing facility.

The study [23] talks about green bricks, Four types of bricks are considered in this study and after comparing all the types, type 2 brick performed better with 8.72 N/ mm² compressive strength with 5.16% water absorption followed by type 4, type 3 and type 1. Concrete brick blocks were tested for 35%, 45% and 55% replacement of cement by GGBS for M30 grade of concrete and, higher compressive and flexure strengths were obtained at 45% replacement of cement by GGBS. It was found that cost of green bricks when calculated for selected layout was 48.9% more than conventional bricks but, total numbers of green bricks were 75% lesser due to flexibility of casting larger size than conventional bricks that makes easier handling and increase speed of construction. The cost of green concrete having 45% cement replacement with GGBS was around 48% lesser than conventional concrete when estimated for chosen layout that makes green concrete more economical when adopted. By conducting this study on selected villa type, it was observed 48% reduction in CO₂ footprint that makes it more environmentally friendly and sustainable solution when compared with conventional concrete.

The study [27] talking about the passive cooling techniques. The traditional communities in the Gulf region were constructed in a manner that aimed to reduce the amount of open space, enhance solar shading, and protect inhabitants from the harsh effects of direct sunlight. The creation of a shaded environment was achieved through the implementation of various techniques, including form-space scale, alley width, open social areas, and covered alleys. Passive cooling techniques

encompass various strategies such as shading, glazing, insulation, and green roofing. The provision of optimal shade through the day is facilitated by shaded areas, whereas heat gain and loss are mitigated by glazing systems. Insulation serves the purpose of preserving indoor thermal comfort by reducing heat transfer and limiting heat gain in the summer months. The implementation of green roofing, whether in the form of intensive or extensive systems, has been shown to effectively mitigate heat transfer into residential spaces, production and mitigating the impact of urban heat islands on ambient temperature.

The study [28] , **Green roofs** are an innovative solution to help mitigate some of the negative environmental impacts of buildings, such as energy consumption and stormwater runoff. They consist of a layer of vegetation and soil, installed on top of a building's roof, which provides a range of environmental benefits. However, to fully realize the potential of green roofs, they need to be integrated into building regulations in similar climatic conditions. By integrating green roofs into building regulations, it would become mandatory for new buildings to include green roofs in their design. Additionally, existing buildings could be retrofitted with green roofs to help reduce their energy consumption and stormwater runoff. The layers required for green roofs would need to be carefully selected to ensure they do not affect the structural integrity of the building as shown in the previous case study. It is worth noting that the energy savings from green roofs depend on the specific design and materials used, as well as the climate in which the building is located. However, green roofs also offer a range of additional benefits beyond energy savings, such as improving air quality and providing habitat for flora and fauna.

The study [29] talks about **replacing the cement and aluminum by others**. It is hoped that, in Saudi Arabia, sustainability and resilience can be integrated to the maximum extent at earliest stages possible within the decision-making processes. The RESAF presented within the paper will help

building construction and design projects create a more favorable long-term legacy at each stage of the material selection process [3]. This was done by illustrating how materials contribute to the two filters of sustainability and resilience. The application of the RESAF tool has shown that minor changes to building material selection (replacing cement with PFA or GGBS) can play a vital role in reducing embodied energy or carbon in the life cycle of materials (by >13%) and the operation of the building (over 22%). It is also worth noting transport practices such as gate-to-grave, which accounted for approximately 12% of the embodied kgCO₂e through RESAF application, is more readily considered. Whilst some choices (i.e., introducing more insulation and adoption of triple-glazed PVC windows) increase the embodied carbon of the building itself (1%), this is far outweighed by the annual savings they bring (17%), which leads to a considerable multiplying effect (between 50 and 100 times) over the lifetime of the building. These are important findings for Saudi Arabia, as they showcase tangible reductions in the environmental effects when using a RESAF.

Sustainable Development Goals (SDGs) and Correlation between Green Building Materials and Sustainable Development

The SDGs are not only a public policy framework; they are an ethical imperative. As per Sustainable Development Report 2023, (Published by Dublin University Press) [8]. Provincial, metropolitan, and city governments are typically at the front line in achieving the SDGs. Nearly 60 percent of the world population now lives in urban areas, and that proportion is likely to rise to at least 70 percent, and probably higher, by mid-century. Moreover, cities constitute at least 85 percent of total world output and energy use. What happens in cities will determine the future of the world, and the success or failure in sustainable development. Local governments have the front-line responsibility for implementing universal health systems, places in school for all children, safe water and sanitation, public transport services, adequate housing, and physical safety in the local environment (from

crime, toxic wastes, and natural hazards). This is why mayors and city councils around the world have rallied to the SDGs, even if their local leadership is sometimes under-appreciated and under-noted because national governments tend to hold the limelight at the United Nations, with the MDBs, and in the media. Cities face one other chronic problem. While they are largely responsible for service delivery, it is national governments that, by and large, collect revenue to fund public investments and social services. Cities are therefore caught between front-line responsibility and back-of-the line access to the necessary public financing. SDSN recognizes this gap in the practical means of implementation of city governments, and is currently working with the major urban think tanks and global urban networks (including the C40 and ICLEI) to address the challenge of sub-national financing of the SDGs. The SDGs are facing strong headwinds. Despite significant efforts in some places, national governments on all continents have fallen short in integrating the SDGs into national policies and public investments. Moreover, societal polarization, populism, and growing geopolitical conflict are hindering the global cooperation needed to achieve the SDGs. Civil society, including academic institutions is becoming more constrained in the midst of intensifying political tensions. The international financial architecture is failing to channel global savings to SDG investments at the needed pace and scale. The UN Sustainable Development Solutions Network (SDSN) is dedicated to finding and amplifying practical solutions to achieve the SDGs and closely related global goals (such as the Paris climate agreement and the Kunming-Montreal Biodiversity Framework). We emphasize that all these global goals are interrelated and must be achieved together. Members of the SDSN Leadership Council offer the following assessments and recommendations to the UN Member States, the United Nations Agencies, international finance institutions, business, and civil society, based on more than a decade of research, measurement, advising, and partnerships across the world.

The SDGs are seriously off track (Figure 2.1). SDG progress was already very slow in the five years to 2020. According to the annual SDG Index, global achievement of the SDGs rose only slightly, from 64 percent in 2015 to 66 percent in 2019 – far too slowly to meet the goals by 2030, and with highly uneven progress within and between countries. Then with the onset of the pandemic, progress stopped. As of 2022, the global SDG Index is below 67%. The multiple geopolitical crises in the world today will no doubt place further obstacles on the path to 2030. If we look at each of the 17 individual SDGs, not a single SDG is projected to be met at the global level.

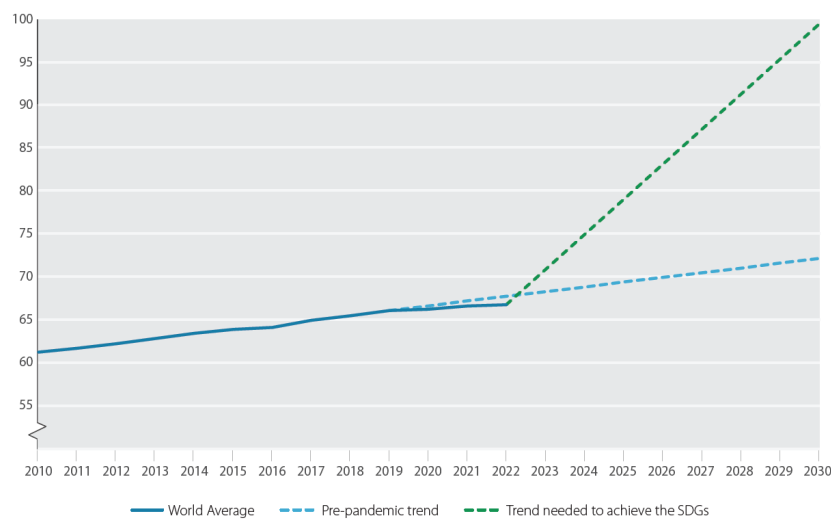


Figure 2.1 SDG Index world average: pre-pandemic trend and trend needed to achieve the SDGs by 2030

The SDG Index is an accountability tool, but it is also a tool to highlight data gaps and areas where further effort is needed to strengthen data availability and timeliness. Overall, this year's edition includes 97 indicators. Yet the SDG Index score and rankings can be explained through a handful of key indicators. Using 17 "headline" indicators that cover SDSN's Six SDG Transformations and other major principles, including leave no one behind, good governance, and the concept of international spillovers, we find a very high and statistically significant correlation (both in terms of scores and ranks) with the overall SDG Index. These indicators are:

- (1) Poverty headcount ratio at US\$2.15/day,
- (2) Prevalence of undernourishment,
- (3) Life expectancy at birth,
- (4) Lower secondary completion rate,
- (5) Share of women parliamentarians,
- (6) Population using at least basic sanitation services,
- (7) Population with access to electricity,
- (8) Unemployment rate,
- (9) Population using the internet,
- (10) GINI coefficient,
- (11) Annual mean concentration of particulate matter of less than 2.5 microns in diameter,
- (12) Imported SO2 emissions,
- (13) CO2 emissions from fossil fuel combustion and cement production,
- (14) Ocean Health Index: Clean Water,
- (15) Red List Index of species survival,
- (16) Corruption perception index, and
- (17) Statistical Performance Index. There are no signs of collinearity among these indicators, [8].

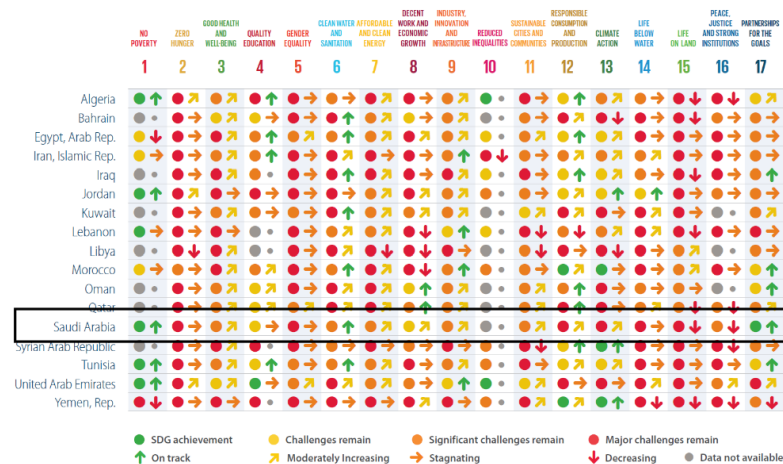


Figure 2.2 2023 SDGs dashboards for Saudi Arabia (levels and trends), [8].

Rank	Country	Score	Rank	Country	Score
89	Cabo Verde	68.8	128	Pakistan	59.0
90	Oman	68.6	129	Gambia, The	58.3
91	Turkmenistan	68.5	130	Syrian Arab Republic	58.2
92	Suriname	68.2	131	Mali	58.0
93	Mauritius	68.0	132	Eswatini	57.9
94	Saudi Arabia	67.7	133	Mauritania	57.2
95	Lebanon	67.5	134	Tanzania	56.8
96	Guyana	67.4	135	Malawi	56.3
97	Panama	67.3	136	Togo	56.3
98	Philippines	67.1	137	Sierra Leone	55.7
99	Nepal	66.5	138	Zimbabwe	55.6
100	Qatar	66.2	139	Cameroon	55.1
101	Bangladesh	65.9	140	Benin	55.1
102	Brunei Darussalam	65.7	141	Uganda	55.0
103	Cambodia	64.8	142	Guinea	54.9
104	Nicaragua	64.8	143	Lesotho	54.9
105	Iraq	64.8	144	Ethiopia	54.5
106	Mongolia	64.7	145	Zambia	54.3
107	Belize	64.6	146	Nigeria	54.3
108	Kuwait	64.4	147	Burundi	53.9
109	Namibia	64.3	148	Papua New Guinea	53.6
110	South Africa	64.0	149	Mozambique	52.7
111	Bahrain	63.7	150	Djibouti	52.7
112	India	63.4	151	Congo, Rep.	52.6
113	Gabon	63.1	152	Haiti	52.6
114	Trinidad and Tobago	63.0	153	Burkina Faso	52.4
115	Lao PDR	63.0	154	Comoros	51.7
116	Honduras	62.9	155	Angola	50.8
117	Venezuela, RB	62.9	156	Madagascar	50.3
118	Botswana	62.7	157	Liberia	49.9
119	Sao Tome and Principe	62.7	158	Afghanistan	49.0
120	Cote d'Ivoire	62.3	159	Congo, Dem. Rep.	48.6
121	Senegal	61.8	160	Sudan	48.6
122	Ghana	61.8	161	Niger	48.3
123	Kenya	60.9	162	Somalia	48.0
124	Bahamas, The	60.9	163	Yemen, Rep.	46.8
125	Myanmar	60.4	164	Chad	45.3
126	Rwanda	60.2	165	Central African Republic	40.4
127	Guatemala	59.4	166	South Sudan	38.7

Figure 2.3 The 2023 SDG index: score and rank, [8].

Scorecard – Transformation 3: Zero-carbon energy systems

Note: Regional and income level averages are population weighted. Details on definitions, sources, and thresholds are available on www.sdgindex.org
Source: Authors' analysis



Transformation 3: Zero-carbon energy systems

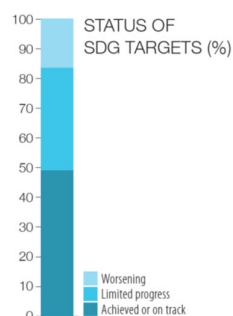
	UN Climate Ambition Alliance Signatory (March 2022, UN)	Law, policy- or NDC-based commitment to reach net-zero emissions by 2050 (April 2023, Energy & Climate Intelligence Unit)	1.5°C Paris-agreement-compatible climate action (April 2023, Climate Action Tracker)	Unconditional fossil fuel subsidies (USD per capita, March 2022, Energy Policy Tracker)
G20 Countries				
Argentina	✓	✓	Highly Insufficient	29.82
Australia	X	✓	Insufficient	65.53
Brazil	X	X	Insufficient	2.71
Canada	✓	✓	Highly Insufficient	537.99
China	X	2060	Highly Insufficient	17.55
France	✓	✓	Insufficient	116.01
Germany	✓	✓	Insufficient	195.23
India	X	X	Highly Insufficient	27.19
Indonesia	X	X	Highly Insufficient	23.66
Italy	✓	✓	Insufficient	65.76
Japan	✓	✓	Insufficient	12.93
Korea, Rep.	✓	✓	Highly Insufficient	97.46
Mexico	✓	X	Highly Insufficient	61.88
Russian Federation	X	2060	Critically Insufficient	35.50
Saudi Arabia	X	2060	Highly Insufficient	158.17
South Africa	X	X	Insufficient	10.66
Türkiye	X	2053	Critically Insufficient	165.68
United Kingdom	✓	✓	Almost Sufficient	589.53
United States	X	✓	Insufficient	217.32
By regions				
East and South Asia	NO DATA	11 of 21	NO DATA	NO DATA
Eastern Europe and Central Asia	14 of 27	20 of 27	NO DATA	NO DATA
Latin America and the Caribbean	21 of 29	18 of 29	NO DATA	NO DATA
Middle East and North Africa	NO DATA	9 of 17	NO DATA	NO DATA
Oceania	12 of 12	6 of 12	NO DATA	NO DATA
OECD members	33 of 38	34 of 38	NO DATA	NO DATA
Sub-Saharan Africa	40 of 49	20 of 49	NO DATA	NO DATA
By income level				
Low-income countries	25 of 27	8 of 27	NO DATA	NO DATA
Lower-middle-income countries	34 of 54	30 of 54	NO DATA	NO DATA
Upper-middle-income countries	32 of 54	33 of 54	NO DATA	NO DATA
High-income countries	43 of 58	47 of 58	NO DATA	NO DATA
More ambitious	signatory	net-zero by 2050	1.5°C compatible	0 USD/capita
Moderately ambitious	N/A	net-zero by 2060	2°C compatible	≤ 50 USD/capita
Less ambitious	not a signatory	no commitment	above 2°C	50+ USD/capita

Figure 2.4 Transformation 3 : Zero carbon energy systems - 2023, [8].

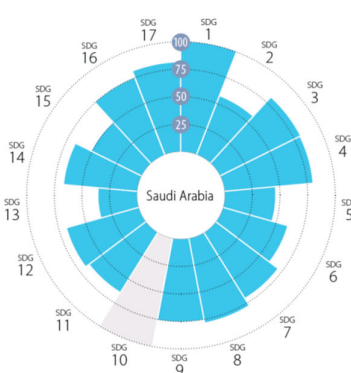
SAUDI ARABIA

Middle East and North Africa

OVERALL PERFORMANCE

COUNTRY RANKING
94/166COUNTRY SCORE
67.7
REGIONAL AVERAGE: 67.1

AVERAGE PERFORMANCE BY SDG

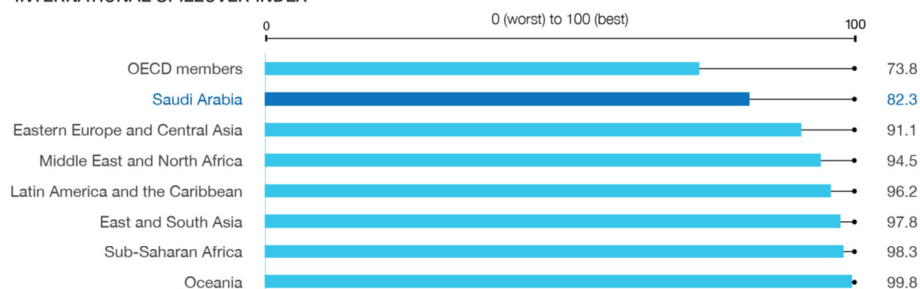


SDG DASHBOARDS AND TRENDS



Note: The full title of each SDG is available here: <https://sustainabledevelopment.un.org/topics/sustainabledevelopmentgoals>

INTERNATIONAL SPILLOVER INDEX



STATISTICAL PERFORMANCE INDEX



MISSING DATA IN SDG INDEX

11%

Figure 2.5 Saudi Arabia profile 1/2 for SDGs - 2023, [8].

SAUDI ARABIA

Performance by Indicator

SDG1 – No Poverty				SDG9 – Industry, Innovation and Infrastructure			
	Value	Year	Rating Trend		Value	Year	Rating Trend
Poverty headcount ratio at \$2.15/day (2017 PPP, %)	* 0.0	2023	● ↑	Rural population with access to all-season roads (%)	61.1	2022	● ●
Poverty headcount ratio at \$3.65/day (2017 PPP, %)	* 0.0	2023	● ↑	Population using the internet (%)	100.0	2021	● ●
SDG2 – Zero Hunger				Mobile broadband subscriptions (per 100 population)	119.5	2021	● ↑
Prevalence of undernourishment (%)	3.7	2020	● ↑	Logistics Performance Index: Quality of trade and transport-related infrastructure (worst 1–5 best)	3.1	2018	● →
Prevalence of stunting in children under 5 years of age (%)	12.4	2022	● →	The Times Higher Education Universities Ranking: Average score of top 3 universities (worst 0–100 best)	50.6	2022	● ●
Prevalence of wasting in children under 5 years of age (%)	4.4	2020	● ↑	Articles published in academic journals (per 1,000 population)	1.3	2021	● ↑
Prevalence of obesity, BMI ≥ 30 (% of adult population)	35.4	2016	● ↓	Expenditure on research and development (% of GDP)	0.5	2020	● ●
Human Trophic Level (best 2–3 worst)	2.3	2017	● →	SDG10 – Reduced Inequalities			
Cereal yield (tonnes per hectare of harvested land)	5.0	2021	● →	Gini coefficient	NA	NA	● ●
Sustainable Nitrogen Management Index (best 0–1.41 worst)	1.2	2018	● ↓	Palma ratio	NA	NA	● ●
Exports of hazardous pesticides (tonnes per million population)	1.0	2020	● ●	SDG11 – Sustainable Cities and Communities			
SDG3 – Good Health and Well-Being				Proportion of urban population living in slums (%)	* 0.0	2020	● ↑
Maternal mortality rate (per 100,000 live births)	16.2	2020	● →	Annual mean concentration of particulate matter of less than 2.5 microns in diameter (PM2.5) (µg/m³)	88.3	2019	● →
Neonatal mortality rate (per 1,000 live births)	3.3	2021	● ↑	Access to improved water source, piped (% of urban population)	NA	NA	● ●
Mortality rate, under-5 (per 1,000 live births)	6.7	2021	● ↑	Satisfaction with public transport (%)	77.0	2022	● ↑
Incidence of tuberculosis (per 100,000 population)	8.2	2021	● ↑	SDG12 – Responsible Consumption and Production			
New HIV infections (per 1,000 uninfected population)	NA	NA	● ●	Municipal solid waste (kg/capita/day)	1.4	2015	● ●
Age-standardized death rate due to cardiovascular disease, cancer, diabetes, or chronic respiratory disease in adults aged 30–70 years (%)	20.9	2019	● →	Electronic waste (kg/capita)	17.6	2019	● ●
Age-standardized death rate attributable to household air pollution and ambient air pollution (per 100,000 population)	91.1	2019	● ●	Production-based SO ₂ emissions (kg/capita)	89.6	2018	● ●
Traffic deaths (per 100,000 population)	18.5	2021	● ↓	SO ₂ emissions embodied in imports (kg/capita)	4.8	2018	● ●
Life expectancy at birth (years)	74.3	2019	● ↑	Production-based nitrogen emissions (kg/capita)	60.1	2018	● →
Adolescent fertility rate (births per 1,000 females aged 15 to 19)	8.2	2010	● ●	Nitrogen emissions embodied in imports (kg/capita)	17.4	2018	● ●
Births attended by skilled health personnel (%)	98.7	2019	● ↑	Exports of plastic waste (kg/capita)	1.2	2021	● ↑
Surviving infants who received 2 WHO-recommended vaccines (%)	97	2021	● →	SDG13 – Climate Action			
Universal health coverage (UHC) index of service coverage (worst 0–100 best)	74	2021	● →	CO ₂ emissions from fossil fuel combustion and cement production (tCO ₂ /capita)	18.8	2021	● →
Subjective well-being (average ladder score, worst 0–10 best)	6.4	2022	● ↑	CO ₂ emissions embodied in imports (tCO ₂ /capita)	1.9	2018	● ↑
SDG4 – Quality Education				CO ₂ emissions embodied in fossil fuel exports (kg/capita)	27,844.6	2021	● ●
Participation rate in pre-primary organized learning (% of children aged 4 to 6)	45.6	2021	● →	SDG14 – Life Below Water			
Net primary enrollment rate (%)	99.4	2021	● ↑	Mean area that is protected in marine sites important to biodiversity (%)	25.3	2022	● →
Lower secondary completion rate (%)	99.9	2021	● ↑	Ocean Health Index: Clean Waters score (worst 0–100 best)	69.2	2022	● →
Literacy rate (% of population aged 15 to 24)	99.5	2020	● ●	Fish caught from overexploited or collapsed stocks (% of total catch)	15.8	2018	● ↑
SDG5 – Gender Equality				Fish caught by trawling or dredging (%)	18.3	2019	● →
Demand for family planning satisfied by modern methods (% of females aged 15 to 49)	* 48.1	2023	● →	Fish caught that are then discarded (%)	6.1	2019	● →
Ratio of female-to-male mean years of education received (%)	92.0	2021	● →	Marine biodiversity threats embodied in imports (per million population)	0.5	2018	● ●
Ratio of female-to-male labor force participation rate (%)	34.7	2022	● →	SDG15 – Life on Land			
Seats held by women in national parliament (%)	19.9	2021	● →	Mean area that is protected in terrestrial sites important to biodiversity (%)	22.0	2022	● →
SDG6 – Clean Water and Sanitation				Mean area that is protected in freshwater sites important to biodiversity (%)	17.7	2022	● →
Population using at least basic drinking water services (%)	100.0	2020	● ↑	Red List Index of species survival (worst 0–1 best)	0.90	2023	● ↓
Population using at least basic sanitation services (%)	100.0	2020	● ↑	Permanent deforestation (% of forest area, 3-year average)	NA	NA	● ●
Freshwater withdrawal (% of available freshwater resources)	974.2	2019	● ●	Terrestrial and freshwater biodiversity threats embodied in imports (per million population)	1.8	2018	● ●
Anthropogenic wastewater that receives treatment (%)	37.7	2020	● ●	SDG16 – Peace, Justice and Strong Institutions			
Scarce water consumption embodied in imports (m³ H ₂ O eq/capita)	3,509.3	2018	● ●	Homicides (per 100,000 population)	0.8	2019	● ●
SDG7 – Affordable and Clean Energy				Unsented detainees (% of prison population)	20.0	2019	● ●
Population with access to electricity (%)	100.0	2020	● ↑	Population who feel safe walking alone at night in the city/area where they live (%)	90	2022	● ●
Population with access to clean fuels and technology for cooking (%)	100.0	2020	● ↑	Birth registrations with civil authority (% of children under age 5)	99.2	2018	● ●
CO ₂ emissions from fuel combustion per total electricity output (MtCO ₂ /TWh)	1.5	2019	● ↑	Corruption Perceptions Index (worst 0–100 best)	51	2022	● ↓
Renewable energy share in total final energy consumption (%)	0.0	2019	● →	Children involved in child labor (% of population aged 5 to 14)	NA	NA	● ●
SDG8 – Decent Work and Economic Growth				Exports of major conventional weapons (TIV constant million USD per 100,000 population)	0.1	2016	● ●
Adjusted GDP growth (%)	-1.6	2021	● ●	Press Freedom Index (worst 0–100 best)	32.4	2023	● ↓
Victims of modern slavery (per 1,000 population)	* NA	NA	● ●	Access to and affordability of justice (worst 0–1 best)	NA	NA	● ●
Adults with an account at a bank or other financial institution or with a mobile-money-service provider (% of population aged 15 or over)	74.3	2021	● →	Timeliness of administrative proceedings (worst 0–1 best)	NA	NA	● ●
Unemployment rate (% of total labor force, ages 15+)	5.6	2023	● ↑	Expropriations are lawful and adequately compensated (worst 0–1 best)	NA	NA	● ●
Fundamental labor rights are effectively guaranteed (worst 0–1 best)	NA	NA	● ●	SDG17 – Partnerships for the Goals			
Fatal work-related accidents embodied in imports (per 100,000 population)	0.2	2018	● ↑	Government spending on health and education (% of GDP)	11.7	2020	● ↑
Victims of modern slavery embodied in imports (per 100,000 population)	83.2	2018	● ●	For high-income and all OECD DAC countries: International concessional public finance, including official development assistance (% of GNI)	0.7	2022	● ↑
				Other countries: Government revenue excluding grants (% of GDP)	NA	NA	● ●
				Corporate Tax Haven Score (best 0–100 worst)	* 0	2021	● ●
				Statistical Performance Index (worst 0–100 best)	80.8	2022	● ↑

* Imputed data point

Figure 2.6 Saudi Arabia profile 2/2 for SDGs - 2023, [8].

The world is also seriously off track to meet the Paris agreement climate targets and SDG 13 (Figure 2.7). Global warming as of 2022 stood at 1.2°C, with warming continuing at more than 0.3°C per decade.⁴ At this rate, the likelihood of overshooting 1.5°C, even within a decade, is very strong. According to the UNEP Emissions Gap Report 2022, current policies put the world on track to reaching a disastrous 2.8°C warming by 2100.⁵ Current Nationally Determined Contribution (NDC) targets, if implemented, would still lead to around 2.4°C warming by 2100. Even taking the net-zero pledges of many countries into account, best-case scenarios given current pledges would lead to around 1.8°C warming by 2100.

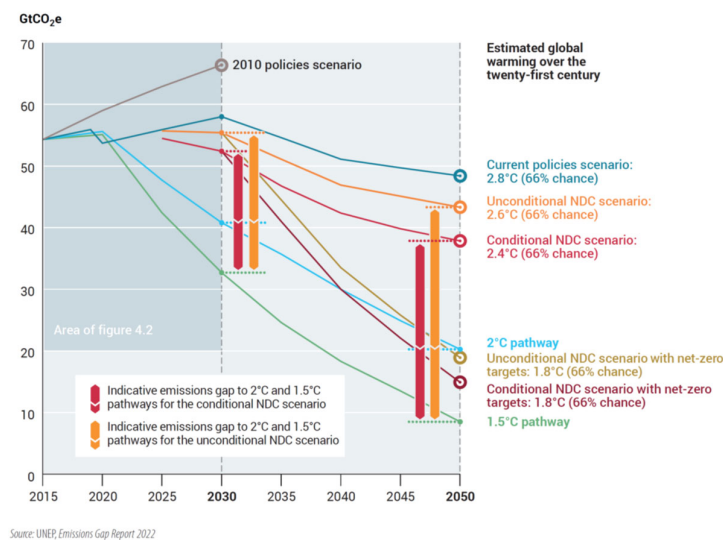


Figure 2.7 Projected global warming under alternative policy scenarios

Biodiversity targets (SDG 15 and targets agreed under the CBD) are also at grave risk. All dimensions of biodiversity, including species abundance, species diversity, and the functioning of ecosystems, are under threat. It has been announced that the current loss of species rate is 1,000–10,000 times more than the natural extinction rate. A combination of land-use change (e.g., dramatic increases of tropical deforestation), global warming, and pollution are driving more and more species, including entire families and orders of species, towards mass extinction. At the same time, Indigenous peoples who have been safeguarding and stewarding these resources for millennia are facing greater threats than ever. Water scarcity affects more than 40% of the world's population. An estimated 1.8 billion people depend on drinking water contaminated by human waste. Unsustainable water management

practices, including chemical discharges into water supply systems for irrigation, affect the functioning of ecosystems services. Global resource consumption assessments for rare earth elements are critical. Although reserves of these elements do not exist in concentrated clusters – which make them inefficient for mining – certain countries are quite dominant in this field, producing 98% of the world's supply. As demand for rare earth elements is increasing tremendously, their scarcity is becoming more evident [8].

The study [7] talks about SDGs. The interrelated nature of the SDGs highlights the interlinking between the economic (e.g., industrialization), social (e.g., health), and environmental (e.g., climate change) sectors. SDG 4 (education and training) is considered a foundational SDG because it affects the accomplishment of most of the other SDGs. Further, it maximizes synergy and minimizes tradeoffs among SDGs. Therefore, the current study suggests that developing nations such as Saudi Arabia should continuously enhance their human capital through targeted education and training programs to achieve the SDGs. Saudi Arabia's Vision 2030 provides a broad framework for developing a knowledge-based economy; however, education and training programs should be tailored to advance the SDGs that have the greatest impact on the economic growth. Therefore, education and training policies should promote gender equality and the empowerment of women, environment protection, decent employment opportunities, and human capital development. The government should encourage educational institutions to combine traditional and digital systems to increase access to education and training. Additionally, the Saudi government should ensure the equitable distribution of socioeconomic opportunities and educate the populace on how to address socioeconomic issues such as food waste. The government of Saudi Arabia should promote laws and regulations that encourage an equitable, healthy, and safe work environment in the current technological workspace. The Saudi government should provide robust institutional support to the

private sector to provide decent and safe employment opportunities, expedite the development of essential infrastructure, and the adoption of emerging technologies. Consequently, Saudi Arabian policymakers should continue to initiate and implement policies that promote education and training, as well as other lifelong learning opportunities, sustainable employment generation, human capital development, economic growth, and technology-enabled socioeconomic empowerment. In addition, the Saudi government should continue to promote prudent education and training policies to expedite economic recovery throughout and after the COVID-19 pandemic. This is because education and training (SDG 4) as a foundational SDG will positively influence Saudi Arabia's economic, socioeconomic, health, and environmental sectors (throughout and after the COVID-19 pandemic).

The study [30] , An advantage of the developed framework is that investigating **the contribution of building materials in the achievement of sustainable development goals** and target impose the demonstration of basic understanding and awareness between designers, project developers, policymakers, professionals and construction stakeholders on how the classification and the selection of building materials have a significant impact in reaching sustainability and mitigating climate hazards. It also allows broad multi-sectoral and multi-stakeholder discussions and offers a possibility to integrate knowledge required in policy formulation and realization of SDGs. The framework is expected to convert the sustainable development goals and their targets into a measurable tool to be achieved in the practice and guide the decision-making process successfully. Moreover, the gathered data offers useful visions about the possibilities and difficulties of implementing building materials to achieve sustainability and it contributes to the identification of further potential themes within the topic that need more investigation. The findings suggest that the selection of building materials based on their performance on health and environment should be

considered as one of the most essential steps to achieving SDGs. Building materials should be identified based on the overlapping benefits from the combined characteristics of the mentioned nine typologies. Therefore, it is essential to create a multi-criteria optimization tool based on identified sustainability indicators to evaluate the efficiency of building materials before integrating them into buildings. However, more discussion is required on the limitations of the employed data sources and adopted methods. In the future, research supposes to show how each type of building materials act towards achieving sustainable development goals and what are the most effective criteria and measures we need to consider for material selection and evaluation to reach the ambition. However, as the progress goes towards the realization of SDGs, the need to address a wide range of tools and science-based analysis is highly required to achieve the goals in the remaining years. In addition, we also call for further applied research in the subject by investigating real case studies with construction industry professionals, decision-makers, materials manufacturers and other construction stakeholders for better understanding the barriers to be overcome in the field of construction and building materials to achieve 2030 agenda.

Chapter 3 Practical Study and its Methodological Procedures

Methodological Procedures

Researchers constantly use two traditional research approaches (qualitative and quantitative), but they sometimes fall short in the resolution of problems and situations that require new perspectives. In this context, the application of mixed methods approaches is important, which allows us to exploit the strengths of both approaches to achieve a more complete understanding of the problems this paper is embarking on resolving. The paper used qualitative data to help explain the initial quantitative results. The path we took was to use an explanatory research methodology to first collect the quantitative data and analyze them, and then the second phase of the qualitative study was developed. Even though explanatory research methodology has some limitations such as the use of a modest number of samples, which could not be for a targeted/ specific type of audience, it is crucial to obtain a solid background from the surveyed stakeholders to be able to assess their level of awareness and design a framework for future research that will cover a wider range of targeted audience. In short, the mixed methods approach allows for:

1. Combining the strengths provided by the two approaches;
2. Attenuating the weaknesses of their separate application; and
3. Gaining a better understanding of key stakeholders' awareness.

The research method of this paper will be of a mixed-method nature, utilizing an online survey to collect responses from a wide range of Saudi society stakeholders in the construction industry. The methodology utilized in this research used a combination of qualitative and quantitative methods where the primary method was a survey sent to the Saudi key stakeholders; unfortunately, a total of

76 participants took part in the survey due to limited time. The secondary data support the findings of the primary data by analyzing the relevant literature on sustainability development goals and the stakeholders' awareness to support the argument [9].

Questionnaire Design

The Google form was used to create the questionnaire [12], and the link was sent to WhatsApp groups and email addresses of the selected participants across the Riyadh zone. The online platforms save cost and time. It permits speedy access to large participants with common interests, and who can be impracticable to reach. Given that this is a sustainability study, the use of an online survey is economical and eco-friendly. The researcher used the questionnaire as primary data and used sustainable development report 2023, (published by Dublin university press) and other literature review as secondary data. The researcher generated the questionnaire questions from 3 groups of literature review and incorporated with **five – point Likert scale questions** as follows:

- 1- Group one [10],[11],[12], and [13] for the section B is benefit/impact of green building materials implementations on sustainable development.
- 2- Group two [2],[6],[9],[14],[15],[16], and [17] for the section C is challenges/obstacles to green building materials implementations.
- 3- Group three [3],[18], and [19] for the section D is green building materials selection criteria.

Field Results

The field results addressed the results and findings of this study, It is divided into four sections, Section A is demographic questions - general information from respondents and sections B, C, and D used Likert scale questions as per the research problems, and the researcher listed the results as follow :

Section A: Demographic Characteristics

The researcher used 10 questions in this section to collect general information about the respondents, but he focused on and analyzed 5 questions as gender, age, years of experience, sector, and green building rating platform. The results show the following:

I. Gender: 76 responses

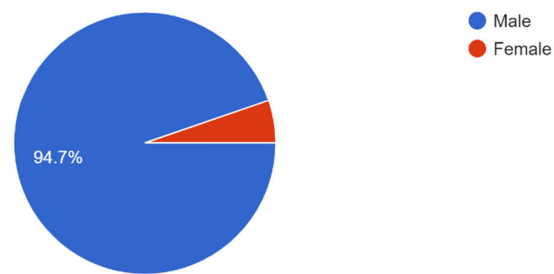


Figure 3.1 Respondent gender.

The results for the first demographic questions show that 5.3% percent were female participants and 94.7% percent were male.

II. Age : 76 responses

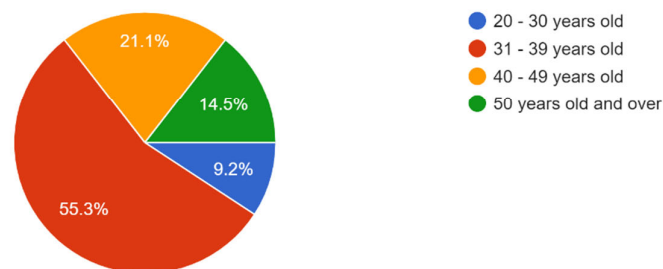


Figure 3.2 Respondent age.

The age of the participants varied was 9.2% between (20-30) years, 55.3% between (31-39) years, 21.1% between (40-49) years, and 14.5% (50 and over).

III. Years of Experience :

76 responses

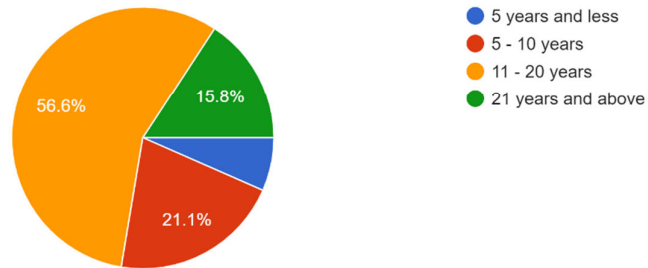


Figure 3.3 Respondent experience.

IV. Sector :

76 responses

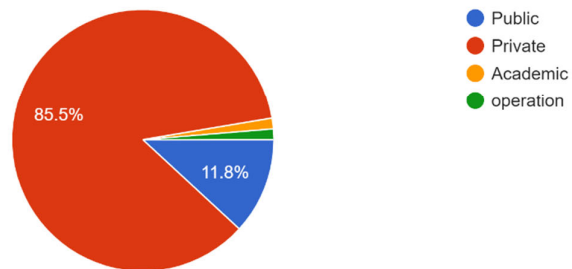


Figure 3.4 Respondent employment sector.

V. Which system will use for green building rating :

76 responses

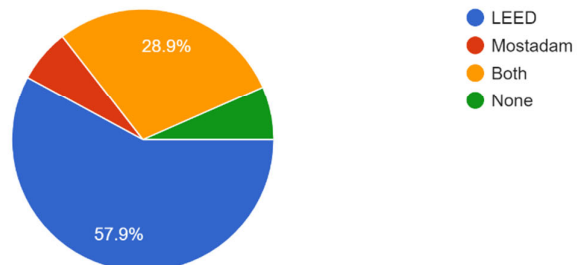


Figure 3.5 Respondent choice of preferred green rating system.

With respect to the choice between selecting LEED or Mostadam as the preferred green building rating system or both, we are on Aug – 2023 and the respondents clearly still showed that LEED superseded Mostadam in the preference of the respondents. Mostadam still showed strength and acceptance to be used in conjunction with LEED. More than 28.9% of the respondents selected the preference of using both rating systems, and this will substantiate the result from the question on the level of awareness of the respondents to the concept of green and sustainable building.

Section B: Benefits of Green Building Materials Implementations

I. Environmental

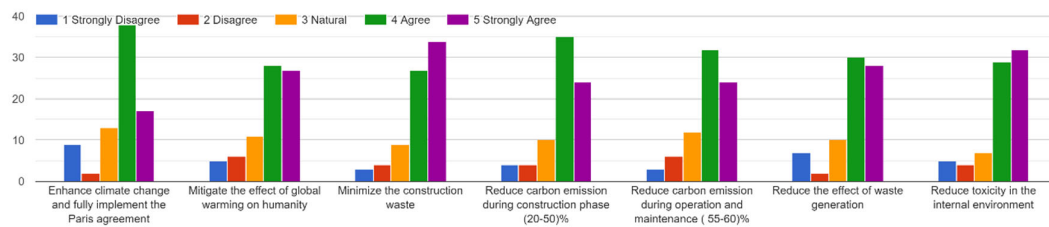


Figure 3.6 Respondents for GBM's impact/benefit on environmental

II. Economic

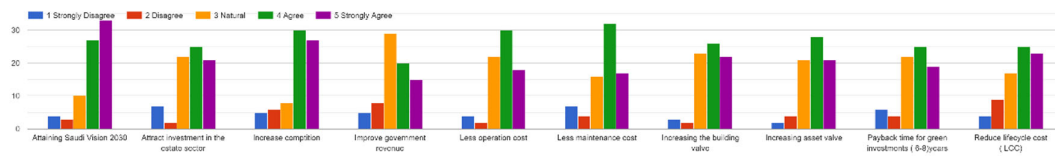


Figure 3.7 Respondents for GBM's impact/benefit on economic

III. Social and Health & Safety

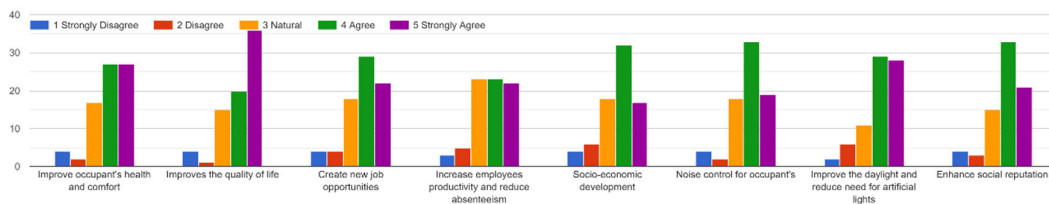


Figure 3.8 Respondents for GBM's impact/benefit on social and health & safety

Table3.1 Benefits of Green Building Materials Implementations	Strongly Disagree	Disagree	Natural	Agree	Strongly Agree	Total of Respondent
I. Environmental						
Enhance climate change and fully implement the Paris agreement	9	2	13	35	17	76
Mitigate the effect of global warming on humanity	5	6	11	27	27	76
Minimize the construction waste	3	4	9	26	34	76
Reduce carbon emission during construction phase (20-50)%	4	4	10	34	24	76
Reduce carbon emission during operation and maintenance	3	6	12	31	24	76
Reduce the effect of waste generation	7	2	10	29	28	76
Reduce toxicity in the internal environment	5	4	7	28	32	76
II. Economic						
Attaining Saudi Vision 2030	4	3	10	26	33	76
Attract investment in the estate sector	7	2	22	24	21	76
Increase competition between service providers and beneficiaries	5	6	8	30	27	76
Improve government revenue generation through tax	5	8	28	20	15	76
Less operation cost by using passive and active design	4	2	22	30	18	76
Less maintenance cost	7	4	16	32	17	76
Increasing the building value for green	3	2	23	26	22	76
Increasing asset value for green versus non-green projects	2	4	21	28	21	76
Payback time for green investments (6-8)years	6	4	22	25	19	76
Reduce lifecycle cost (LCC)	4	9	17	23	23	76
III. Social and Health & Safety						
Improve occupant's health and comfort	4	2	17	26	27	76
Improves the quality of life	4	1	15	20	36	76
Create new job opportunities	4	4	18	28	22	76
Increase employee's productivity and reduce absenteeism	3	5	23	23	22	76
Socio-economic development	4	6	18	31	17	76
Noise control for occupant's	4	2	18	33	19	76
Improve the daylight and reduce need for artificial lights	2	6	11	29	28	76
Enhance social reputation	4	3	15	33	21	76

Section C: Challenges/Obstacles to Green Building Materials Implementation

I. Policy Challenges

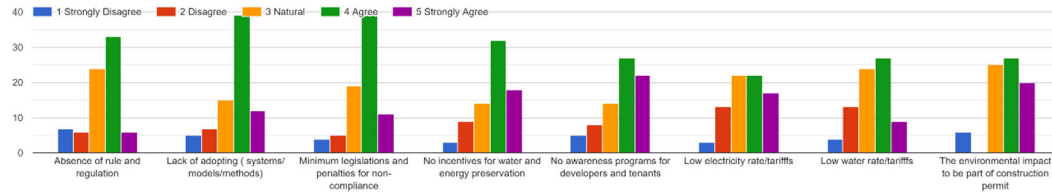


Figure 3.9 Respondents for policy challenges to use GBM's

II. Mostadam Pillars for Green Building Rating System

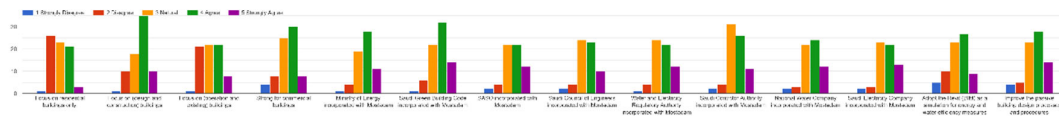


Figure 3.10 Respondents for Mostadam role for using GBM's

III. Stakeholders Interest

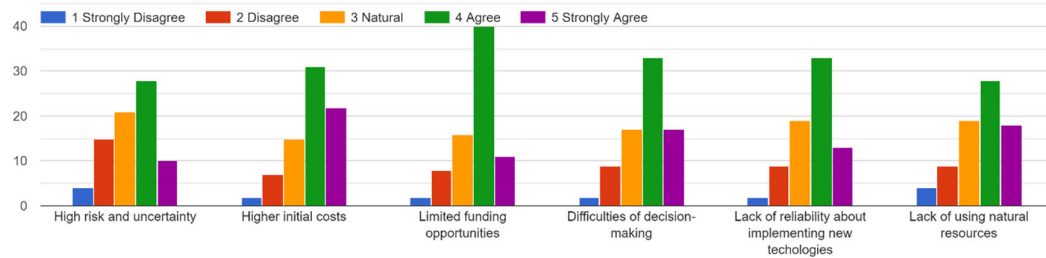


Figure 3.11 Respondents for stakeholders' interest for using GBM's

IV. Stakeholders Awareness

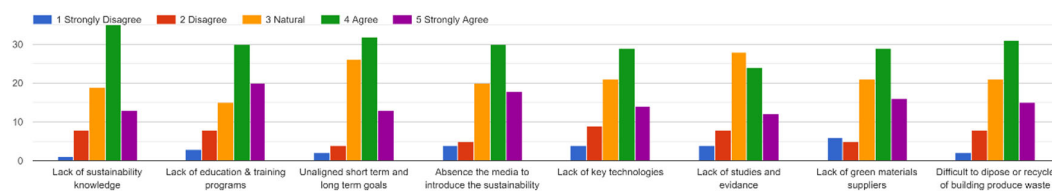


Figure 3.12 Respondents for stakeholders' awareness for using GBM's

Table 3.2 Challenges/Obstacles to Green Building Materials Implementation	Strongly Disagree	Disagree	Natural	Agree	Strongly Agree	Total of Respondent
I. Policy Challenges						
Absence of rule and regulation	7	6	24	33	6	76
Lack of adopting (systems/models/methods)	5	7	15	37	12	76
Minimum legislations and penalties for non-compliance	4	5	19	37	11	76
No incentives for water and energy preservation	3	9	14	32	18	76
No awareness programs for developers and tenants	5	8	14	27	22	76
Low electricity rate/tariffs	3	13	22	21	17	76
Low water rate/tariffs]	4	13	24	26	9	76
The environmental impact to be part of construction permit	6	0	25	25	20	76
II. Mostadam Platform for Green Building Rating System						
Focus on residential buildings only.	1	26	23	21	3	74
Focus on (design and construction) buildings	1	10	18	35	10	74
Focus on (operation and existing) buildings	1	21	22	22	8	74
Strong for commercial buildings	4	8	25	30	8	75
Ministry of Energy incorporated with Mostadam	1	4	19	28	11	63
Saudi Green Building Code incorporated with Mostadam	1	6	22	32	14	75
SASO incorporated with Mostadam	2	4	22	22	12	62
Saudi Council of Engineers incorporated with Mostadam	2	4	24	23	10	63
Water and Electricity Regulatory Authority incorporated with Mostadam	1	4	24	22	12	63
Saudi Contractor Authority incorporated with Mostadam	2	4	31	26	11	74
National Water Company incorporated with Mostadam	2	3	22	24	12	63
Saudi Electricity Company incorporated with Mostadam	2	3	23	22	13	63
Adopt the Revit (BIM) as a simulation for energy and water efficiency measures	5	10	23	27	9	74
Improve the passive building design processes and procedures	4	5	23	28	14	74

III. Stakeholders Interest	Strongly Disagree	Disagree	Natural	Agree	Strongly Agree	Total of Respondents
High risk and uncertainty	4	15	21	26	10	76
Higher initial costs	2	7	15	30	22	76
Limited funding opportunities	2	8	16	39	11	76
Difficulties of decision-making	2	9	17	31	17	76
Lack of reliability about implementing new technologies	2	9	19	33	13	76
Lack of using natural resources]	4	9	19	28	18	78
IV. Stakeholders Awareness						
Lack of sustainability knowledge	1	8	19	35	13	76
Lack of education & training programs	3	8	15	30	20	76
Unaligned short term and long-term goals	2	4	26	31	13	76
Absence the media to introduce the Saudi public to the concept of sustainability	4	5	20	29	18	76
Lack of key technologies	4	9	21	28	14	76
Lack of studies and evidence	4	8	28	24	12	76
Lack of green materials suppliers	6	5	21	28	16	76
Difficult to dispose or recycle of building produce waste as plastic pipes, packing, & etc..	2	8	21	30	15	76

Section D: Green Building Materials Selection Criteria

I. Resource Efficiency

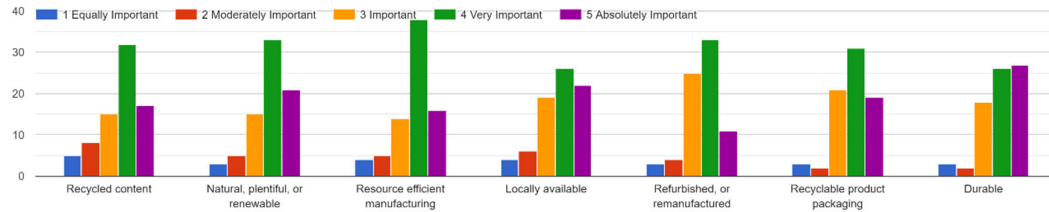


Figure 3.13 Respondents for resource efficiency of GBM's

II. Indoor Air Quality

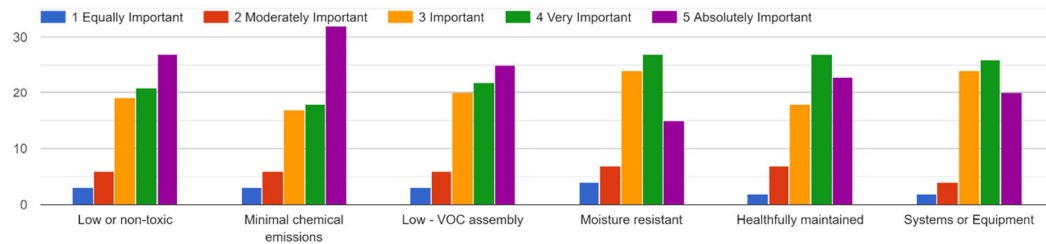


Figure 3.14 Respondents for indoor air quality of GBM's

III. Energy Efficiency

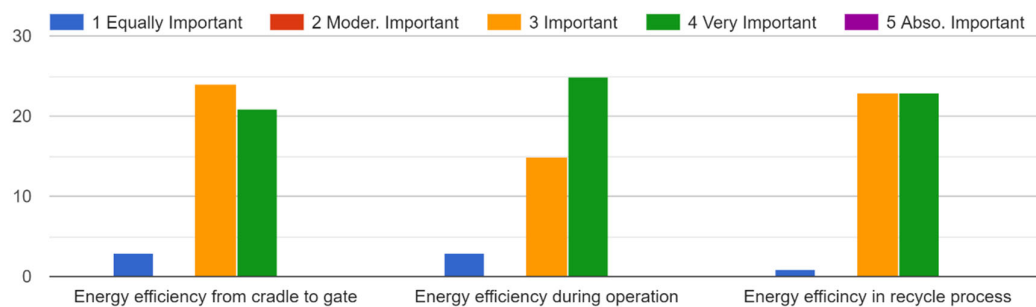


Figure 3.15 Respondents for energy efficiency of GBM's

IV. Water Efficiency

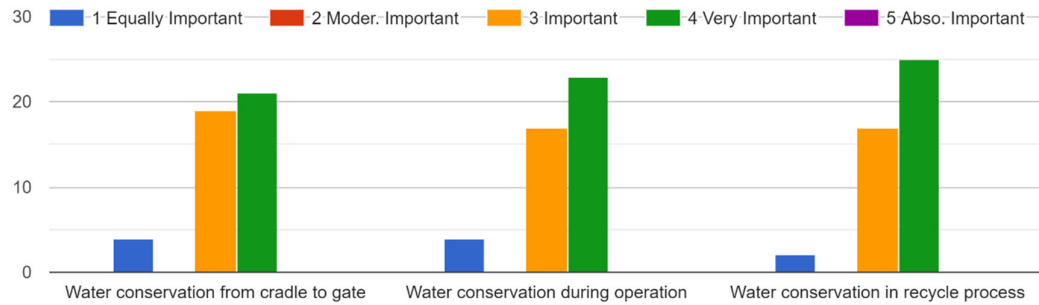


Figure 3.16 Respondents for water efficiency of GBM's

V. Affordability

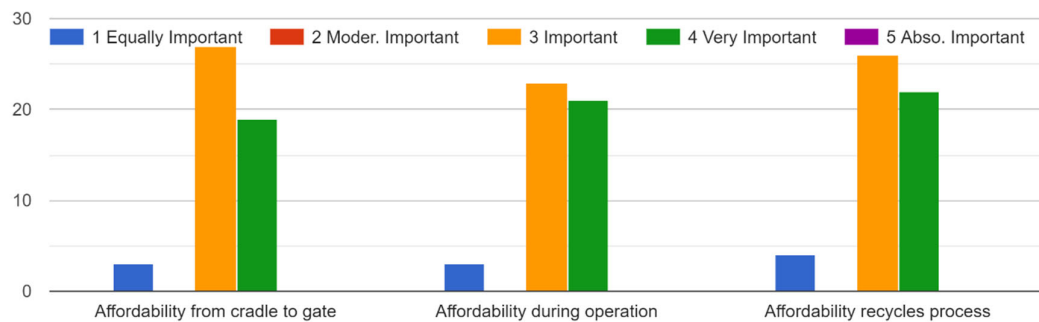


Figure 3.17 Respondents for affordability of GBM's

Table 3.3 Green Building Materials Selection Criteria	Equally Important	Moderately Important	Important	Very Important	Absolutely Important	Total of Respondents
I. Resource Efficiency						
Recycled content	5	8	15	31	17	76
Natural, plentiful, or renewable	3	5	15	31	21	75
Resource efficient manufacturing	4	5	14	37	16	76
Locally available	4	6	19	25	22	76
Refurbished, or remanufactured	3	4	25	33	11	76
Recyclable product packaging	3	2	21	31	19	76
Durable	3	2	18	26	27	76
II. Indoor Air Quality						
Low or non-toxic	3	6	19	21	27	76
Minimal chemical emissions	3	6	17	18	32	76
Low - VOC assembly	3	6	20	22	25	76
Moisture resistant	4	7	24	26	15	76
Healthfully maintained	2	7	18	26	23	76
Systems or Equipment	2	4	24	26	20	76
III. Energy Efficiency						
Energy efficiency from cradle to gate	3	0	24	21	0	48
Energy efficiency during operation	3	0	15	25	0	43
Energy efficiency in recycle process	1	0	23	23	0	47
IV. Water Efficiency						
Water conservation from cradle to gate	4	0	19	21	0	44
Water conservation during operation	4	0	17	23	0	44
Water conservation in recycle process	2	0	17	25	0	44
V. Affordability						
Affordability from cradle to gate	3	0	27	19	0	49
Affordability during operation	3	0	23	21	0	47
Affordability recycles process	4	0	26	22	0	52

Results and Proposal Analysis

The questionnaire results in Table 3.1 and Figures 3.6, 3.7, and 3.8 prove that there is a high correlation between green building materials and the three pillars of sustainability (environmental, Economic, and social, and health & safety), Improving the quality of life got the highest scores other than others, then minimizing the construction waste, then Attaining Saudi Vision 2030, then Reduce toxicity in the internal environment .

With regard to section C challenges/obstacles to green building materials implementation, Table 3.2 and Figures 3.9, 3.10, and 3.11, prove that there are many challenges to performing green building materials, higher initial costs got the highest scores other than others, then lack of education & training programs, limited funding opportunities, and absence incentives for water and energy preservation were the 2nd highest scores .

For section D green building materials selection criteria, Table 3.3 and Figures 3.13, 3.14, 3.15, 3.16, and 3.17, prove that the selection of green building materials is very important and based on criteria, resource-efficient manufacturing got the highest scores other than others, then natural, plentiful, or renewable, then recyclable product packaging and minimal chemical emissions.

Research Limits

Unfortunately, several policymakers did not reply to our studies such as the Saudi Building Code, Ministry of Energy, Saudi Council of Engineers, Water and Electricity Regulatory Authority, Mostadam Platform, and Saudi Contractors Authority, and due to the hacking phenomenon which spread recently, most people do not like to open any external links and these reasons made the researcher could not reach the target of sample numbers.

Chapter 4 Conclusions

Conclusions and Recommendations

This study sets out to assess the benefit and impact of green building materials on sustainable development goals, discussed the level of awareness of Saudi Arabia stakeholders in Riyadh, and identified and discussion the Green Building Materials Selection Criteria, it was concluded that the green building materials plays high role for achieving the sustainable development goals, SDG 3 improve people health and well-being, SDG 7 use the renewable energy becoming cheaper to run, SDG 8 create job and boosts the economy, SDG 9 can spur innovation and contribute to climate resilient infrastructure, SDG 11 are the fabric of sustainable communities and cities, SDG 12 use circular principle where resources are not wasted, SDG 13 produce fewer emissions, helping to combat climate change, SDG 17 strong partnerships can be created.

There are some critical challenges with policymakers whose sole reference is to adopt and apply the necessary regulations and roles to keep Riyadh city on track with sustainable development and to provide the Riyadh market with awareness programs for developers, incentives for water and energy preservation, and legislations and penalties for non-compliance.

Also, the researcher highly recommended increasing Mostadam staff to have branch offices in the Municipality, Saudi Building Code, Ministry of Energy, Saudi Council of Engineers, Water and Electricity Regulatory Authority, Mostadam Platform, Saudi Contractors Authority, and others in order to activate their important roles.

The researcher could not reach to accepted result due to limited time and there is no fast responsive from concern stakeholders and local authorities to achieve the target sample.

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Questionnaire & Arabic Cover



جامعة ميدأوشن

كلية الإدارة

ماجستير إدارة مشاريع

أثر إستخدام مواد البناء الخضراء في التنمية المستدامة بالرياض

إعداد الطالب /

عبد اللطيف ماهر محمود السويمه

رقم الجامعي : 20212005285

إشراف /

د. وليد صديق

العام الدراسي:

2023

Questionnaire

The Impact of the Green Building Materials on Sustainable Development in Riyadh

Dear Respondent,

I am a master's candidate (Project Management) at the University of Midocean currently, I am conducting a study titled " **The Impact of the Green Building Materials on Sustainable Development in Riyadh** " to evaluate and analyze the effectiveness and potential benefits of incorporating the green building materials onto of sustainable development goals.

I would like to request your cooperation to answer this questionnaire. Any information obtained will be kept confidential and only used for academic purposes. Your cooperation is highly appreciated.

Thank you in advance for agreeing to participate in this study. If you have any questions, please do not hesitate to contact my honorable supervisor, Associate Professor Dr. Walid Seddik, or myself (Master Candidate).

Supervisor (Associate Professor Dr. Walid Seddik)

Faculty of Management

Walid@esu.ac.ae

Master's Candidate (Abdellatif Alswaimeh)

Faculty of Management

Midocean University

Alswimah2008@gmail.com

Phone # 00966509322401

* Indicates required question

Border Region Study (Riyadh City)



Section A

A: Demographic Characteristics

I. 1- Your Name (Optional) :

2. 2- Your Email (Optional) :

3. 3- Company Name (Optional) :

4. 4- Mobile Number (Optional) :

5. 5- Gender: *

Mark only one oval.

☐ Male

☐ Female

6. 6- Age : *

Mark only one oval.

☐ 20 - 30 years old

☐ 31 - 39 years old

☐ 40 - 49 years old

☐ 50 years old and over

7. 7- Years of Experience : *

Mark only one oval.

☐ 5 years and less

☐ 5 - 10 years

☐ 11 - 20 years

☐ 21 years and above

8. **8- Position :** *

Mark only one oval.

- ☐ Building's Owner
- ☐ Real Estate Developer
- ☐ Investor
- ☐ Facility Manager
- ☐ Green Consultant
- ☐ Design Expert
- ☐ Contractor
- ☐ Supplier
- ☐ Policymaker
- ☐ Other: _____

9. **9- Sector :** *

Mark only one oval.

- ☐ Public
- ☐ Private
- ☐ Academic
- ☐ Other: _____

10. **10- Which system will use for green building rating :** *

Mark only one oval.

- ☐ LEED
- ☐ Mostadam
- ☐ Both
- ☐ None

Section B : Benefits of Green Building Materials Implementations

Please indicate your degree of agreement or disagreement with the following statements, so please sign (mark) for the choice that reflects your opinion by choosing one of the five alternatives.

The following set of statements measures green building materials and their effect on sustainable development in Riyadh. Please mark according to your level of agreement.

11. I. Environmental *

Check all that apply.

	1 Strongly Disagree	2 Disagree	3 Natural	4 Agree	5 Strongly Agree
Enhance climate change and fully implement the Paris agreement	☐	☐	☐	☐	☐
Mitigate the effect of global warming on humanity	☐	☐	☐	☐	☐
Minimize the construction waste	☐	☐	☐	☐	☐
Reduce carbon emission during construction phase (20- 50)%	☐	☐	☐	☐	☐
Reduce carbon emission during operation and maintenance (55-60)%	☐	☐	☐	☐	☐

Reduce the
effect of
waste
generation



Reduce
toxicity in
the internal
environment



12. II. Economic *

Check all that apply.

	1 Strongly Disagree	2 Disagree	3 Natural	4 Agree	5 Strongly Agree
Attaining Saudi Vision 2030	☐	☐	☐	☐	☐
Attract investment in the estate sector	☐	☐	☐	☐	☐
Increase comptition between service providers and beneficiaries	☐	☐	☐	☐	☐
Improve government revenue generation through tax	☐	☐	☐	☐	☐
Less operation cost by using passive and active design	☐	☐	☐	☐	☐
Less maintenance cost	☐	☐	☐	☐	☐
Increasing the building	☐	☐	☐	☐	☐

valve for
valve for
green versus
green versus
non-green
non-green
projects
projects
from (5-8)%
from (5-8)%
according to
according to
AEC Firms
AEC Firms

Increasing
Increasing
asset value
asset value
for green
for green
versus non-
versus non-
green
green
projects (4
projects (4
-7)%
-7)%
according to
according to
owners
owners

☐☐☐☐☐

Payback
Payback
time for
time for
green
green
investments
investments
(6-8)years
(6-8)years

☐☐☐☐☐

Reduce
Reduce
lifecycle
lifecycle
cost (LCC)
cost (LCC)

☐☐☐☐☐

13. III. Social and Health & Safety *

Check all that apply.

	1 Strongly Disagree	2 Disagree	3 Natural	4 Agree	5 Strongly Agree
Improve occupant's health and comfort	☐	☐	☐	☐	☐
Improves the quality of life	☐	☐	☐	☐	☐
Create new job opportunities	☐	☐	☐	☐	☐
Increase employees productivity and reduce absenteeism	☐	☐	☐	☐	☐
Socio- economic development	☐	☐	☐	☐	☐
Noise control for occupant's	☐	☐	☐	☐	☐
Improve the daylight and reduce need for artificial lights	☐	☐	☐	☐	☐
Enhance social reputation	☐	☐	☐	☐	☐

Section C : Challenges/Obstacles to Green Building Materials Implementation

The following set of statements measures the barriers/obstacles of using the green building materials and in Riyadh. Please mark according to your level of agreement.

14. I. Policy Challenges *

Check all that apply.

	1 Strongly Disagree	2 Disagree	3 Natural	4 Agree	5 Strongly Agree
Absence of rule and regulation	☐	☐	☐	☐	☐
Lack of adopting (systems/models/methods)	☐	☐	☐	☐	☐
Minimum legislations and penalties for non-compliance	☐	☐	☐	☐	☐
No incentives for water and energy preservation	☐	☐	☐	☐	☐
No awareness programs for developers and tenants	☐	☐	☐	☐	☐
Low electricity rate/tariffs	☐	☐	☐	☐	☐
Low water rate/tariffs	☐	☐	☐	☐	☐
The environmental impact to be part of construction permit	☐	☐	☐	☐	☐

15. II. Mostadam Paltform for Green Building Rating System

Check all that apply.

	1 Strongly Disagree	2 Disagree	3 Natural	4 Agree	5 Strongly Agree
Focus on residential buildings only.	☐	☐	☐	☐	☐
Focus on (design and construction) buildings	☐	☐	☐	☐	☐
Focus on (operation and existing) buildings	☐	☐	☐	☐	☐
Strong for commercial buildings	☐	☐	☐	☐	☐
Ministry of Energy incorporated with Mostadam	☐	☐	☐	☐	☐
Saudi Green Building Code incorporated with Mostadam	☐	☐	☐	☐	☐
SASO incorporated with Mostadam	☐	☐	☐	☐	☐

Saudi Council of Engineers and Technicians Incorporated with Mostadam Mostadam	☐	☐	☐	☐	☐
Water and Electricity Regulatory Authority incorporated with Mostadam Mostadam	☐	☐	☐	☐	☐
Saudi Sector Authority incorporated with Mostadam Mostadam	☐	☐	☐	☐	☐
National Water Company incorporated with Mostadam Mostadam	☐	☐	☐	☐	☐
Saudi Electricity Company incorporated with Mostadam Mostadam	☐	☐	☐	☐	☐
Adopt the Revit (BIM) simulation for water and water efficiency measures	☐	☐	☐	☐	☐

Improve the
passive the
building
design
processes
and
procedures



I 6. III. Stakeholders Interest *

Check all that apply.

	1 Strongly Disagree	2 Disagree	3 Natural	4 Agree	5 Strongly Agree
High risk and uncertainty	☐	☐	☐	☐	☐
Higher initial costs	☐	☐	☐	☐	☐
Limited funding opportunities	☐	☐	☐	☐	☐
Difficulties of decision- making due to lack of using building information modeling (BIM) in the early design	☐	☐	☐	☐	☐
Lack of reliability about implementing new technologies	☐	☐	☐	☐	☐
Lack of using natural resources	☐	☐	☐	☐	☐

17. IV. Stakeholders Awareness *

Check all that apply.

	1 Strongly Disagree	2 Disagree	3 Natural	4 Agree	5 Strongly Agree
Lack of sustainability knowledge	☐	☐	☐	☐	☐
Lack of education & training programs	☐	☐	☐	☐	☐
Unaligned short term and long term goals	☐	☐	☐	☐	☐
Absence the media to introduce the Saudi public to the concept of sustainability	☐	☐	☐	☐	☐
Lack of key technologies	☐	☐	☐	☐	☐
Lack of studies and evidance	☐	☐	☐	☐	☐
Lack of green materials suppliers	☐	☐	☐	☐	☐
Difficult to dispose or recycle of	☐	☐	☐	☐	☐

The following set of statements measures green building materials criteria for selection and its effect on sustainable development in Riyadh. Please mark according to your level of importance.

The following set of statements measures green building materials criteria for selection and its effect on sustainable development in Riyadh. Please mark according to your level of importance.

18. I. Resource Efficiency **Check all that apply.*

	1 Equally Important	2 Moderately Important	3 Important	4 Very Important	5 Absolutely Important
Recycled content	☐	☐	☐	☐	☐
Natural, plentiful, or renewable	☐	☐	☐	☐	☐
Resource efficient manufacturing	☐	☐	☐	☐	☐
Locally available	☐	☐	☐	☐	☐
Refurbished, or remanufactured	☐	☐	☐	☐	☐
Recyclable product packaging	☐	☐	☐	☐	☐
Durable	☐	☐	☐	☐	☐

19. II. Indoor Air Quality *

Check all that apply.

	1 Equally Important	2 Moderately Important	3 Important	4 Very Important	5 Absolutely Important
Low or non-toxic	☐	☐	☐	☐	☐
Minimal chemical emissions	☐	☐	☐	☐	☐
Low - VOC assembly	☐	☐	☐	☐	☐
Moisture resistant	☐	☐	☐	☐	☐
Healthfully maintained	☐	☐	☐	☐	☐
Systems or Equipment	☐	☐	☐	☐	☐

20. **III. Energy Efficiency ***

Check all that apply.

	1 Equally Important	2 Moderately Important	3 Important	4 Very Important	5 Absolutely Important
Energy efficiency from cradle to gate	☐	☐	☐	☐	☐
Energy efficiency during operation	☐	☐	☐	☐	☐
Energy efficiency in recycle process	☐	☐	☐	☐	☐

21. IV. Water Efficiency *

Check all that apply.

	1 Equally Important	2 Moderately Important	3 Important	4 Very Important	5 Absolutely Important
Water conservation from cradle to gate	☐	☐	☐	☐	☐
Water conservation during operation	☐	☐	☐	☐	☐
Water conservation in recycle process	☐	☐	☐	☐	☐

22. V. Affordability *

Check all that apply.

	1 Equally Important	2 Moderately Important	3 Important	4 Very Important	5 Absolutely Important
Affordability from cradle to gate	☐	☐	☐	☐	☐
Affordability during operation	☐	☐	☐	☐	☐
Affordability recycles process	☐	☐	☐	☐	☐

Section E : Open - Ended Questions

23. E1 : Please provide ANY other comments regarding this study.

24. E2 : Please provide any comments regarding any aspect that appears to be lacking in this study.

Gratitude :

We appreciate you for sparing your time to fill out the survey.

Your involvement means a lot to us and we highly value it. The information you shared is significant to our analysis.

Once again, we are very grateful for your contribution.

Sincerely

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