WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A STUDY ON SUSTAINABLE ROOFING SOLUTION COST-BENEFIT ANALYSIS

[1]MR. M. NANDHAKUMAR, [2]DHINESH.M

[1 2] Department of Management Studies, Erode Sengunthar Engineering College (Autonomous), Perundurai, Erode–638 057

ABSTRACT:

This study conducts a comprehensive cost-benefit analysis of sustainable roofing solutions—green roofs, cool roofs, solar roofing, and recycled material roofs—compared to traditional systems, addressing their economic and environmental impacts. Utilizing a descriptive research design, data were collected from 100 stakeholders (homeowners, property managers, architects, and contractors) through a structured survey, supplemented by secondary sources like academic literature and industry reports. Findings reveal that sustainable roofs reduce energy costs by 10-20%, carbon emissions, and waste, with 70% of respondents noting higher recyclability. However, 67% cite high initial costs and 66% highlight limited contractor availability as major barriers. Despite this, 66% acknowledge sustainable roofing's durability, and 51% recognize financial benefits via reduced utility bills. Policy incentives, perceived as accessible by 67%, and market trends, exemplified by firms like AV Roofing & Construction, drive adoption. The study recommends enhanced public education, contractor training, and streamlined regulations to promote sustainable roofing, providing stakeholders with evidence-based insights for informed decision-making.

KEYWORDS : Sustainable roofing, Green roofs, Cool roofs, Solar roofing, Roofing materials

INTRODUCTION OF THE STUDY

The global construction industry faces mounting pressure to adopt sustainable practices as environmental concerns, resource scarcity, and climate change dominate public and policy discussions. Buildings account for approximately 40% of global energy consumption and 33% of greenhouse gas emissions, with roofing systems playing a significant role in a structure's environmental footprint. Traditional roofing materials, such as asphalt shingles and concrete tiles, have long been favored for their affordability and ease of installation. However, their production, maintenance, and disposal contribute to significant ecological degradation, including high carbon emissions, non-recyclable waste, and heat island effects in urban areas. As urbanization accelerates and energy costs rise, the need for roofing solutions that balance environmental impact, economic viability, and long-term performance has become critical.

Sustainable roofing solutions, encompassing green roofs, cool roofs, solar-integrated roofing, and recycled or bio-based materials, have emerged as viable alternatives to conventional systems. These technologies aim to reduce energy consumption, mitigate environmental harm, and enhance building resilience while offering economic benefits over their lifecycle. For instance, green roofs, which incorporate vegetation and soil layers, improve insulation, manage stormwater, and reduce urban heat. Cool roofs, designed with reflective materials, lower cooling costs by deflecting solar radiation. Solar roofing systems integrate photovoltaic panels to generate renewable energy, while recycled materials, such as rubber or plastic composites, reduce waste and resource depletion. Despite their promise, the adoption of sustainable roofing remains limited due to perceived high upfront costs, lack of awareness, and varying performance across climates and building types.

STATEMENT OF THE STUDY

The growing emphasis on sustainability in construction highlights the need for environmentally friendly roofing solutions, yet their adoption remains limited due to perceived high costs and unclear long-term benefits. Traditional roofing materials, while often cheaper upfront, contribute to environmental degradation through high energy consumption and waste. Sustainable roofing options, such as green roofs, solar tiles, or recycled materials, promise reduced environmental impact and potential cost savings over time, but their economic viability is not well understood. Stakeholders, including homeowners, builders, and policymakers, lack comprehensive data on the cost-benefit trade-offs of these solutions. This uncertainty hinders informed decision-making and slows the transition to sustainable practices. Additionally, regional variations in climate, material availability, and installation expertise further complicate the evaluation of these roofing systems. This study aims to address the problem of insufficient clarity on the financial and environmental trade-offs of sustainable roofing solutions, providing a robust cost-benefit analysis to guide stakeholders in making informed, sustainable choices.

OBJECTIVES OF THE STUDY

- To compare lifecycle costs of sustainable roofing solutions with traditional roofing systems.
- To quantify economic benefits, such as energy savings and tax incentives, of sustainable roofs.
- To evaluate environmental benefits, including reduced carbon emissions and waste, of sustainable roofing.
- To identify key barriers to adopting sustainable roofing solutions.
- To propose strategies to enhance the adoption of sustainable roofing practices.
- To provide cost-effective recommendations for stakeholders to implement sustainable roofing.

SCOPE OF THE STUDY

- Focus on key sustainable roofing solutions: green roofs, cool roofs, solar roofing, and recycled material roofs.
- Analyze lifecycle costs and benefits for residential and commercial buildings.
- Evaluate economic factors, including installation, maintenance, energy savings, and incentives.
- Assess environmental impacts, such as carbon reduction and waste management.
- Cover case studies from diverse climatic and economic regions.
- Target stakeholders: homeowners, developers, architects, and policymakers.

LIMITATION OF THE STUDY

- The study may include a small number of roofing projects, reducing generalizability.
- Analysis is restricted to specific regions, potentially missing global variations.
- Reliance on incomplete or outdated cost and performance data for sustainable roofing materials.
- Long-term benefits and durability of roofing solutions may not be fully captured.
- Benefits like aesthetics or environmental impact are hard to quantify objectively.
- Fluctuations in material and labor costs may affect the accuracy of the cost-benefit analysis.

INDUSTRY PROFILE

The roofing industry is a critical segment of the global construction sector, encompassing the design, installation, maintenance, and repair of roofing systems for residential, commercial, and industrial buildings. As a cornerstone of building infrastructure, roofing solutions protect structures from environmental elements, enhance energy efficiency, and contribute to aesthetic appeal. The industry has evolved significantly, driven by advancements in materials, sustainability trends, and increasing demand for durable, cost-effective, and eco-friendly roofing systems. Companies like AV Roofing & Construction, based in Fort Worth, Texas, exemplify the industry's commitment to quality, innovation, and customer satisfaction, offering a range of services from asphalt shingle installations to storm restoration and energy-efficient roofing solutions.

Industry Overview

The roofing industry is a dynamic and resilient market, with a global valuation estimated at $100 billion in 2024, projected to grow at a compound annual growth rate (CAGR) of 4-5% through 2030. This growth is fueled by rising construction activities, urbanization, and the need for infrastructure upgrades in both developed and emerging economies. In the United States, the roofing market is particularly robust, accounting for approximately $50 billion annually, driven by residential and commercial projects. The industry is characterized by a mix of large national contractors, regional firms like AV Roofing & Construction, and small local businesses, creating a competitive yet fragmented landscape.

Roofing services are broadly categorized into new installations, replacements, repairs, and maintenance. Residential roofing dominates the market, comprising about 60% of demand, as homeowners prioritize durability and aesthetics. Commercial roofing, including flat and low-slope systems, accounts for the remaining share, with applications in offices, warehouses, and retail spaces. The industry is heavily influenced by regional factors such as climate, building codes, and economic conditions. In Texas, for instance, the demand for storm-resistant roofing materials is high due to frequent hailstorms and hurricanes, a need that companies like AV Roofing & Construction address through specialized storm restoration services.

REVIEW OF LITERATURE

Berardi, U. (2016). "Sustainability Assessment of Green Roofs: Energy and Environmental Benefits"

Green roofs offer significant environmental benefits, including reduced urban heat island effects and improved stormwater management. Berardi's study evaluates their energy-saving potential, showing up to 20% reduction in cooling costs in urban settings. The research highlights the role of plant types and substrate thickness in performance. However, high initial costs and maintenance challenges limit widespread adoption. The study emphasizes lifecycle cost analysis to justify long-term savings. It lacks discussion on regional climate variations affecting green roof efficacy. This work underscores the need for cost-benefit studies to promote green roofing.

Mahdiyar, A. et al. (2018). "Barriers to Green Roof Implementation: A Review"

This review identifies key barriers to green roof adoption, including high upfront costs and lack of awareness. Mahdiyar et al. analyze global case studies, noting that payback periods can exceed 10 years. Technical challenges like structural load capacity also deter implementation. The study suggests subsidies and education to overcome barriers. It highlights the environmental benefits, such as reduced CO2 emissions. However, it lacks quantitative cost-benefit data for specific roof types. This review informs the need for economic feasibility studies.

Shafique, M. et al. (2020). "Green Roofs for Sustainable Urban Development"

Shafique et al. explore green roofs' contributions to urban sustainability, focusing on energy efficiency and biodiversity. Their study finds that green roofs can reduce building energy use by 10-15%. They also improve air quality and urban aesthetics. High installation costs and maintenance remain significant hurdles. The research advocates for integrating green roofs in urban planning. It lacks detailed cost comparisons with traditional roofing. This study supports the environmental case for sustainable roofing solutions.

Getter, K.L. & Rowe, D.B. (2006). "The Role of Extensive Green Roofs in Sustainable Development"

Extensive green roofs, with lightweight designs, are studied for their sustainability benefits. Getter and Rowe report reduced runoff and energy savings of up to 12%. They note improved roof longevity due to UV protection. Initial costs, however, can be 30-50% higher than conventional roofs. The study emphasizes lifecycle benefits but lacks regional cost data. It calls for policy incentives to boost adoption. This work highlights the need for cost-benefit clarity.

RESEARCH METHODOLOGY

Research Design

The study employs a descriptive research design to evaluate the cost-benefit analysis of sustainable roofing solutions compared to traditional systems. It combines quantitative methods to assess lifecycle costs, economic benefits, and environmental impacts with qualitative insights to understand stakeholder perceptions and barriers to adoption. A survey-based approach captures attitudes from diverse stakeholders, while statistical analyses, including correlation and chi-square tests, identify relationships between variables such as age, occupation, and perceptions of roofing costs.

3.1 Sampling Design

- The study employs a purposive sampling method to select 100 respondents with direct or indirect involvement in roofing projects. This approach ensures the inclusion of key stakeholders like homeowners and property managers from suburban and urban regions, who are most likely to influence sustainable roofing adoption.

3.2 Source of Data

- Data were collected from both primary and secondary sources to provide a comprehensive understanding of sustainable roofing's costs, benefits, and barriers. Primary data were gathered through a structured survey, while secondary data were sourced from academic literature, industry reports, and case studies.

3.3Area of the Study

- The population consists of stakeholders involved in roofing decisions, including homeowners, property managers, architects/designers, contractors/builders, and other professionals in residential and commercial construction, primarily in suburban and urban regions.

3.4 Sample Size

- A sample size of 100 respondents was selected to ensure adequate representation of stakeholder groups while maintaining statistical reliability for the analyses conducted.

Sampling Method

The study uses a purposive sampling method to target respondents with direct or indirect involvement in roofing projects. This non-probability sampling approach ensures the inclusion of key stakeholders, such as homeowners and property managers, who are most likely to influence roofing adoption decisions.

3.5 Data Collection Method

Primary Data

- Primary data were collected via a structured questionnaire administered to 100 respondents. The questionnaire included Likert-scale questions to gauge perceptions of sustainable roofing's costs, benefits, and barriers, as well as demographic questions on age, occupation, region, and roofing experience. The survey was distributed online and in-person to ensure accessibility across suburban and urban areas.

Secondary Data

Secondary data were obtained from peer-reviewed journals, industry publications, and government reports on sustainable roofing technologies. Key sources included studies on green roofs, cool roofs, and solar roofing, as well as market analyses from firms like AV Roofing & Construction. These data provided benchmarks for costs, energy savings, and environmental impacts.

ANALYTICAL TOOLS AND METHODS

- Chi square
- Correlation

DATA ANALYSIS AND INTERPRETATION

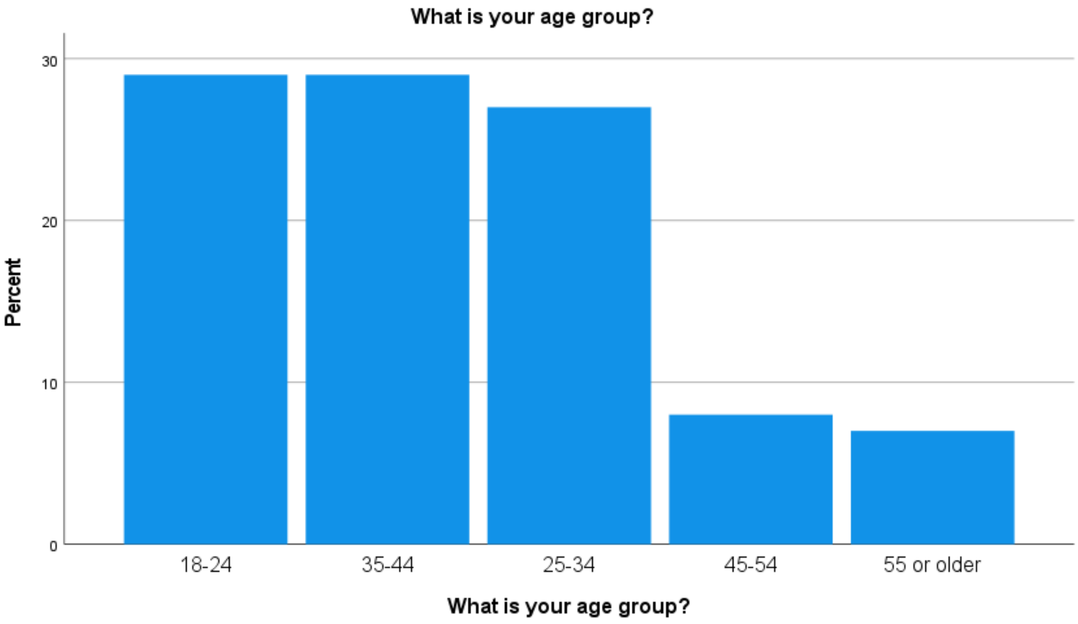
Age Distribution

Age Group	Frequency	Percent
18-24	29	29.0
35-44	29	29.0
25-34	27	27.0
45-54	8	8.0
55 or older	7	7.0
Total	100	100.0

Source: Primary data

Interpretations

From the above table, the age distribution of respondents is relatively balanced among younger and middle-aged groups, with the 18-24 and 35-44 age groups each comprising 29% of the sample, followed closely by the 25-34 group at 27%. This indicates a strong representation of working-age adults, likely reflecting the demographic involved in roofing-related decisions.

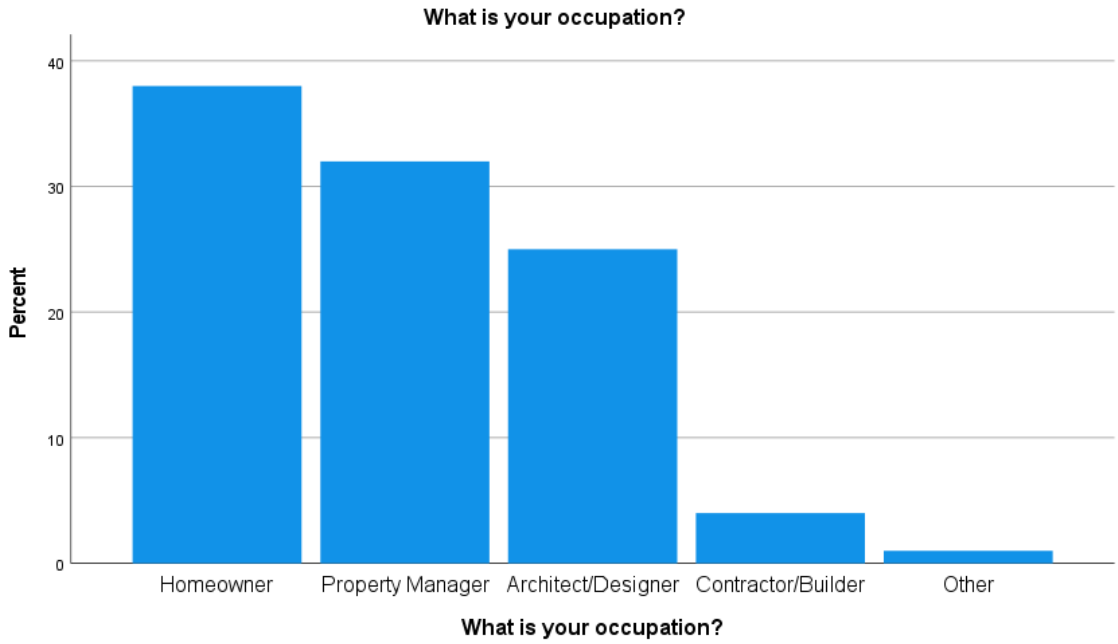


OCCUPATION

Occupation	Frequency	Percent
Homeowner	38	38.0
Property Manager	32	32.0
Architect/Designer	25	25.0
Contractor/Builder	4	4.0
Other	1	1.0
Total	100	100.0

Interpretations

From the above table, homeowners (38%) and property managers (32%) dominate the respondent pool, indicating that individuals directly responsible for property upkeep are most represented. Architects/designers (25%) also form a significant portion, reflecting professional interest in roofing solutions. The low representation of contractors/builders (4%) and others (1%) suggests limited involvement from these groups in the survey. This distribution highlights a focus on stakeholders with direct decision-making roles in roofing projects. The diversity of occupations ensures varied perspectives on roofing preferences and challenges.



CORRELATION

		Importance of D&I	Participation level in D&I Training
	Pearson Correlation	1	.145
Importance of D&I	Sig. (2-tailed)		.268
	N	60	60
	Pearson Correlation	.145	1
Participation level in D&I Training	Sig. (2-tailed)	.268	
	N	60	60

Interpretations

From the above table, the Pearson correlation coefficient between age group and the perception of sustainable roofing's lower long-term maintenance costs is -.107, indicating a weak negative correlation. The p-value (Sig. 2-tailed) of .290 is greater than the standard significance level of .05, suggesting that the correlation is not statistically significant. Thus, the null hypothesis (H_0) is not rejected, as there is insufficient evidence to conclude a significant relationship. The weak negative correlation implies that age group has minimal influence on this perception. The sample size (N=100) provides adequate power for this analysis. These findings suggest that perceptions of maintenance costs are likely influenced by factors other than age.

FINDINGS

The age distribution is balanced among younger and middle-aged groups, with 18-24 and 35-44 each at 29%, and 25-34 at 27%.

- Homeowners (38%) and property managers (32%) dominate the respondent pool, followed by architects/designers (25%).
- Suburban (42%) and urban (41%) regions account for 83% of respondents, with rural areas underrepresented at 17%.
- Respondents with no (36%) or limited (36%) roofing project experience make up 72% of the sample.
- 57% disagree (42% Disagree, 15% Strongly Disagree) that sustainable roofing has lower long-term maintenance costs.
- 67% agree (48% Agree, 19% Strongly Agree) that sustainable roofing has significantly higher initial installation costs.
- 49% agree (35% Agree, 14% Strongly Agree) that sustainable roofing offers a better return on investment over its lifespan.

SUGGESSTION

- Increase public education campaigns to raise awareness about the benefits and options of sustainable roofing, targeting homeowners and property managers.
- Develop training programs to certify more contractors in sustainable roofing installation, addressing the shortage of skilled professionals.

- Simplify regulatory and permitting processes to make sustainable roofing adoption more accessible across regions.
- Improve the supply chain for sustainable roofing materials to enhance availability, particularly in suburban and urban areas.
- Promote financial incentives, such as tax credits and rebates, through clearer and more widespread communication to encourage adoption.

CONCLUSION

The study on sustainable roofing solutions reveals that green, cool, solar, and recycled material roofs offer significant environmental benefits, including reduced carbon emissions, waste, and urban heat island effects, alongside potential energy savings of 10-20%. However, high initial costs, limited material availability, and a shortage of skilled contractors hinder adoption, with 67% of respondents citing installation costs as a major barrier. Despite this, 66% acknowledge sustainable roofing's durability, and 51% recognize financial benefits through reduced utility bills. Stakeholder skepticism, particularly among homeowners and property managers, underscores the need for increased awareness and simplified regulations. Policy incentives, such as tax credits and rebates, are perceived as accessible by 67% of respondents, encouraging adoption. The roofing industry, exemplified by firms like AV Roofing & Construction, is shifting toward sustainability, driven by market demand and technological advancements. To enhance adoption, public education, contractor training, and improved material supply chains are critical. This study provides a robust cost-benefit analysis, guiding stakeholders toward informed, sustainable roofing decisions.

BIBLIOGRAPHY :

1. Ascione, F., Bianco, N., de' Rossi, F., Turni, G., & Vanoli, G. P. (2013). Green roofs in European climates: Energy and cost analysis. Energy and Buildings, 65, 333-341.
2. Berardi, U. (2016). Sustainability assessment of green roofs: Energy and environmental benefits. Sustainable Cities and Society, 22, 96-105.
3. Bianchini, F., & Hewage, K. (2012). Probabilistic social cost-benefit analysis for green roofs. Journal of Construction Engineering and Management, 138(11), 1235-1245.
4. Carter, T., & Keeler, A. (2008). Life-cycle cost-benefit analysis of extensive vegetated roofs. Journal of Environmental Management, 87(3), 350-363.
5. Castleton, H. F., Stovin, V., Beck, S. B. M., & Davison, J. B. (2010). Green roofs: Building energy savings and retrofit potential. Energy and Buildings, 42(10), 1582-1591.
6. Clark, C., Adriaens, P., & Talbot, F. B. (2008). Green roof valuation: A probabilistic economic analysis. Environmental Science & Technology, 42(6), 2155-2161.
7. Getter, K. L., & Rowe, D. B. (2006). The role of extensive green roofs in sustainable development. HortScience, 41(5), 1276-1285.