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An Analysis on Life Cycle Assessment and its impact on Environmental and Economic Perspectives

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Abstract

Rapid urbanization and population growth in Bangalore have significantly increased the demand for residential buildings, leading to environmental and economic challenges. To address these issues, integrating sustainability principles into the construction industry is essential. This research comprehensively analyses the environmental and economic sustainability of residential buildings in Bangalore using the Life Cycle Assessment (LCA) methodology.

The study began with an extensive literature review to identify key sustainability indicators for residential buildings. A multi-faceted data collection approach was employed, including on-site measurements and surveys with contractors and residents. Data were gathered from residential projects such as Prestige Group, Brigade Gateway, and Puravankara Magadi Road. The collected information was analyzed to assess the environmental impact and economic feasibility of buildings across their life cycle—from raw material extraction to construction, operation, and end-of-life phases. Reliability and validity tests, including Cronbach's Alpha and KMO, were conducted using the JMP software tool.

By integrating LCA with economic evaluation techniques, the study quantified sustainability indicators and identified key areas for sustainable interventions. The findings provide valuable insights for developers, architects, and residents, serving as a decision-support tool. Additionally, the research contributes to sustainable development policies and guidelines for future residential projects in Bangalore and other urban areas facing similar challenges.

Key words: Life Cycle Assessment (LCA), Environmental Impact, Economic Viability, Sustainable Development

Introduction and Motivation for the Study

"Environmental Sustainability: Principles, Challenges, and Practical Applications" by Dr. Emily Thompson, published in Sustainability Today by Green Earth Publishing on June 30, 2023, provides a comprehensive overview of environmental sustainability. It explores the fundamental principles, significance, and real-world applications of sustainability in balancing human activities with the long-term health of the planet.

The article highlights critical environmental challenges, including climate change, pollution, biodiversity loss, and resource depletion. It explains essential sustainability concepts such as the triple bottom line, which integrates economic, social, and environmental factors, as well as the ecological footprint and sustainable development. Additionally, it examines various sustainable practices, including the adoption of renewable energy, efficient waste management, sustainable agriculture, and the circular economy.

By offering a clear and accessible discussion, the article aims to encourage individuals, organizations, and policymakers to implement sustainable practices. It serves as a valuable resource in promoting responsible environmental stewardship and ensuring a sustainable future for generations to come.

Literature Survey:

Economic sustainability plays a crucial role in fostering long-term prosperity by promoting resilient economies, optimal resource allocation, and equitable wealth distribution. In her article published in the *Sustainable Economic Review* on November 15, 2022, Dr. Sarah Johnson examines the negative consequences of unsustainable economic practices such as excessive consumerism, income inequality, and environmental degradation. She highlights the importance of sustainable business models, responsible investments, and inclusive economic policies to ensure economic vitality while preserving social and environmental well-being. Similarly, Dr. Lisa Anderson, an expert in Life Cycle Assessment (LCA), explores the significance of LCA as a tool for sustainable decision-making in her article published in the *Sustainable Environment* journal on April 10, 2023. LCA provides a comprehensive approach to evaluating environmental impacts throughout a product or system's entire life cycle, covering aspects such as resource depletion, energy consumption, and waste generation. Dr. Anderson underscores its application across industries, including construction, energy, and waste management, to support evidence-based sustainability assessments. In the context of residential buildings, Dr. Rajesh Kumar's study, published in *Sustainable Development Perspectives* on June 1, 2023, focuses on the environmental and economic sustainability of residential buildings in Bangalore, a city experiencing rapid urbanization. His research highlights the significance of assessing residential buildings using LCA, considering factors like energy use, greenhouse gas emissions, and waste management. The study identifies economic implications of sustainable building practices and offers recommendations for policymakers, developers, and stakeholders to improve sustainability efforts in Bangalore's residential sector. By integrating economic sustainability principles, LCA methodology, and real-world applications in residential construction, these studies contribute to the broader discourse on sustainable development and provide valuable insights for fostering responsible urban growth.

Motivation for the Study

The rapid urbanization and exponential growth of Bangalore's residential construction sector serve as the primary motivation for this study. As Bangalore, known as the Silicon Valley of India, experiences a surge in population and urban development, the environmental and economic impacts of residential buildings have become increasingly significant. This study seeks to evaluate the sustainability of residential buildings in Bangalore, assess their long-term viability, and identify key areas for improvement. By addressing these concerns, the research aims to contribute to sustainable urban development and provide valuable insights for policymakers, developers, and other stakeholders.

Environmental challenges:

The environmental challenges associated with residential buildings in Bangalore are significant, as their construction and operation contribute to high energy consumption, leading to greenhouse gas emissions and pressure on energy resources. Additionally, these buildings generate large amounts of waste and consume substantial water, straining local ecosystems and water supplies. The depletion of natural resources, habitat destruction, and biodiversity loss further exacerbate the environmental impact of residential construction and occupancy. Addressing these issues is crucial for promoting sustainable and ecologically responsible urban development. On the economic front, sustainable residential buildings offer considerable long-term benefits. Energy-efficient designs reduce energy consumption and operational costs, leading to financial savings for residents and building owners. Moreover, adopting green building practices enhances property value and attracts environmentally conscious buyers and tenants. By integrating renewable energy sources, optimizing resource utilization, and obtaining green building certifications, residential developments in Bangalore can achieve both environmental sustainability and economic viability. These sustainable strategies not only mitigate ecological harm but also contribute to the growth of a more resilient and cost-effective housing sector. A commitment to sustainable residential construction can ensure a balance between environmental responsibility and economic prosperity, paving the way for a more sustainable urban future in Bangalore.

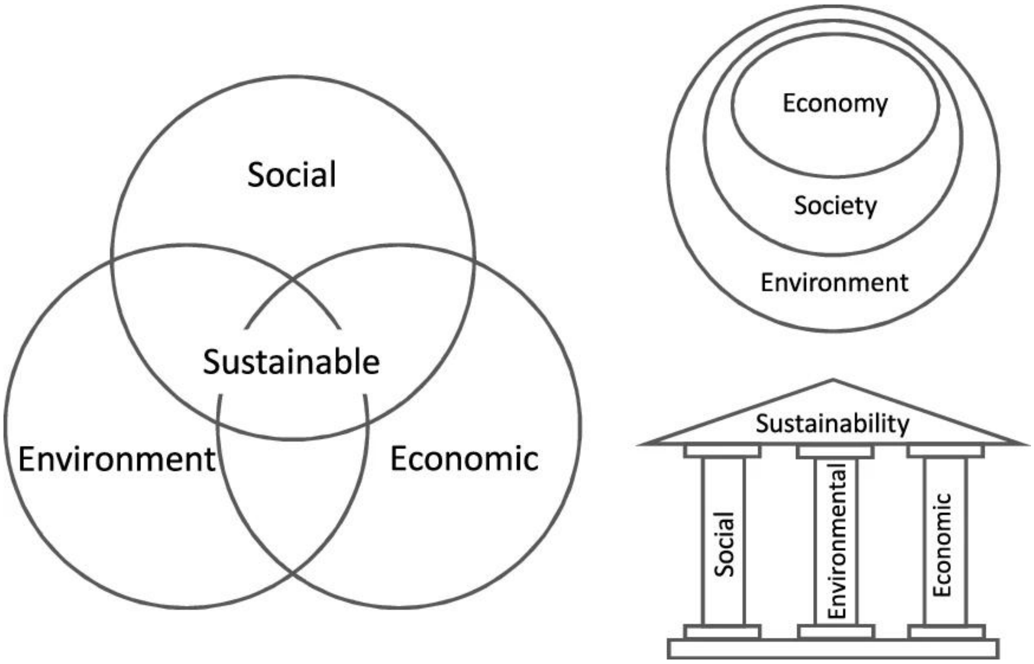

Figure: Sustainability

From the following figure shows the Sustainability where connects Economical sustainability, Environmental Factor and Life Cycle Assessment (LCA).

Summary of Literature Survey

Building Life Cycle Assessment (LCA) research plays a crucial role in evaluating the environmental impact of buildings across their entire lifespan. Various studies have applied bibliometric analysis, quantitative assessments, and case study approaches to understand the contributions, trends, and limitations of LCA research in sustainable construction.

Geng et al. (2018) conducted a bibliometric analysis to assess the research performance and trends in building LCA studies. Their review identified key academic contributions, research directions, and the impact of LCA on sustainable energy practices in construction. Their work underscores the importance of LCA in guiding policy and practice in building sustainability.

Ingrao et al. (2018) examined LCA applications for energy efficiency and environmental performance in buildings. Their review emphasized the role of LCA in selecting sustainable building materials, referencing Pineda et al. (2017), who found that mortars with higher pozzolan content had better structural integrity and reduced environmental impact. This study highlighted the growing significance of LCA in material selection for sustainable building design.

Janjua et al. (2019) analyzed the sustainability performance of residential buildings using LCA. Their study focused on the influence of different materials, such as fly ash and ground granulated blast slag, on sustainability performance and service life. They identified gaps in existing research, particularly in the assessment of social aspects, sustainability indicators, and certification standards, emphasizing the need for further investigations in these areas.

Islam et al. (2020) explored LCA and Life Cycle Costing (LCC) in residential buildings. Their review aimed to identify inconsistencies in LCA/LCC findings across different studies. By comparing various research approaches, they highlighted key factors contributing to disparities in results and provided insights into the financial and environmental trade-offs in sustainable housing design.

Crosbie et al. (2019) focused on energy profiling in LCA research, particularly in integrating information and communication technologies (ICTs) to enhance energy performance measurement in buildings. Their review highlighted the benefits of ICTs in assessing energy performance and discussed challenges related to the adoption of energy-profiling tools in the construction sector.

Apostolopoulos et al. (2023) introduced an integrated approach combining LCA and LCC methodologies for sustainable building renovation. Their study presented the VERIFY tool, which provides dynamic assessment capabilities for building retrofitting projects. The review emphasized the need for integrated assessment tools to bridge methodological gaps and enhance decision-making in building renovations.

Overall, the literature highlights the evolving role of LCA in sustainable construction, emphasizing material selection, energy efficiency, cost considerations, and technological advancements. The findings underscore the necessity for more comprehensive, standardized, and interdisciplinary approaches to enhance the applicability and impact of LCA research in the built environment.

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Aim and Objectives

Aim:

To assess the environmental and economic sustainability of residential buildings in Bangalore, with a special focus on Life Cycle Assessment (LCA).

Objectives:

1. To identify key environmental and economic factors that influence the sustainability of residential buildings.
2. To examine existing construction management practices and their effectiveness in integrating Life Cycle Assessment for sustainable residential construction.
3. To analyze the impact of these factors and provide recommendations for enhancing Life Cycle Assessment and sustainability in residential buildings

Conceptual Framework:

A conceptual framework is an analytical tool with several variations and contexts. It can be applied in different categories of work where an overall picture is needed. It is used to make conceptual distinctions and organize ideas.

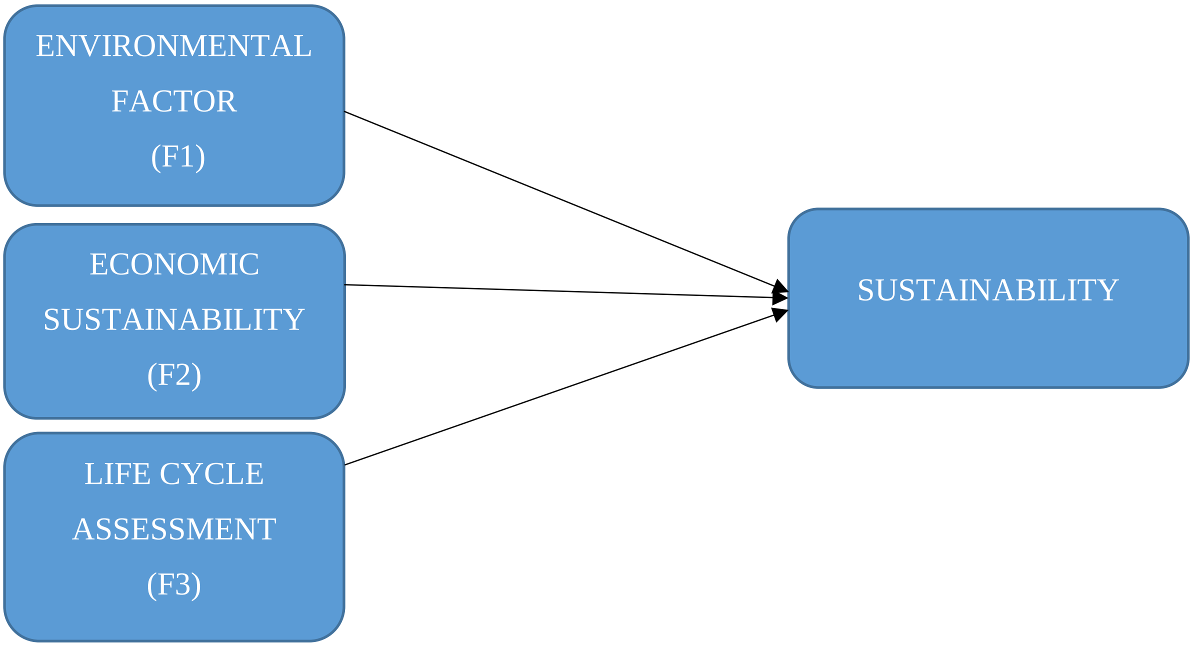

Figure: Conceptual Framework

From the following figure this research mainly consider of three factors are (Environmental factor, Economic Sustainability, Life Cycle Assessment).In this research focus on the conceptual framework with refers to sustainability and a competitive advantage.

Factors and Variable to Develop a Questionnaire

TABLE: Factors and variable to develop a questionnaire

DEMOGRAPHIC PROFILE	Age, Life Style, Income Group, Qualification.
ENVIRONMENTAL FACTOR (F1)	Environmentally Friendly, Residential Building, Government Regulations, Sustainable Construction Practices, Green Building Certification, Heat During Summer.

ECONOMIC SUSTAINABILITY (f2)	Residential Construction, Affordable Housing Options, Residential Building, Minimizing Construction Waste, Long term Cost Saving, Compromising Quality, Energy Efficient Systems, Design.
LIFE CYCLE ASSESSMENT (F3)	Life Of Building, Thermal Comfort Provided by Ceiling, Discomfort Caused by Thermal Ceiling, Place for a Conventional Hall, Theft in the Apartment, Garden in the Apartment, Availability of Medical Facility in the Apartment, Transport Facilities for Old Age People in The Apartment, Child Care Facilities in the Apartment.
SUSTAINABILITY (F4)	Ambulance facility in the layout, Transport facilities for old age, Access to transport option, Connectivity to nearby amenities, Access to safe and convenient pedestrian and cycling infrastructure, Residential building that prioritizes, connectivity and transport sustainability.

Methods and Methodology/Approach to attain each objective:

Table Methods and Methodology

Objective No.	Statement of the Objective	Method/ Methodology
1	To identify the factors influencing the environmental and economical factor which affects sustainability of residential buildings.	Analysis the survey with primary data
2	To investigate the prevailing construction management for effective and efficient usage of life cycle assessment for sustainability in residential building construction.	Develop a survey questionnaire and conducting a pilot study

3	To analyse and suggest suitable recommendations on the influencing factor pertaining to the Life Cycle Assessment and Sustainability of residential.	Using JMP software for Reliability test and Validity test

From the following table 3.6 the methods and methodology has been adapted with reference to identified the factors, investigate the prevailing construction management through Environmental Factor, Economic Sustainability, Life Cycle Assessment (LCA) and the Sustainability.

Table: Sampling Size

Sampling Technique	Simple Random Sampling
Sampling Size	Sample Size -500 No: Of Sample Collected -236 Balance Rejected Due to Improper Data -264
Targeted Area	Dollar's Colony (Prestige Group), Mathikere, Sanjaynagar, Hebbal, Bangalore.

From the above Table 4 sampling size is adapted for Simple Random Sampling were 500. Number of sample collected 236, the remaining sample were rejected due to improper data is 264.

Data Analysis:

Data analysis has been analysed using JMP software and the descriptive statistics is also the analyse the Demographic Profile.

Descriptive Statistics:

Descriptive statistics is the branch of statistics that involves summarizing and interpreting data to provide a concise overview of its main characteristics, such as central tendency, variability, and relationships among variables. It helps in understanding data patterns, making comparisons, and drawing insights from the data. It involves various statistical measures, including measures of central tendency (such as mean, median, and mode), measures of dispersion (such as standard deviation, range, and variance), measures of shape (such as skewness and kurtosis), and measures of association (such as correlation coefficients). Author name is Parampreet Kaur and the published year is 2012.

Descriptive Statistics Demographic Profile

	Age	Gender
N – Valid	236	236
Mean	30.57709	42.34
Standard Error	0.389409	1.363834
Median	31	42
Mode	38	54
Standard Deviation	5.867037	13.63834
Sample Variance	34.42213	186.0044
Range	20	45
Minimum	20	20
Maximum	40	65

Descriptive Statistics Demographic Profile:

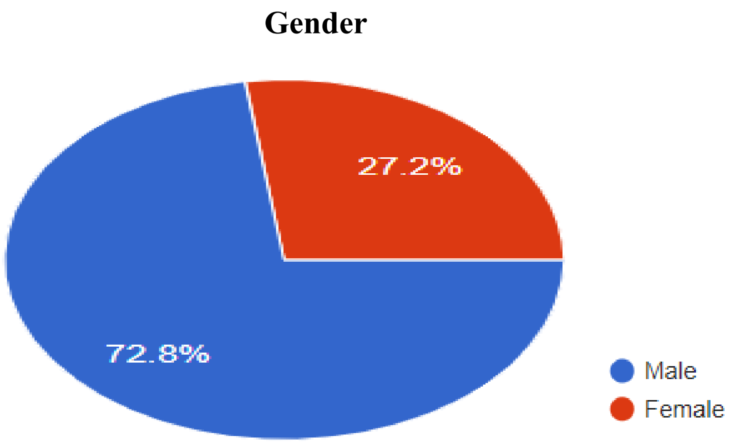

Figure 4.2.1 Gender

From the above sample of 236 majority people were Male of 72.8% and Female were 27.2% in the Sample Size.

Age

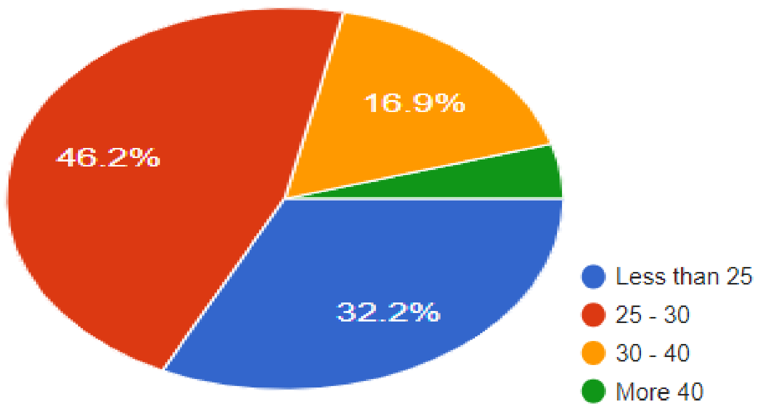

Figure Age

From the above sample of 236 majority of the people comes under the age group of 25-30 were 46.2%, the next highest age group is less than 25 were 32.2% and then 30 -40 were 16.9% and at last more than 40 where 4.7%.

Income Group

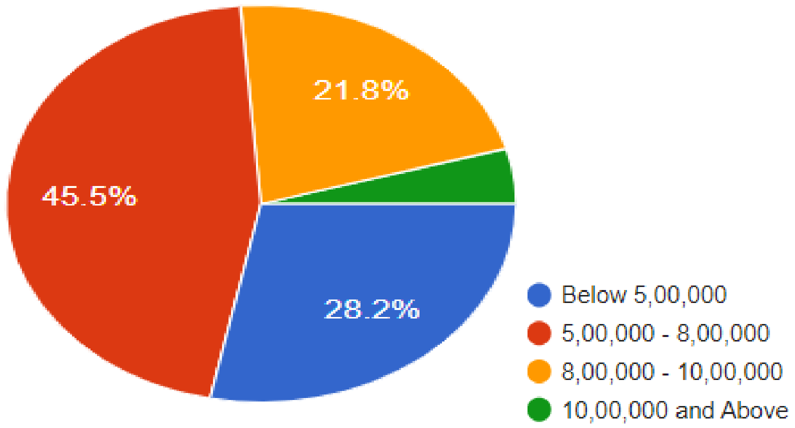

Figure Income Group

From the above Sample of 236 majority of the people comes under the income Group of 5-8 Lakh of 45.5%, the next highest income group below 5 Lakh of 28.2%, the next income group is 8 -10 Lakh where 21.8% and the last income group were 4.5%.

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Qualification

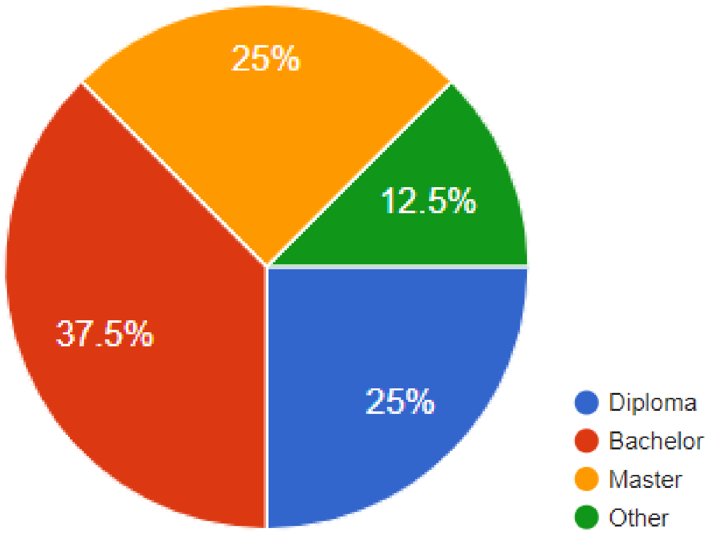

Figure:Qualification

From the Sample of 236 majority of the people comes under the qualification of education Bachelor were 37.5%, Diploma were 25 %, Master were 25 % and the rest of the people were selected other as 12.5%

Reliability test (Cronbach's Alpha Test)

A reliability test, in the context of psychometrics and research methodology, refers to a statistical analysis or procedure used to assess the consistency, stability, or reproducibility of a measurement instrument or scale. It is used to determine the extent to which a measure produces consistent and reliable results over time, across different samples, or among different items within the measure itself. Reliability testing is particularly important when working with psychological assessments, surveys, questionnaires, or any other type of measurement tool. It helps to evaluate the internal consistency and dependability of the instrument by examining the extent to which multiple items or questions within the measure are measuring the same construct or attribute.

Published year was 1995. **The Author name** is Patrick V. Gaffney, PhD. -St. Thomas University (Miami, Florida).

Table Limitations of Reliability Test

Cronbach's Alpha Internal Consistency	
α >= 0.9	**Excellent**
0.9 > α >= 0.8	**Good**
0.8 > α >= 0.7	**Acceptable**
0.7 > α >= 0.6	**Questionable**

0.6 > α >= 0.5	**Poor**
0.5 < α	**Unacceptable**

Purpose of reliability test:

The purpose of a reliability test is to assess the consistency and dependability of a measurement instrument or scale. It is used to determine the extent to which a measure produces consistent and reliable results over time, across different samples, or among different items within the measure itself.

Reliability testing is important for several reasons:

Ensuring Consistency: Reliability tests help ensure that a measurement instrument consistently measures the same construct or attribute. They provide evidence of the instrument's stability and consistency in producing similar results when used repeatedly.

Establishing Validity: Reliability is a fundamental aspect of validity. A measure cannot be valid if it is not reliable. By assessing the reliability of a measure, researchers can establish a foundation for its validity. If a measure is unreliable, it is unlikely to accurately represent the construct being measured.

Minimizing Measurement Error: Reliability testing allows researchers to identify and minimize measurement errors that can occur due to various factors, such as response bias, item ambiguity, or administration inconsistencies. By identifying and addressing these sources of error, researchers can improve the quality and accuracy of their measurements.

Commonly used reliability tests were included:

Cronbach's Alpha: This test assesses the internal consistency of a scale by measuring the average correlation between different items within the scale.

The formula for Cronbach's Alpha is:

$$\alpha = (k / (k - 1)) * (1 - (\Sigma\sigma^2 i / \sigma^2 x))$$

Where:

α = Cronbach's Alpha coefficient

k = number of items in the scale

$\sigma^2 i$ = variance of each item

$\sigma^2 x$ = variance of the total score

Cronbach's Alpha ranges from 0 to 1, with higher values indicating greater internal consistency.

Calculate for the Reliability test:

Reliability can be estimated by comparing different versions of the same measurement.

Table Reliability Statistics:

Cronbach Alpha Based on Standardized Items	0.84

From the above table 4.3.4 Reliability of [the Nature of Solutions and Solubility—Diagnostic Instrument] was represented by using the Cronbach alpha coefficient were 0.84. Cronbach alpha values of 0.7 or higher indicate acceptable internal consistency**. Author name** is Keith S. Taber. **Published on**: 07 June 2017.

Validity Test (KMO Test)

Validity testing refers to the process of evaluating the extent to which a measurement instrument or test accurately measures the construct or attribute it is intended to assess. It assesses the degree to which the scores obtained from a measure are meaningful, representative, and valid for making inferences and drawing conclusions.

Validity is a fundamental aspect of measurement quality and plays a crucial role in ensuring the accuracy and appropriateness of research findings. A measurement instrument can be reliable but lack validity, meaning that it consistently produces consistent results but does not actually measure the intended construct accurately. **Author name** is Henry Kaiser. **Published on** 1970.

There are two types of validity tests used to assess different aspects of validity:

Criterion-Related Validity: Criterion-related validity assesses the degree to which the scores from a measure are related to an external criterion that represents the construct being measured. It involves comparing the scores obtained from the measure with scores on another measure or an outcome variable that is already established as a valid criterion.

Convergent and Discriminant Validity: Convergent validity assesses the extent to which a measurement instrument produces similar results to other measures that are theoretically related to the same construct. Discriminant validity, on the other hand, examines the extent to which a measure produces different results from measures that are theoretically unrelated.

Purpose of a validity test

The purpose of a validity test is to assess and establish the extent to which a measurement instrument or test accurately measures the construct or attribute it is intended to assess. Validity testing is crucial in research and assessment contexts for some reasons:

Ensuring Measurement Accuracy: Validity tests help ensure that a measurement instrument accurately measures the intended construct or attribute. They provide evidence that the scores obtained from the measure are meaningful, representative, and valid representations of the construct being measured.

Enhancing Research Credibility: Validity is a critical aspect of measurement quality and research credibility. By conducting validity tests, researchers can provide evidence to support the accuracy and appropriateness of their measurement instruments. Valid measures increase the trustworthiness and credibility of research findings and conclusions.

Calculate for the Validity test:

Validity is harder to assess, but it can be estimated by comparing the results to other relevant data or theory.

$$KMO = \frac{\sum\sum_{j\neq k} r_{jk}^2}{\quad}$$

where r_{jk} is the correlation between the variable in question and another, and p_{jk} is the partial correlation.

Figure KMO test:

The value of the KMO measure always lies between 0 and 1.

Table: KMO statistics:

Kaiser –Meyer- Olkin measure of sampling	0.76

From the above table 4.4.2 KMO values between 0.7 and 1 indicate the sampling is adequate. So, it refers that the 0.76.

Data Analysis:

Data analysis refers to the process of inspecting, cleaning, transforming, and interpreting data to discover meaningful patterns, draw conclusions, and make informed decisions. It involves applying various statistical and analytical techniques to explore and extract insights from the data.

Purposes of Data Analysis:

Descriptive Analysis: Data analysis helps in describing and summarizing the main characteristics of the data, such as central tendency, variability, distribution, and patterns. Descriptive analysis provides a concise overview of the data and facilitates the understanding of its key features.

Inferential Analysis: Data analysis enables researchers to make inferences and draw conclusions beyond the observed data. Inferential analysis involves using statistical techniques to generalize findings to a larger population, test hypotheses, and make predictions based on the data.

Decision-Making: Data analysis provides valuable information to support decision-making processes. By analysing data, decision-makers can identify trends, patterns, and relationships that inform strategies, interventions, or policy decisions.

Hypothesis Test:

A hypothesis test is a statistical procedure used to make inferences or draw conclusions about a population based on a sample of data. It involves formulating a hypothesis about a population parameter, collecting and analysing sample data, and then making a decision about the validity of the hypothesis.

The primary purpose of a hypothesis test is to assess the evidence in favour of or against a particular claim or hypothesis about a population.

In statistical terms, the hypothesis being tested is typically divided into two mutually exclusive statements: the null hypothesis (H0) and the alternative hypothesis (H1 or Ha). The null hypothesis represents a statement of no effect, no difference, or no relationship.

By conducting a hypothesis test, we aim to determine if the evidence from the sample supports the rejection of the null hypothesis in favour of the alternative hypothesis. Hypothesis testing is widely used in various fields, including scientific research, quality control, medicine, economics, and social sciences. By using hypothesis tests, we can make objective and informed decisions, assess the significance of relationships or differences.

$(\boldsymbol{H_0})$ =$(\boldsymbol{H_0})$ is called as null hypothesis

$(\boldsymbol{H_a})$ =$(\boldsymbol{H_a})$ is called as alternative hypothesis.

An alternative hypothesis (Ha) states that there is a statistically significant relationship between the two variables. The null hypothesis says there is no statistical relationship between the two variables.

There are three types of Hypothesis test are right-tailed, left-tailed, and two-tailed.

HYPOTHESIS TEST

Objectives	**Alternate Hypothesis** $(\boldsymbol{H_a})$	**P value**	**Results**
$(\boldsymbol{H_a}$**1)Environmental Factor**	Environmental Factor has direct and positive impact with Economical Sustainability	0.0965	Accept Null Hypothesis

(H_a2)Economic Sustainability	Economical Sustainability has direct and positive impact with Life Cycle Assessment	0.095	Accept Null Hypothesis
(H_a3) LifeCycle Assessment	Life Cycle Assessment has direct and positive impact with Sustainability	0.091	Accept Null Hypothesis

Table 4.6.2 P-value

P- Value	**Definition**
Less than 0.05	Reject Null(H_0) Hypothesis statistically different between groups.
Greater than 0.05	Fail To Reject null (H_0) Hypothesis No Statistical different between groups, or not even evidence (data) to find a difference.

The Author name for null hypothesis test is **Black Welder** and the year is **1982** were published.

Null hypothesis test:

In hypothesis testing, the null hypothesis (H0) is a statement or assumption that represents a lack of effect, difference, or relationship between variables. It is the hypothesis we want to test and potentially reject based on the evidence from the sample data.

The null hypothesis often takes the form of a specific value or condition of a population parameter. For example, it could state that the mean of a population is equal to a specific value, the proportion of a population follows a certain distribution, or there is no association between two variables.

The null hypothesis is typically denoted as H0, and it serves as the default position or the starting point for the hypothesis test

The purpose of a null hypothesis test is to assess the strength of evidence against the null hypothesis. By analysing the sample data, we calculate a test statistic that quantifies the discrepancy between the observed data and what would be expected if the null hypothesis were true. We then compare the test statistic to a critical value or calculate a p-value to determine the level of statistical significance. **Author name** is Fisher and the **Published year** is 1955.

Correlation Test:

A correlation test is a statistical analysis method used to determine the relationship between two or more variables.

The primary purpose of using a correlation test is to examine and quantify the relationship between variables.

Author name is Francis Galton and the **Published year** is 1996.

Here are some key aspects of correlation tests:

Strength of Association: A correlation test provides a numerical value, called the correlation coefficient, which represents the strength of the relationship between variables. The correlation coefficient ranges from -1 to +1, where -1 indicates a perfect negative relationship, +1 indicates a perfect positive relationship, and 0 indicates no relationship.

Direction of Relationship: The sign of the correlation coefficient indicates the direction of the relationship. A positive correlation coefficient suggests that as one variable increases, the other variable also tends to increase. A negative correlation coefficient suggests that as one variable increases, the other variable tends to decrease.

H_a1: Environmental Factor has direct and positive impact with Economical Sustainability

Environmental Factor

	Environmentally f	*rate environ*	*nable const*	*at incorpor*	*nentally su*	*litional buil*	*efficient ap*	*uilding certification*
Environmental friendly	1							
Residential building	-0.07154	1						
Government Regulations	0.004415	0.118256	1					
Sustainable construction	-0.02774	0.107708	0.022862	1				
Green Building	0.047069	0.033919	-0.04859	0.058596	1			
Certification	0.062822	-0.04259	0.050214	-0.03375	-0.09359	1		
Heat during summer	0.070596	-0.06927	-0.10162	-0.0658	0.003938	-0.00855	1	
Residential building that	-0.07251	0.012745	0.026417	-0.00545	0.095378	-0.11665	-0.03995	1

From the above table for correlation test we have been taken factor 1 and factor 2 are Environmental factor and economic sustainability

P-value

P- Value	**Definition**
Less than 0.05	Reject Null($\boldsymbol{H_0}$) Hypothesis statistically different between groups.
Greater than 0.05	Fail To Reject Null($\boldsymbol{H_0}$) Hypothesis No Statistical different between groups, or not even evidence (data) to find a difference.

From the above table 4.8.1.1 P Value 0.0965 > 0.05 which signifies that we Accept Null Hypothesis.

H_a2 -Economical Sustainability has direct and positive impact with Life Cycle Assessment:

Economic Sustainability

	Environmentally f	rate environ	nable constr	at incorpor	mentally su	litional buil	efficient ap	uilding certification
Environmental friendly	1							
Residential building	-0.07154	1						
Government Regulations	0.004415	0.118256	1					
Sustainable construction	-0.02774	0.107708	0.022862	1				
Green Building	0.047069	0.033919	-0.04859	0.058596	1			
Certification	0.062822	-0.04259	0.050214	-0.03375	-0.09359	1		
Heat during summer	0.070596	-0.06927	-0.10162	-0.0658	0.003938	-0.00855	1	
Residential building that	-0.07251	0.012745	0.026417	-0.00545	0.095378	-0.11665	-0.03995	1

From the above table for correlation test we have been taken factor 1 and factor 2 are Economic sustainability and Life Cycle Sustainability.

P-value

P- Value	Definition
Less than 0.05	Reject Null(H_0) Hypothesis statistically different between groups.
Greater than 0.05	Fail To Reject Null(H_0) Hypothesis No Statistical different between groups, or not even evidence (data) to find a difference.

From the above table 4.8.2.1 P Value 0.095 > 0.05 which signifies that we Accept Null Hypothesis or Fail to Reject the null hypothesis.

H_a3 -Life Cycle Assessment has direct and positive impact with Sustainability

Life Cycle Assessment

	In your layout any ambulanc	facilities fo	nsit or cyc	od connecti	hat offers c	enient pede	uildings th	nectivity and transport
In your layout any ambu	1							
Do you have any specifi	0.038332	1						
How important is acces	0.09741	0.056208	1					
In your opinion, how im	-0.0348	-0.04226	-0.09992	1				
Are you willing to pay a	0.033316	0.028637	0.028881	-0.04645	1			
How important is it for	0.022938	-0.01082	0.036582	-0.02613	-0.06709	1		
How likely are you to re	-0.11143	0.006286	-0.06948	0.016553	-0.02308	0.016289	1	
Prioritize connectivity a	-0.08629	-0.1396	-0.12802	0.083385	-0.02008	0.018432	0.004448	1

From the above table for correlation test we have been taken factor 1 and factor 2 are Life Cycle Sustainability (LCA) and Sustainability.

Table P-value

P- Value	**Definition**
Less than 0.05	Reject Null($\boldsymbol{H_0}$) Hypothesis statistically different between groups.
Greater than 0.05	Fail To Reject Null($\boldsymbol{H_0}$) Hypothesis No Statistical different between groups, or not even evidence (data) to find a difference.

From the above table 4.8.3.1 P Value 0.091 > 0.05 which signifies that we Accept Null Hypothesis or Fail to Reject the null hypothesis.

FORMULA FOR CORRELATION TEST:

Formula for correlation test:

$$r = (\Sigma ((X - \bar{X}) (Y - \bar{Y}))) / (\sqrt{(\Sigma (X - \bar{X})^2)} * \sqrt{(\Sigma (Y - \bar{Y})^2)})$$

Where:

X and Y are the respective values of the two variables.

$\bar{X}$ and $\bar{Y}$ are the means (average) of the X and Y values, respectively.

Σ represents the summation symbol, indicating that you need to sum up the values over a given set of data points.

AUTHOR NAME is, Karl Pearson "On the Theory of Contingency and Its Relation to Association and Normal Correlation," and it was **Published** on 1904.

FINDINGS FROM THE RESEARCH:

1) The integration of three dimensions, namely environmental, economic, and sustainability, in residential buildings presents a noteworthy challenge as these aspects often come into conflict with one another.
2) The findings suggest that achieving a balance among these dimensions is complex and requires careful consideration. On one hand, incorporating environmentally friendly features such as renewable energy systems or energy-efficient materials may incur higher initial costs, posing economic challenges.
3) This intricate interplay between the environmental, economic, and sustainability aspects calls for comprehensive strategies, innovative approaches, and collaborative efforts across various stakeholders to create residential buildings that effectively address these dimensions and contribute to a more sustainable future
4) Implementing sustainable design strategies, such as passive solar design and efficient building envelope systems, offers a range of advantages including economic benefits, improved energy efficiency, reduced environmental impacts, and maximized natural light and heat from the sun. This is achieved through building orientation, window placement, and thermal mass, which minimize the need for artificial lighting and heating
5) Green buildings often enjoy increased market value, enhanced occupant comfort and well-being, and improved overall performance.

SUGGESTIONS FOR FUTURE PURPOSE:

1) Encouraging the widespread adoption of renewable energy sources and energy-efficient systems in residential buildings is crucial for enhancing environmental sustainability. By promoting the use of renewable energy such as solar panels, wind turbines, and geothermal systems, we can significantly reduce reliance on fossil fuels and decrease harmful greenhouse gas emissions.
2) These renewable energy sources provide a clean and sustainable alternative, ensuring a more sustainable future for our planet. Additionally, implementing energy-efficient systems within residential buildings can greatly contribute to environmental sustainability.

3) By incorporating technologies such as LED lighting, smart thermostats, and energy-efficient appliances, we can significantly reduce energy consumption and minimize the environmental impact associated with excessive energy use.

4) Taking into account factors such as temperature, humidity, wind patterns, and solar orientation, architects and engineers can design structures that maximize natural ventilation, utilize passive cooling and heating techniques, and capitalize on renewable energy sources.

5) Additionally, considering resource availability in the design and construction process allows for efficient use of materials, reduced waste generation, and lower environmental footprint.

6) Emphasizing sustainable design and construction practices tailored to local conditions promotes a harmonious relationship between the built environment and its surroundings, fostering a more sustainable and resilient future for communities and the planet.

CONCLUSION:

1) The analysis highlights the significant environmental impact of residential buildings in Bangalore throughout their life cycle, emphasizing the need for sustainable practices.

2) Life cycle assessment provides valuable tool into the environmental burdens associated with the construction, occupancy and end of the period.

3) By prioritizing sustainability and adopting green building practices, stakeholders can not only reduce environmental impact but also realize long-term economic benefits through energy and resource efficiency.

4) Implementing sustainable strategies and utilizing LCA in the design and construction process will play a crucial role in achieving the desired environmental and economic sustainability outcomes in residential buildings in Bangalore. By considering factors such as energy efficiency, material selection, waste management, and indoor environmental quality, sustainable strategies can be effectively implemented to minimize environmental impacts and optimize economic benefits.

5) These findings contribute to a deeper understanding of the challenges and opportunities for achieving sustainability goals in residential construction in Bangalore.

6) Based on these results, it is possible to draw meaningful conclusions and recommendations for future actions aimed at improving environmental and economic performance in the residential building sector.

7) The study on environmental and economic sustainability in residential buildings in Bangalore was carried out by employing rigorous data analysis methods using JMP software and Excel.

LIMITATIONS FOR THE RESEARCH STUDY:

1) The presence of time constraints during the study undoubtedly had an impact on the responses, resulting in limitations that restricted both the depth and breadth of the analysis. The collection of samples from diverse residential buildings further complicated matters, as it led to inaccuracies in their responses.
2) This issue arises due to variations in building types, sizes, and occupants, which can significantly influence data accuracy. Furthermore, the availability and accuracy of data, particularly when attempting to acquire local and specific information for a city like Bangalore, pose considerable challenges.
3) The complex nature of life cycle assessment, a comprehensive methodology employed in this analysis, necessitated the adoption of simplifications to facilitate the evaluation process.
4) While these simplifications may have facilitated the analysis, they also introduced certain trade-offs in terms of precision and completeness.
5) Despite these limitations, the study provides valuable insights into the subject matter and serves as a foundation for future research endeavours aimed at addressing these challenges and refining the methodology for a more comprehensive and accurate analysis of sustainable practices in residential buildings.

FUTURE SCOPE FOR FURTHER STUDY:

1) For future studies, there is a scope to consider a broader range of factors that can further enhance the depth and comprehensiveness of the research. While the survey conducted in this study provided valuable insights, it is important to acknowledge that it was based on a relatively small sample size.
2) Conducting the survey on a larger scale, encompassing a wider range of participants and diverse settings, would yield more robust and representative results. Moreover, expanding the survey to include different cities such as Chennai, Bangalore, Mumbai, and Delhi would offer valuable regional perspectives, allowing for a more comprehensive understanding of sustainable design practices across various urban contexts.
3) Furthermore, while the focus of the survey was primarily on residential buildings, it is worth exploring the applicability of sustainable practices in other building types, including commercial, industrial, and educational buildings.

4) This broader scope would provide a holistic view of sustainable design and construction practices across different sectors and enable a more comprehensive assessment of their environmental and economic impacts.

5) By incorporating these considerations into future studies, researchers can expand the knowledge base and contribute to the development of more effective and adaptable sustainable building practices.

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