Challenges in Implementing Sustainable Construction in Humla District, Nepal

Shovansing Rokaya[1] Uttam Neupane[2] Subash Kumar Bhattarai[3] Asha Bohara[4]

[1, 2, 3, 4] Mid-West University, Graduate School of Engineering, Surkhet

Correspondence Email: *shovansing.rokaya@gmail.com*

Keywords:
Sustainable construction, high altitude region, challenges, awareness

Abstract

Sustainable construction practices have become essential to supporting environmentally friendly development, particularly in ecologically sensitive locations like the high-altitude mountains of Nepal. This study explores the challenges in implementing sustainable construction methods in Humla District. The study uses a qualitative methodology that includes questionnaire surveys and KII to identify important elements that affect in implementing in sustainable construction. Using an Exploratory Factor Analysis (EFA), this study determines the main obstacles to implementing sustainable construction practices in Humla. The Factor analysis identified the ten major components that influence in implementing the sustainable construction in high altitude region. The key component factors are infrastructure and transportation limitations, workforce and skill gaps, energy and disaster resilience, climate and material resilience, local and planning issues, lack of technology and skilled work force, social and governance barriers, etc. The survey discovered that respondents strongly agreed that implementing sustainable construction methods is feasible, so long as there is better material management approaches, more worker training, legislative changes, and improved infrastructure. In order to overcome these challenges and advance sustainable development in high-altitude areas like Humla, this research highlights the critical need for specialized policy solutions, capacity-building efforts, and advanced construction technology. The goal of this research is to promote sustainable development goals in high-altitude regions by adding to the increasing body of knowledge on sustainable construction in the challenging environments.

Received: 15 November 2024
Revised: 2 December 2024
Accepted: 10 January 2025

ISSN: 3102-0763 (Print)
3102-0771 (Online)

1. Introduction

Even though the terms "green building," "ecological building," and "sustainable architecture" had been around for a while, Charles Kibert introduced the first concept of sustainable construction at the First International Conference on Sustainable Construction in Tampa, 1994: "The creation and responsible management of an environment that is healthy based on resource efficient and ecological principles" is what sustainable construction truly is about. The International Council for Research and Innovation in

Building and Construction (CIB) defines sustainable construction as "the sustainable production, use, maintenance, demolition, and reuse of constructions and buildings or their components" [1].

Sustainability refers to initiatives that aim to fulfill human needs while being attentive to reducing any potential harm to the environment. Since the idea of sustainable development has been subject to many different interpretations, it would seem establishing to provide an overview of the concept's development within the framework of the environmental movement and to suggest a workable framework for achieving this goal in the construction sector [2]. However, this industry produces between 45 and 65% of the garbage deposited in landfills and contributes 35% of global CO2 emissions. Furthermore, the construction industry and related activities generate an enormous quantity of harmful emissions; specifically, operations related to the construction process account for around 30% of global greenhouse gas emissions, with the transportation and processing of building materials accounting for 18% of these emissions [3]. As environmental and climate change concerns have increased, attention has turned to how new buildings are built and constructed, especially in terms of their energy and resource usage. More consumers are realizing that structures must be planned with their impact on society and the environment in account [4].

The construction sector is sometimes characterized as being harsh and unfriendly to the environment. The ongoing destruction and significant environmental impact of the construction industry have drawn the attention of several researchers. However, to address this issue, sustainable construction has become a guiding concept for developing a new type of built environment that satisfies human needs now without compromising the capacity of future generations to meet their own needs. The successful implementation of sustainable building is challenged by a number of barriers, such as conflict with cultural change, a lack of government commitment, fear about the high cost of investments, a lack of professional skills, and a lack of regulations[5]. The process of creating structures utilizing resource-efficient and environmentally friendly methods at every stage of a building's life cycle, from design to construction to operation, maintenance, repair, and deconstruction, is called "green building," or "sustainable building." Green building is the best example of sustainable construction practices, but many studies show the obstacles to the adoption of green building construction. According to the research, the main cause of slow development and inability to get involved in green buildings is a lack of understanding, even among architects, consultants, and clients. Similarly, low investment and participation from the government and private companies create challenges[6]. The idea of sustainability has just lately been presented to developing countries, and it is not currently an important issue. The main obstacle to sustainable construction would be getting sustainability on the priorities of the public and clients, national and local governments, educational institutions, and financial institutions [7].

Addressing environmental, social, and economic issues in the construction industry requires sustainable construction. It is challenging to implement in high-altitude, remote regions like Humla, Nepal, because of extreme weather, inadequate infrastructure, scarcity of resources, and high cost of transportation. Progress is further hampered by a lack of trained personnel, locally available resources, awareness, and supportive legislation, underscoring the urgent demand for focused study, customized solutions, and regulations.

The main purpose of this study is to find out the main obstacles/challenges to implementing sustainable construction methods in actual in the Humla District. The research aims to identify obstacles and suggest workable solutions by thoroughly examining the different aspects. This study advances our knowledge of sustainable development in isolated and environmentally sensitive regions by highlighting the particular circumstances of high-altitude construction.

2. Methodology

The study area selected for this study is the Karnali Province of Nepal's Humla District. It is one of the most isolated and underdeveloped districts, characterized by its difficult terrain, harsh weather, and poor infrastructural access. Geographic isolation, ecological sensitivity, and the region's growing need for sustainable development were the main factors in the selection decision.

Primary data is the base of the research. It includes questionnaire, an interview, and focus group. The questionnaire survey was focused on respondents /engineers working in the Humla district in various organizations, at the local level, governmental and non-governmental organizations. A KII was done with the industry experts who had worked in a high altitude district and are promoting sustainable construction practices in Nepal. Qualitative approaches were used in the study of survey responses from engineers about their sustainable construction practices. **Statistical Descriptive Analysis** was likely used to quantify and describe the feasibility or not feasibility in implementing sustainable construction practices in high altitude district. This included calculating percentages and frequencies. Exploratory Factor Analysis (EFA) is a Factor analysis that is a data reduction technique that summarizes many variables into smaller factors based on inter-correlations, where initial variables are observed, extracted factors are latent, and it is commonly used to develop scales or questionnaires for measuring constructs that are not directly observable in real life.

The study gathered qualitative data through open-ended questions about the challenges of implementing sustainable practices in high-altitude areas. **Content Analysis** was probably employed to categorize responses into coherent themes such as accessibility and infrastructure issues, environmental challenges, and policy gaps. Each theme was then likely explored in depth to draw out commonalities and variances in the data, highlighting specific issues like "limited road access," "extreme weather conditions," and "lack of skilled manpower." The study population for the research comprised of engineers working in various sectors in Humla district. The respondents were selected to collect the data for the questionnaire survey and KII. Since the research is based on the qualitative approach, three respondents from purposive sampling who worked in high altitude district were taken for the KII and all engineers working in each local level along with other sectors were taken for the questionnaire survey. From questionnaire survey 30 respondents did responses on the submitted questionnaire among 42 to whom questionnaire were distributed.

3. Result and Discussion

3.1. Feasible or not feasible in implementing sustainable construction practices in high altitude district like Humla

The study was to determine the perception of the respondents regarding the feasibility assessment of implementing sustainable construction practices in high altitude district like Humla. Under this, one generic question related to how feasible is it to implement sustainable construction practices in high-altitude districts like Humla? Was asked to the respondents. The responses showed that majority of them approximately 92% of them (respondents) said that there is feasible to implement sustainable construction practices in high altitude area i.e. Humla district but with some existing challenges associated with this and only nearly 8 percent of the respondent said feasible. Majority of the respondents considered that there exist some challenges while implementing sustainable construction, which needed to be identify. Hence, the main objective of the research study is to identify the core challenges existing while implementing the sustainable construction practices in high altitude areas.

3.2 Major challenges in implementing the sustainable construction practices in high-altitude district

Three KIIs (Key Informant Interview) was conducted with the relevant stakeholders working in the high-altitude area like Humla to take the perception of them regarding the existing challenges in implementing the sustainable construction practices in high altitude district like Humla. An open question was asked to give their responses and has been analyzed. The challenges identified from the KII has been further coded and Exploratory Factor Analysis was done by collecting the responses from the respondents who are working in various public and private sectors in the Humla district. The 39 different challenges identified from the KII after thematic study in the form of 5-point Likert's scale data were asked to the respondents stating 1- Not a challenge to 5- Critical Challenge.

Exploratory Factor Analysis (EFA) is a Factor analysis that is a data reduction technique that summarizes many variables into smaller, and it is commonly used to develop scales or questionnaires for measuring constructs that are not directly observable in real life. To achieve these results, the study followed three major steps for factor analysis: (a) assessing the suitability of the data, (b) extracting factors, and (c) rotating and interpreting the factors.

Table 13 the category of the factors and their coding

Code	Challenges	Code	Challenges	Code	Challenges	Code	Challenges
C1	Climate Change	C11	Suitable Material Selection	C21	Landslides	C31	Lack of Proper Coordination and Cooperation
C2	Lack of Energy Resources	C12	Working Procedure	C22	High Cost of Materials	C32	Lack of Effective Training & Skill Enhancement
C3	Lack of Transportation Service	C13	Field Difficulties and Problems	C23	Weather Challenges	C33	Lack of Specified Materials
C4	Lack of Trained Human Resources	C14	Education and Lack of Knowledge	C24	Instability Among Stakeholders	C34	Inaccessibility of Transportation
C5	Natural Disaster	C15	Lack of Policy Regarding Sustainable Development	C25	Manpower Shortages	C35	Lack of Proper Monitoring and Inspections
C6	High Rate of Migration	C16	Extreme Weather Condition	C26	High Construction & Transportation Costs	C36	Equipment Availability

C7	Transport, Climate, and Geo-Diversity	C17	Limited Accessibility	C27	Local People's Perspective	C37	Lack of Information
C8	Familiarization with Local HR and Climate	C18	Environmental Impact	C28	Lack of Infrastructure	C38	Lack of Qualified Manpower
C9	Identifying Actual Requirement & Building Type	C19	Material Availability	C29	Lack of Effective Technology and Skilled Manpower	C39	Remoteness with Less Access Roads
C10	Environmental Challenges	C20	Terrain & Geology	C30	Lack of Public Awareness		

Step a: Suitability of Data for Factor Analysis

The Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity were used to assess whether factor analysis was suitable. The data's suitability for factor analysis was confirmed by the significant results of Bartlett's test ($\chi 2 = 566.857$, $p < 0.001$) and the KMO value of 0.753, which indicated acceptable sampling.

Step b: Factor Extraction for Challenges

The main challenges to implementing sustainable construction were identified through the application of Factor Analysis method. The Scree Test and Kaiser's Criterion (Eigenvalues >1) were used to calculate the number of factors. Ten of the 39 main components have been found, which accounts for 89.984% of the variation overall, much more than the recommended 50% requirements. 32.532% of the variation was explained by the first component (Eigenvalue = 12.687), whilst the second and third factors, respectively, explained 10.608% (Eigenvalue = 4.137) and 9.013% (Eigenvalue = 3.515). 7.882%, 7.563%, 6.308%, 5.729%, 4.400%, 3.292%, and 2.657% were the remaining components that contributed to the overall variation, suggesting that they had an important role in explaining the challenges. The findings demonstrate the factor analysis successfully pinpointed the main fundamental challenges to implementing sustainable construction techniques in high-altitude areas

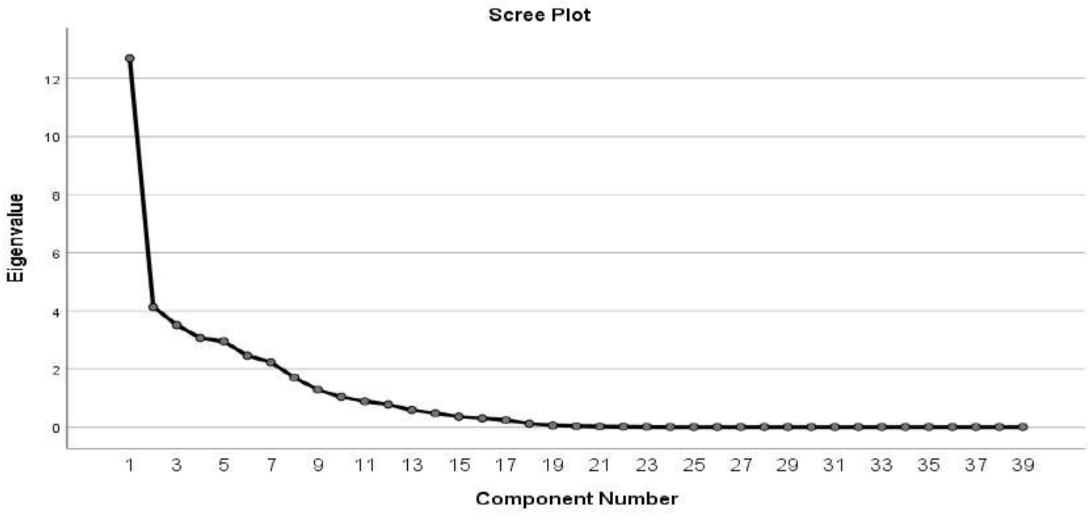

Figure 1 Scree Plot for Evaluation of Existing Challenges

Table 2 Eigenvalues (EV) and Total Variance Explained Extraction Method

Total Variance Explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.687	32.532	32.532	7.168	18.380	18.380
2	4.137	10.608	43.140	4.283	10.982	29.362
3	3.515	9.013	52.153	4.164	10.677	40.039
4	3.074	7.882	60.035	3.655	9.371	49.410
5	2.950	7.563	67.598	3.227	8.275	57.685
6	2.460	6.308	73.906	2.965	7.602	65.287
7	2.234	5.729	79.634	2.910	7.460	72.747
8	1.716	4.400	84.034	2.707	6.941	79.688
9	1.284	3.292	87.326	2.227	5.711	85.398
10	1.036	2.657	89.984	1.788	4.586	89.984
11	.896	2.297	92.281			
12	.778	1.995	94.276			
13	.587	1.505	95.781			
14	.483	1.238	97.020			
15	.357	.915	97.935			
16	.307	.788	98.723			
17	.239	.612	99.335			
18	.121	.310	99.645			
19	.063	.161	99.806			
20	.036	.093	99.899			
21	.021	.054	99.953			
22	.012	.032	99.985			
23	.006	.015	100.000			
24	7.032E-16	1.803E-15	100.000			
25	4.326E-16	1.109E-15	100.000			
26	3.516E-16	9.015E-16	100.000			
27	1.039E-16	2.664E-16	100.000			
28	5.725E-17	1.468E-16	100.000			
29	3.638E-17	9.329E-17	100.000			
30	-2.260E-17	-5.795E-17	100.000			
31	-8.804E-17	-2.258E-16	100.000			
32	-1.141E-16	-2.926E-16	100.000			
33	-1.695E-16	-4.347E-16	100.000			
34	-2.185E-16	-5.603E-16	100.000			
35	-4.585E-16	-1.176E-15	100.000			
36	-6.023E-16	-1.544E-15	100.000			
37	-6.377E-16	-1.635E-15	100.000			
38	-9.579E-16	-2.456E-15	100.000			
39	-1.633E-15	-4.186E-15	100.000			

Step c. Factor Rotation and Interpretation on current challenges

Since we can see some the factors has been cross-loaded. Cross loading refers to the situation where a variable (management strategy, in this case) has significant loadings on multiple factors. In this analysis the cross loading is due to Overlap of Concepts, Factor Rotation and Insufficient Distinction between Factors. Therefore, to omit the cross loading the rotated matrix has been replotted along with the minimum values that are not relevant to the loading. To reduce or omit cross-loadings, we can focus only on the highest loadings for each variable. This makes the factors clearer and easier to interpret.

Table 3 Revised Rotated Component Matrix

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
C1								0.495		
C2			0.767							
C3			0.843							
C4		0.585								
C5			0.696							
C6										
C7					0.788					
C8					0.818					
C9					0.704					
C10										0.755
C11				0.623						
C14									0.800	
C19	0.943									
C20								0.518		
C21										
C22										
C23				0.764						
C24	0.63									
C25		0.891								
C26	0.943									
C28				0.496						
C29						0.532				
C30							0.689			
C33		0.891								
C35										

The Exploratory Factor Analysis (EFA) discovered ten major categories of obstacles that impact sustainable construction in high-altitude regions. These findings provide us a clearer understanding of the complex challenges at hand and point out certain areas that require attention and solutions.

Component 1(Infrastructure and Transportation Limitations): This component shows that a shortage of supplies, expensive transportation, and inadequate stakeholder cooperation pose major challenges. Construction is costly and slow in remote areas. Better roads, domestic material manufacturing, and improved teamwork are required to address issue.

Component 2(Workforce and Skill gaps): This component draws attention to the serious lack of qualified personnel and specialized supplies needed for high-altitude building. Reliance on old techniques results from these gaps, which make it difficult to employ sustainable methods. There is an immediate demand for technical institution assistance and job training.

Component 3(Energy and Disaster Resilience): This element draws attention to high-altitude region's frequent natural disasters, inadequate transportation, and limited access to energy. These problems hinder construction, create delays, and pose safety hazards. Better roads, disaster-resilient construction techniques, and renewable energy are some of the solutions.

Component 4(Climate and Material Resilience): Extreme weather, inappropriate materials, and inadequate infrastructure are highlighted as major challenges in this component. Essential solutions include seasonal planning with long-lasting local materials and climate-adaptive construction.

Component 5(Local Adaption and planning issue): This component shows how construction practices frequently do not align with the needs of the community, the local climate, and the landscape. Project success can be increased by including locals and adapting designs for the area.

Component 6(Lack of technology and skill force): This component draws attention to the lack of qualified labor and modern technology, which results in low quality and low productivity. Efficiency and sustainability can be increased by utilizing modern methods and technology.

Component 7(Social and Governance Barriers): This aspect shows how efforts to create sustainably are hampered by a lack of public awareness. To secure support and guarantee project success, community engagement and education are essential.

Component 8(Project Complexity and Execution risks): This shows how difficult terrain and climate change raise risk and difficulty of construction. Successful engineering solutions must be terrain-adapted and climate responsive.

Component 9(Awareness and Knowledge gaps): This element illustrates how the adoption of sustainable construction is hampered by stakeholders' ignorance and lack of education. Workshops and local education initiatives are essential to removing this challenge.

Component 10(Environment Barriers): It draws attention to environmental issues and inadequate enforcement of laws in remote regions. To guarantee sustainable construction, improved rules and increased government-private cooperation are required.

As shown by the 10 components, sustainable construction in high-altitude regions is impacted by multiple challenges. Cooperation across sectors is required to address these issues, and improved infrastructure, technology, legislation, and skills are all necessary.

4. Conclusions

According to this study, 92% of respondents think sustainable construction is feasible in Humla, considering challenges like lack of resources and environmental circumstances. Enhancing training, developing sustainability guidelines unique to Nepal, and encouraging the use of renewable energy and local materials are crucial. Government support, strong regulations, and cooperation between engineers, legislators, and corporations are all necessary for effectiveness.

The study's exploratory factor analysis (EFA) identified 10 crucial components that identify the main challenges to putting sustainable building practices into implementation in high-altitude areas like Humla. According to the findings, the most important problems are those related to infrastructure and energy, workforce and skill shortages, resource and cost limitations, environmental and climate resilience, and local adaptation and planning concerns. Moreover, it was found that administrative errors, stakeholder opposition, coordination and policy difficulties, social and governance obstacles, sustainability and regulatory issues, and sustainability concerns all had a major influence on sustainable construction projects. Lack of materials, excessive prices, and unpredictable stakeholder participation are major obstacles to sustainable development, according to the factor analysis. Construction projects are further limited by a lack of specialized supplies, a shortage of labor, and inadequate infrastructure for training. Infrastructure issues are made worse by inadequate transportation, poor energy supplies, and natural disaster sensitivity, which makes it challenging to successfully apply sustainable construction techniques. Additionally, the use of durable construction techniques and materials is required due to severe weather and environmental issues.

At last, the findings demonstrate that poor planning, unstable political environments, and weak laws make local adaptation difficult. It is crucial to take a comprehensive approach focusing on strong policies, stronger infrastructure, skilled personnel, and community engagement. By addressing these elements collectively, construction in high-altitude regions can become more sustainable and successful.

References

C. D. PLESSIS, “A strategic framework for sustainable construction in developing countries,” Construction Management and Economics, pp. 67–76, 2007, doi: 10.1080/01446190600601313.

H. Richard C. and B. Paul A., “Sustainable construction: principles and a framework for attainment,” Construction Management and Economics, pp. 223–239, 1996, doi: http://dx.doi.org/10.1080/014461997372971.

L. Lima et al., “Sustainability in the construction industry: A systematic review of the literature,” Journal of Cleaner Production, 2020, doi: https://doi.org/10.1016/j.jclepro.2020.125730.

C. S. Hayles and T. Kooloos, “The challenges and opportunities for sustainable building practices,” Construction in Developing Countries: Procurement, Ethics and Technology, 2008, [Online]. Available: https://www.researchgate.net/publication/228350441_The_challenges_and_opportunities_for_sustainable_building_practices

O. Ametepey et al., “Barriers to successful implementation of sustainable construction in the Ghanaian construction industry,” Elsevier, 2015, doi: 10.1016/j.promfg.2015.07.988.

M. Reza bin Esan et al., “Obstcles in implementing Green Building Projects in Malaysia,” Australian Journal of Basic and Applied Science, pp. 1806–1812, 2011.

du C. Plessis, “Agenda 21 for sustainable construction in developing countries,” CSIR Building and Construction, [Online]. Available: https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Agenda+21+for+Sustainable+Construction+in+Developing+Countries&btnG=