Proceedings of 14th IOE Graduate Conference
Peer Reviewed
Year: 2023 Month: December Volume: 14
ISSN: 2350-8914 (Online), 2350-8906 (Print)

Identifying the causes and effects of Waste due to Non-Value Adding Activities on Road construction projects in Nepal

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Abstract
Waste is inevitable in the construction. During the construction process a lot of waste are generated due to non-value adding activities which is responsible to increase the overall project parameters of project's productivity. These waste factors are sometimes can be avoided or in some cases are unavoidable ones. This research gives insight into the prevalent issue of Non-Value-Adding Activities (NVAAs) within road construction projects in Nepal. It employs a robust framework comprising groups like construction process, design and documentation-related factors, material handling, transportation, and storage, management, workers, construction site, environment and other external factors, material management on-site related, on-site operation related, and equipment and machinery. This framework, established through extensive literature review and expert validation, forms the basis for assessing the impact of NVAAs. Stakeholder perspectives from clients, consultants, and contractors were gathered through structured questionnaire surveys, utilizing the Likert scale questions. The study ranks these factors systematically, shedding light on their relative significance within Nepal's road construction context, aided by the calculation of the Relative Importance Index (RII) for all 11 groups and 82 factors. Additionally, it assesses the tangible consequences of NVAAs by ranking their effects on Time, Cost, Quality, and Productivity. Importantly, the research identifies the top factors driving NVAAs, offering targeted insights for immediate intervention. This data-driven approach equips stakeholders with valuable tools for informed decision-making and proactive NVAAs management, contributing to more efficient and sustainable road construction in Nepal. In essence, this study not only pinpoints the challenges but also provides a structured pathway for optimizing road construction processes and promoting infrastructure development in Nepal

Keywords
Non-Value-Adding Activities (NVAAs),Road Construction Projects in Nepal, Waste in Construction, Sustainable Development, Project Productivity

1. Introduction

Construction industry contributes a significant portion of GDP in Nepal. According to the report of economic survey report 078/79, this sector contributed to around 5.82%[1] of the GDP in the country. Three major concerned parties are client, contractor and consultant [2]. Because of very rapid need of transportation sector particularly road sectors, the design and construction is a must [3].

During the design and construction process many wasteful activities are there. These activities not only consume time and resources but are responsible for dissatisfaction to the parties involved in the construction. Many of the national pride projects in Nepal in the last fiscal year failed to meet the target by 50% [4]. The implementation of projects in Nepal has remained ineffective and in most of the cases has resulted in the Time and cost overruns [5].

The main objective of any construction project is to translate the owner's expressed intention into real artifacts that fulfill that wish. The highest levels of efficiency in human and material resource management must be attained in order for such reforms to be cost-effective [6].

The construction worldwide generates a lot of waste activities in construction and design phase [7]. The matter of fact is that construction activities involve in Nepal faces poor performance in project parameters in time, cost, improper quality, excess construction waste. In Nepal, construction projects have consumed a excess of around 70% of an entire development expenditure [8]. Road construction, a major backbone for the country, have a significant amount of waste during construction and design phase. Only 34% of the overall targeted milestone was achieved in 078/79 fiscal year with relation of construction of black topped road. For the earthen road for the same fiscal year only 41% of the target set was achieved (DoR) [9]. This show that the project performance in the road project in Nepal is not in the level of expectation. This summarize the fact that the project performance needs to be revisited. Various studies suggest that minimization of wastes in construction have led to better Project Outcomes in terms of Time, Cost and Quality such as : Reduced Delay on Project Completion (Time); Client's Budget Saving (Cost) ; Increase Contractor's Profit (Cost)[10]. A study in Nepal shows Effects of Non value adding activities in the construction sector as: Cost Overrun, Time Overrun, Client dissatisfaction, Interruptions'/disruptions to activity sequence [8]. It can be inferred that the minimization of Non value adding activities have a positive impact on the Project Outcomes (in terms of Time, Cost and Quality). This study uses a problem-solving approach with root cause method wherein the solution of any problem is determined by eliminating its root causes.

Furthermore, evaluation of the causes and minimization techniques was done using statistical measurements.

The different types of wastes is shown in Table 1.

Table 1: Types of Waste

S.N.	Waste	Interpreted Definition
1	Defect	Effect due to incorrect information, reworks, etc.
2	Overproduction	Production of excess materials as compared to demands
3	Waiting	Waiting for further step in a process
4	Transportation	Improper movement of materials
5	Extra-Processing	When more work or more quality is required for the customers
6	Inventory	Excess products and over storage
7	Motion	Needless movement of people
8	Non-utilized talent	Lack of using people's qualification

Waste in construction refers to any unwanted products or materials, which can manifest as inefficiencies leading to the excessive use of equipment, materials, labor, or capital beyond what is necessary for the construction process. [11]. Lean production philosophies now define waste as "any inefficiency that leads to the use of equipment, materials, labor, or capital in greater quantities than those considered to be necessary" [12]. This encompasses non-value adding activities, which entail tasks consuming resources, time, or space without contributing value to the final product or service (Becher, 2020)

Formoso et al. classified Waste in construction into natural waste (unavoidable waste) and avoidable waste. Natural waste, also referred to as unavoidable waste, is waste produced during construction for which the investment required to reduce it is more than the financial gains obtained from doing so. In essence, getting rid of this kind of waste is difficult or expensive. Highly specialized materials, complex design, site conditions, etc. are example of unavoidable waste. Waste produced in construction projects that could have been prevented for a lower cost is referred to as avoidable waste. In other words, reducing or getting rid of this kind of waste is economically viable. Over-ordering of materials, poor workmanship, lack of communication among the project parties, inadequate planning of project, etc. are the examples of avoidable waste [13]. Viana et al [14] (2003) distinguish between direct and indirect waste. the direct waste has the loss of materials due to damage, leading to complete wastage. In contrast, indirect waste pertains to incorrect work that deviates from the intended design. For instance, constructing a concrete slab that does not align with the specified requirements can be considered an example of indirect waste. Yahya and Boussabaine [15]classify construction waste into three primary groups: a) Waste related to labor; b) Waste associated with materials; and c) Waste linked to machinery. Waste is generated by construction activities as a combination of inert materials (such as soil, earth, and slurry) and non-inert materials (including metal, timber, and packaging waste) [16]. Construction waste is divided into two main groups: physical waste and non-physical waste. Non-physical waste emerges during the construction process and encompasses factors like time and financial aspects. Conversely, physical waste is a result of the actual construction activities themselves [7].

Key findings from different literature and study conducted are summarized in Table 2.

Table 2: Key Findings in Construction Industry

Author	Country	Key Findings
Teo and Loosemore (2001)[17]	Australia	Waste is inevitable due to management's lower priority on waste management, lack of resources, and incentive support.
Alwi et al. [18]	Indonesia	In the Indonesian construction industry, repair works, waiting for materials, use of non-skilled workers, poor supervision, and raw materials are major contributing factors to waste.
Ekanayake and Ofori [19]	Singapore	Design, operation, and material handling are the major sources of waste.
Osmani et al. [20]	UK	Last-minute changes were rated as the highest cause of waste in the UK construction industry by contractors and architects.
Esin and Cosgun [21]	Turkey	Waste generation factors resulted from poor workmanship due to unskilled labor, insufficient tools, and poor workplace conditions.
Al-Sari et al. [22]	Palestine	Labor-intensive techniques, contractor attitude, and the use of unskilled workers contribute to waste in the Palestine construction industry.

From the extensive study of literature, 11 groups and total 82 factors are listed in Table 3. Literature review suggest that the most of the study focused on the waste due to NVAAs in the sectors other than road and there is the gap that what these factors of waste has the highest RII and major effects on the road sectors in Nepal. To bridge this gap, this research uses determination of the factors of NVAAs in road sectors in Nepal and their effects with relation with the project parameters in relation in Nepalese construction industry.

2. Research Methodology

This research aimed to determine the major causes of wastes due to NVAAs in road sector and their effects with respect to project parameters in Nepal. The research employed alot of tools and techniques to identify the factors and their grouping of waste factors in road construction industry in Nepal. At an

Table 3: Causes of Waste

Classification	Causes
Procurement related waste(G1)	Factors (F): Ordering errors, Incorrect estimated quantity, Substitution of a material by a more expensive one, Waiting for replacement, Suppliers errors, Different method of estimation, Unnecessary packaging of materials, Poor schedule of material procurement, Changes in material prices, Unsuitability of materials supplied to site, Under-buying
Construction process (G2)	Factors (F):Rework during a construction phase, Wrong construction methods, Control and supervision, Coordination problems, Ineffective planning and scheduling, Poor waste management, Mis-use of materials, Inadequate sequence of work
Design and documentation related factors (G3) Factors (F):	Design change and revision, Lack of knowledge about construction techniques during design activities, Complex designs, Selection of low-quality products, Construction drawing errors, Poor communication between parties leading to mistakes and errors, Incomplete contract documents at commencement of the project, Poor site layout, Contractors non-involvement, Lack of design information, Inexperienced designer, Poor/wrong specifications, Overlapping of design and construction, Last-minute client requirements resulting in rework
Material handling, transportation, and storage (G4)	Factors (F):Improper handling of materials, Improper storage of materials, Accidents during handling and transportation, Double handling of materials, Damage during transportation
Management (G5)	Factors (F):Unnecessary requirements, Excessive control, Lack of control, Poor planning, Scarcity of equipment, Lack of waste management plans, Lack of management commitment
Classification	Causes
Workers (G6)	Factors (F):Workers' mistakes during construction, Poor attitudes of workers, Insufficient training for workers, Poor workmanship, Too much overtime for workers, Lack of experience, Shortage of skilled workers
Construction site related factors (G7)	Factors (F): Excess materials on the construction site, Congestion on-site, Inference of others at the site, Left-over materials on-site
Environment and other related factors (G8)	Factors (F): Safety records, Clarification needs, Festival celebration, Unpredictable local conditions, Political instability, Economic fluctuations, Government authority instruction/policy, Restiveness due to protest/strikes, Severe weather conditions, Effects of subsurface conditions
Material Management on site (G9)	Factors (F): Overproduction, Defects, Unnecessary inventories, Inadequate site access for materials delivery and movement, Quality control and inspection
On-site operation related factors (G10)	Factors (F): Theft and vandalism, Slow response from consultant engineer to contractor in queries, Change orders, Lack of skilled subcontractors, Incompetent contractor's technical staff, Lack of positive incentive that aims to waste reduction, Accident due to negligence, Interaction between various specialists
Equipment and machinery related factors (G11)	Factors (F): Inappropriate Equipment, Equipment malfunction and breakdown, Inadequate equipment maintenance

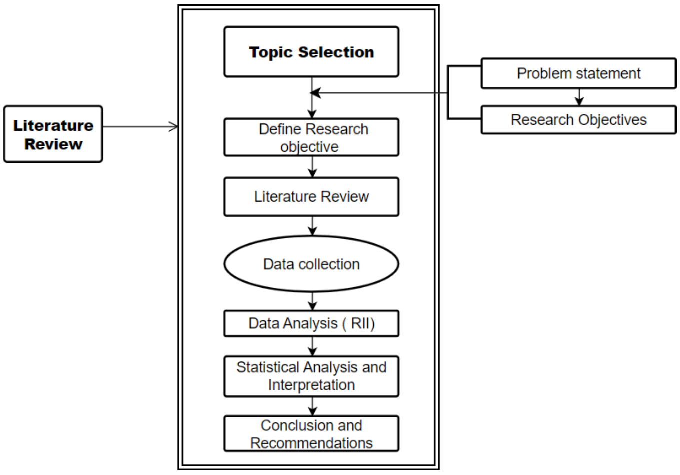

Figure 1: Research Methodology

initial stage, a comprehensive review of literature review was done so as to identify the factors and their associated groups that contributes the waste during construction process. The identified factors were later reviewed, modified and grouped so as to align with the context in Nepalese construction industry.11 groups and 82 factors were used for the questionnaires survey in the likert scale form using KoboToolbox.The Responses were taken from the project parties involved in the construction of road in Nepal and their responses were analyzed with SPSS and excel software. RII and ranking for each groups and factors based on the project stakeholders were made. Furthermore, the responses were analyzed to know the effect of these waste in relation with the project performance outcomes.

2.1 Research Strategy

A quantitative technique is applied in this investigation. Additionally, the statistical, mathematical, or numerical examination of data gathered by surveys is done using the quantitative approach.

2.2 Survey Planning

Using a questionnaire survey, the goals of this research study were achieved. Contractors, consultants, and government representatives working on the road project participated in a questionnaire study. The survey was conducted using a web-based platform, and respondents received a thorough explanation of its goal and methodology. To improve the understanding of the responders, appropriate instructions were given. The information that was gathered was kept private.

2.3 Questionaries Design

On the basis of a literature research, a preliminary questionnaire was created. 10% of the sample group with more than ten years of relevant expertise pretested the draft questionnaires.[23] The major goals of the pretesting are to weed out any queries that aren't crucial and to examine the assurances of clarity and feasibility. Additionally, it is crucial to make sure that all the data collected from the respondents will be helpful in reaching the study's goals. The proposed questionnaire was modified after taking into account the experts' suggestions. The final questionnaire was created after some extraneous questions were removed and others that weren't on the list were inserted.

The structure of the questionnaire consists of four sections.

Section 1: Defines the construction process waste in road sector.

Section 2: Enquires about the causes of construction process waste factors in road construction in Nepal. For this, causes of construction process waste were grouped in eleven categories through literature review from previous studies (Emuze et al., 2014).

Section 3: Enquires the effect of construction process waste in project performance parameters. For this, 14 effects were generated through literature review from previous studies.

Section 4: Defines the demographic features of the respondent.

2.4 Sample Population

The population included contractors, consultants and government officials having experience of road construction in Nepal mainly focusing the respondent of Kathmandu valley. For the purpose of this study, the population of consultants is sourced from SCAEF. Also sourcing data from the Federation of contractors' association of Nepal. The population of government officials is found from DOR. The sample size for questionnaire was computed using Cochran's Formula based on precision and confidence level for infinite population.

Sample size for different groups is summarized in table below. The sample size for questionnaire was computed using Cochran's Formula based on precision and confidence level:

$$n_o = \frac{z^2 pq}{e^2} \tag{1}$$

where,
n_o = Cochran's sample size
e = margin of error (10%)
p = estimated proportion of Population
$q = (1-p)$
z = area under the normal curve which is 1.65 for 90% confidence interval

Using above formula, sample size is found to be 68.

2.5 Source Data

Primary data is collected by questionnaire survey from contractor, consultant and government officials having experienced in road construction in Kathmandu valley. The secondary data is collected from different available published literatures of the concerned topics. Basically, Journals, articles, dissertations, survey reports are the sources of secondary type data.

2.6 Data Measurement

In this research, Likert scale was used to rate the causes and effects of construction process waste. The numbers assigned (1, 2, 3, 4, 5) do not indicate that the interval between scales are equal, nor do they indicate absolute quantities. They are merely numerical labels.

Table 4: Ordinal Scale for Data Measurement

Item	Scale
Strongly Disagree	1
Disagree	2
Neutral	3
Agree	4
Strongly Agree	5

The Relative Importance Index (RII) is used to analyze the data that have been collected. The statistical metric known as RII is used to rank various aspects according to the relevance level or rating given by the respondents. The RII for all the factors is between 0 to 1.

$$RII = \frac{\sum_{i=1}^{N} Ai \cdot Ni}{\cdot A \cdot N} \tag{2}$$

2.7 Research Instrument Reliability Test

The consistency with which a measure measures whatever it is is referred to as the measure's reliability. One of the most used methods for measuring reliability is Cronbach's alpha. It evaluates a scale's items' level of internal consistency. It shows how closely the questionnaire's items are related to one another.[24]

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{i=1}^{K} \sigma_{yi}^2}{\sigma_x^2}\right) \tag{3}$$

Where, k= number of items in a scale σ_x^2: Variance of observed scores of the test
σ_{yi}^2: Variance of component i for the current sample of persons
Cronbach's alpha is calculated. It is expressed as a number between 0 and 1, where a higher value indicates more consistency and reliability.

The Cronbach's alpha for the study was calculated using Microsoft Excel. The value of alpha calculated for the study is greater than 0.7, which indicates acceptable internal consistency for respondents [25].

3. Results and Discussions

3.1 Questionnaire Feedback

Data analysis was carried out from the questionnaire which were distributed to contractors, consultants and government officials. The questionnaire was carried out by sending google form. One hundred and ten (146) sets of questionnaires were distributed to individuals. Respondents having less than 1 year of experience were excluded. Valid responses received were Eighty two (81) at the end of survey period. This equates to a required response. The data were organized and presented in more simplified and easier way to understand them, such as chart form and table. It is shown in the Table ?? and Figure ?? as follow:

Table 5: Statistical Data of Questionnaires

S.N.	Respondent
1	Contractor (26)
2	Consultant (29)
3	Government Officials (26)
Total	81

Based on the collected data, 32% of the respondents are from contractors, 36% are form consultants and 32% are from government.

3.2 Demographic data

The table presents respondent data from a study, revealing that 84% of the participants were male, while 16% were female. In terms of working experience, 57% had less than 5 years, 23% had 5-10 years, 9% had 10-15 years, and 11% had over 15 years. In the specialization category, 82% were Civil Engineers, 4% were Architects, and 14% fell into other unspecified specializations.The responses are shown in a tabular form as shown in table 6.

Table 6: Respondent Data/Characteristics

Gender	**Percentage (%)**
Male	84
Female	16
Working Experience	**Percentage (%)**
< 5 years	57
5-10 years	23
10-15 years	9
> 15 years	11
Specialization	**Percentage (%)**
Civil Engineer	82
Architects	4
Others	14

3.3 Statistical Analysis

From the data collected from questionnaires survey, tools like SPSS, excel were used. The internal consistency of the data set was determined from Cronbach's alpha. Table 9 shows the internal consistency and reliability of the groups and factors selected within the range.

The most often employed tests to assess the normality of a data set are the K-S and Shapiro-Wilk tests.[26] The P-value returned from that test was less than 0.05, demonstrating the sample's non-normal distribution. Therefore, non-parametric statistical measures are used in this study. The agreement between project partners using RII based on client, consultant and contractor was determined using Spearman's rank order correlation approach and shown in Table 8. At level 0.01, the agreement between all parties is significant.

Table 7: Cronbach's Alpha for Reliability Analysis

Group	Sample size	No. of Factors	Cronbach's Alpha
G1	81	11	0.722
G2	81	8	0.862
G3	81	14	0.905
G4	81	5	0.861
G5	81	7	0.831
G6	81	7	0.872
G7	81	4	0.844
G8	81	10	0.889
G9	81	5	0.741
G10	81	8	0.875
G11	81	3	0.778

Table 8: Agreement between Project Parties

	Client	**Consultant**	**Contractor**
Client	1.000		
Consultant	.668**	1.000	
Contractor	.456**	.496**	1.000

** Correlation is significant at the 0.01 level (2-tailed)

The Spearman's Correlation coefficient matrix for each groups is calculated for each group's factor and one of the calculation is shown as shown in the table 9.

Table 9: Group 2 Correlation Matrix

	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**
F1	1							
F2	.609**	1						
F3	0.19	.333**	1					
F4	.293*	.458**	.444**	1				
F5	.257*	.433**	.543**	.487**	1			
F6	.391**	.368**	0.2	.430**	.394**	1		
F7	.335**	.305**	.312**	.497**	.406**	.443**	1	
F8	.298**	0.19	.330**	.358**	.348**	.258*	.447**	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

3.4 Results

Each factor's significance is evaluated by clients, consultants, contractors, and the overall ranking. Notably, Material Handling ranks highest, with a top position in both the client and contractor perspectives, reinforcing its overall significance. Construction Process is the top-ranked factor according to contractors. On the other hand, Environment ranks consistently low across all groups, signifying its relatively lower impact on waste management in construction. The ranking is Waste groups is shown in Table 12. Based upon the responses of the three parties: client, consultant and contractor, the RII of each groups with highest relative importance of the factors are illustrated in Tables 11, 12 and 13 respectively.

Table 10: Ranking of Construction Process Waste by Group

Grouping of Waste	Group Frequency			Overall Rank
	Client	**Consultant**	**Contractor**	
Procurement	4	10	5	5
Construction Process	2	23	1	2
Design and Documentation	8	13	3	7
Material Handling	1	18	2	1
Management	5	11	4	4
Workers	6	10	5	8
Construction Site	6	8	8	5
Environment	11	3	11	11
Material Management	3	10	5	3
On-Site Operation	8	5	9	9
Equipment and Machinery	8	4	10	10

Critical areas that need to be addressed by all stakeholder groups in construction projects are shown by the analysis of the ranking of construction process waste. The glaring disparity in opinions on some waste types is especially notable. When it comes to construction process waste, for example, consultants find it far more problematic than clients or contractors do. This suggests that there may be a difference in how consultants perceive or comprehend inefficiencies that occur during project execution. This disagreement emphasizes how crucial it is for stakeholders to have open lines of communication and a common understanding in order to successfully discuss and resolve inefficiencies. Furthermore, the fact that material handling and material management are consistently identified as the leading causes of waste emphasizes how urgent it is to put focused interventions into resource allocation and logistics. Project teams might utilize these information to create customized waste management plans, possibly integrating lean construction concepts.

Table 11: Highest RII for groups related to causes (according to client)

S.N	Groups	Client
1	Procurement Related Factors	Unsuitability of materials supplied to the site
2	Construction Process	Poor waste management
3	Design and Documentation Related Factors	Poor communication between parties leading to mistakes and errors
4	Material Handling, Transportation, and Storage	Improper handling of materials
5	Management	Lack of waste management plans
6	Workers	Poor workmanship
7	Construction Site	Left-over materials on site
8	Environment and Other External Factors	Severe weather conditions
9	Material Management on Site Related	Inadequate site access for materials delivery and movement
10	On-Site Operation Related	Lack of positive incentives that aim to waste reduction
11	Equipment and Machinery	Equipment malfunction and breakdown

Table 11 suggests that among which group, the RII value of the factors have the highest impact within the group from the prospective of client. It draws attention to important issues such inadequate waste management during construction, inappropriate materials delivered to the site, misunderstandings that result in bad design, problems with material handling, and inefficient transportation. To tackle these concerns, cooperative endeavors, enhanced communication channels, and focused interventions that optimize procurement procedures, improve material handling techniques, and promote sustainable construction practices are all necessary. Table 13, 14 and 15 suggests that the alignment of concerns across these groups highlights shared challenges within the construction industry. Issues like unsuitability of materials, poor waste management, improper handling of materials, and poor workmanship emerge as common themes, indicating systemic issues that impact project efficiency and resource utilization. The consistency in identifying these factors underscores the need for concerted efforts to address them comprehensively. For instance, the recurrence of concerns regarding improper handling of materials emphasizes the critical role of logistics and material management in waste reduction strategies. Furthermore, the presence of factors like poor communication and inadequate site access for materials underscores the importance of effective coordination and planning throughout the project life cycle. The findings suggest the necessity for collaborative solutions that involve all stakeholders, encompassing improved communication channels, streamlined procurement processes, enhanced training and skill development programs, and the implementation of robust waste management plans. By addressing these factors collectively, project stakeholders can mitigate construction process waste, optimize project outcomes.

Top 20 waste factors (non value added activities) based on overall ranking, and with the ranking of client, consultant, and contractor is shown in table 17.Poor waste management" holds the highest overall RII, securing the top position in the overall rank, as well as among clients. Factors like "Last minute client requirement resulting in rework" and "Wrong Construction methods" also rank high, indicating their significance in the context of non-value-adding activities in construction. These rankings provide valuable insights for prioritizing and addressing these issues effectively in construction projects.It demonstrates that, constantly ranking top among all stakeholder groups, inadequate waste management emerges as the most critical issue contributing to construction waste. This draws attention to a crucial area where waste reduction tactics need to be strengthened. Poor workmanship and last-minute client requirements that necessitate rework also rank highly among stakeholders, suggesting recurrent issues that affect the effectiveness of projects. Furthermore, a number of factors are highlighted, underscoring the significance of sound project management

Table 12: Highest RII for categories related to causes (according to consultant)

S.N	Groups	Consultant
1	Procurement Related Factors	Incorrect estimated quantity
2	Construction Process	Wrong Construction methods
3	Design and Documentation Related Factors	Lack of knowledge about construction techniques during design activities
4	Material Handling, Transportation, and Storage	Improper handling of materials
5	Management	Poor Planning
6	Workers	Poor workmanship
7	Construction Site	Left-over materials on site
8	Environment and Other External Factors	Unpredictable local conditions
9	Material Management on Site Related	Inadequate site access for materials delivery and movement
10	On-Site Operation Related	Change orders
11	Equipment and Machinery	Equipment malfunction and breakdown

Table 13: Highest RII for categories related to causes (according to contractor)

S.N	Groups	Contractor
1	Procurement Related Factors	Unsuitability of materials supplied to the site
2	Construction Process	Poor waste management
3	Design and Documentation Related Factors	Last-minute client requirements resulting in rework
4	Material Handling, Transportation, and Storage	Accidents during handling and transportation
5	Management	Lack of waste management plans
6	Workers	Poor workmanship
7	Construction Site	Left-over materials on site
8	Environment and Other External Factors	Economic fluctuations
9	Material Management on Site Related	Defects
10	On-Site Operation Related	Change orders
11	Equipment and Machinery	Equipment malfunction and breakdown

and logistics procedures, including inadequate planning and scheduling, inaccurately calculated quantities, and inappropriate handling or storage of goods.Issues with coordination and communication between stakeholders are also found to be major causes of waste, highlighting the necessity of better cooperation and clarity all the way through the project lifecycle. Furthermore, issues with a lack of trained workers and inadequate training exacerbate waste production, indicating areas that could benefit from funding workforce development programs. Overall, the results highlight the complexity of building waste and the need for all-encompassing approaches that take into account a number of underlying variables, such as strengthening waste management procedures and coordinating and planning projects better.

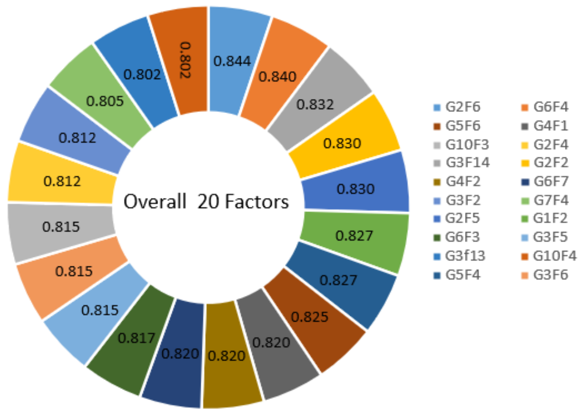

Figure 2: Overall Top 20 factors

Table 14: Effects of Construction Process Waste

Effect	Client RII	Client Rank	Consultant RII	Consultant Rank	Contractor RII	Contractor Rank	Overall RII	Overall Rank
Time Overrun	0.792	9	0.814	2	0.769	5	0.793	3
Cost Overrun	0.846	1	0.841	1	0.862	1	0.849	1
Variation and Claims	0.823	2	0.800	4	0.777	4	0.800	2
Client Dissatisfaction	0.808	5	0.807	3	0.723	9	0.780	5
Interruptions to Sequence	0.800	7	0.752	8	0.754	6	0.768	8
Non-conformance	0.762	10	0.717	11	0.754	6	0.743	11
Overlapping of Activities	0.762	10	0.766	5	0.700	11	0.743	10
Overtime	0.823	2	0.745	10	0.723	9	0.763	9
Additional Resource Allocation	0.808	5	0.759	6	0.792	2	0.785	4
Time-Space Conflicts	0.800	7	0.759	6	0.785	3	0.780	6
Accidents	0.823	2	0.752	8	0.738	8	0.770	7
Damage to Environment	0.846	1	0.800	4	0.769	5	0.805	2

Table 14 provides a detailed analysis of the effect of various factors on construction projects, as perceived by Clients, Consultants, and Contractors. Each factor is evaluated in terms of Relative Importance Index (RII) and assigned specific ranks for the three parties involved. "Cost Overrun" emerges as the most impactful factor, with the highest RII across all groups and securing the top rank in all categories. It is followed closely by "Damage to Environment" and "Variation and Claims." These rankings offer valuable insights into the key areas that need attention to ensure successful project outcomes, such as managing costs and minimizing environmental impact.

Table 15: Overall Top 20 Waste Factors

S.N	Factors	Overall RII	Overall Rank	Client Rank	Cons. Rank	Cont. Rank
1	Poor waste management	0.844	1	1	10	3
2	Poor workmanship	0.840	2	4	4	3
3	Last minute client requirement resulting in rework	0.832	3	11	27	1
4	Wrong Construction methods	0.830	4	4	1	29
5	Ineffective planning and scheduling	0.830	5	11	5	6
6	Incorrect estimated quantity	0.827	6	17	1	22
7	Poor Planning	0.827	7	4	3	22
8	Lack of waste management plans	0.825	8	2	10	17
9	Improper handling of materials	0.820	9	4	10	17
10	Improper storage of materials	0.820	10	4	20	11
11	Shortage of skilled workers	0.820	11	11	10	13
12	Insufficient training for workers	0.817	12	17	5	22
13	Construction drawing errors	0.815	13	42	5	6
14	Poor communication between parties leading to mistakes and errors	0.815	14	4	10	29
15	Change orders	0.815	15	42	10	3
16	Coordination problems	0.812	16	17	33	6
17	Lack of knowledge about construction techniques during design activities	0.812	17	24	5	22
18	Left-over materials on site	0.805	18	20	20	22
19	Overlapping of design and construction	0.802	19	24	27	17
20	Lack of skilled subcontractors	0.802	20	11	17	38

Table 15 and Figure 2 provides the top RII and ranking based on client, consultant and contractor.

Based on the expert opinion and feedback the minimization of waste (non value added activities) during construction of road projects in Nepal were taken and some of them are summarized below:

Effective Waste Management: To reduce construction waste, effective waste management is crucial. The quantity of waste delivered to landfills can be greatly decreased by implementing an all-encompassing waste management strategy that incorporates recycling, reuse, and ethical disposal techniques. Achieving sustainable waste reduction targets can be facilitated by conducting routine monitoring and audits of waste management procedures.

Workforce Training and Skill Development: The best way to cut down on construction waste brought on by shoddy work and mistakes is to invest in workforce training and skill development. Workers can perform their tasks more accurately and with less error and rework if they are given the proper training and information. Regular training programs, safety precautions, and quality control procedures can all help create a workforce that is more skilled and effective.

Effective Communication and Collaboration: Clients, consultants, and contractors are just a few of the many stakeholders that are involved in construction projects. These parties can avoid misunderstandings, change requests, and delays by working together effectively and communicating. Using integrated project management tools, regular project meetings, and clear communication channels can improve collaboration and reduce waste.

Comprehensive Project Planning and Design: Inadequate project planning and design are the root of many waste concerns in the construction process. Comprehensive planning that includes construction professionals from the very beginning of the design process can aid in identifying potential difficulties and preventing problems like overlapping operations, variances, and design errors. Detailed project plans and accurate cost projections can help to further lower the danger of cost and time overruns.

Sustainable Construction Practices: Adopting sustainable construction methods is crucial for reducing waste and the impact on the environment. Utilizing eco-friendly materials, energy-efficient technologies, and reducing resource usage are some examples of these activities. Construction workers can lessen waste production, use less energy, and lessen environmental harm by incorporating sustainability into their projects and implementing lean construction principles

4. Conclusion

Significant insights for the construction industry can be gained from the investigation of the causes of waste in the construction process and the resulting consequences. As the most important factor, "poor waste management" stands out, highlighting how crucial it is to adopt efficient waste management techniques across all projects. Poor workmanship" underscores the need for maintaining high-quality construction standards to minimize waste. The need of precise project specifications and careful planning to reduce waste is emphasized by the significant mention of "last-minute client requirements resulting in rework" and "wrong construction methods." The phrases "incorrect estimated quantity" and "ineffective planning and scheduling" are further examples of areas that might be improved to increase project efficiency.

On the impacts side, "cost overrun" comes in first place, highlighting the serious economic consequences of waste in construction projects. The terms "damage to the environment" and "time overrun" are equally important, emphasizing the negative effects of waste on the environment and scheduling. The terms "variation and claims" and "client

dissatisfaction" highlight the significance of waste management for client satisfaction and conflict avoidance.
While "non-conformance" and "overlapping of activities" are ranked lower, they nevertheless lead to project inefficiencies and increased costs. To address these issues, a complex strategy comprising better planning, quality control, waste management procedures, and stakeholder engagement is required. The construction industry may increase efficiency, cut costs, and ultimately improve project outcomes by emphasizing waste reduction tactics and matching construction techniques with project specifications.

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