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Analysis of Labor Productivity in Bricklaying Operation of Building Construction in Surkhet, Nepal

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Abstract

The development of the nation's infrastructure depends heavily on the construction industry. The entire labor productivity during the project has a significant impact on construction productivity. Therefore, it is necessary to investigate the origins and consequences of labor productivity in the context of the Nepalese construction industry. The methodology involved in conducting the research is the formation of the problem statement, developing research objectives, literature review, data collection, data analysis, conclusion, and recommendations. The data for this research is collected by a literature review as well as a questionnaire and physical observations of building construction. The literature review helped to identify several elements that have an impact on labor productivity. To determine the factors that influenced labor productivity the most, a questionnaire survey was undertaken with a Likert scale. The required information was then produced by processing, analyzing, and interpreting the data using Microsoft Excel and SPSS software tools. The Cronbach's Alpha value was computed using SPSS to measure the internal consistency and found to be 0.976 which shows the better reliability of the research and data collection. From the study, we can conclude that the results obtained from the relative importance index (RII), mean response analysis (MRA), and sensitivity analysis through Artificial Neural Network (ANN) meets the same conclusion as the highest influencing factor affecting labor productivity is 'Material related factors' followed by 'Leadership related factors', 'Manpower related factors', and the last 'Other factors'.

Keywords: Artificial Neural Network (ANN), Bricklaying, Labor Productivity, Relative Importance Index (RII), Root Mean Square Error (RMSE), Sensitivity Analysis, Statistical Package for Social Sciences (SPSS)

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1. Introduction

One of the biggest and most difficult businesses in the country is the construction industry. 10-12 % of Nepal's GDP (gross domestic product) was attributed to construction. Contractors are used to spend almost 60% of the country's development budget. Measurement of construction productivity is necessary to advance the construction Industry, as it is a significant sector that positively affects the nation's economy as a whole and employs a huge number of people. In Nepal, the construction industry plays a crucial role in the country's development and infrastructure growth. Increased consumption that results from increased living standards is closely correlated with labor productivity, which also determines the caliber of building work. One of the key metrics for measuring a project's performance is its productivity. The construction industry is a labor-dependent industry, making labor the primary productive resource. As a result, productivity in this sector is heavily reliant on human performance and effort. As a result, it is essential for determining productivity. Productivity can be represented mathematically as:

$$\text{Labor Productivity} = \frac{\text{Output}}{\text{Total labor hours}}$$

Labor costs generally make up 33 to 50 % of total project cost. Therefore, to lower labor costs and overall project costs and make the contract job financially successful, productivity must be increased [1]. To improve labor productivity, numerous factors influence productivity but vary according to projects or even between tasks within the same project. Contractors have often focused on labor productivity rates as the primary source of the overall success or failure of a project. The volume of work and production of goods and services produced from a certain budget and time is directly dependent on labor productivity. This output growth enables consumers to purchase more goods and services at ever-lower prices [2].

Timely completion and cost of construction projects are two vital parameters to determine the performance of a construction project. However, in Nepal, due to various reasons the cost and time of a construction project significantly vary from its initial estimated cost and time. One of the reasons behind such change is to frequent occurrence of variations. Variations were common concerning labor productivity in all types of construction projects [3]. Any construction project in Nepal is led by a client, consultant, and contractor including a labor workforce to execute the project. In building projects, it is common for the design created during project preparation to require adjustment throughout execution, which is why deviations occur. Any of the stakeholders, such as the client's changing wants, the complexity of the construction for the contractors, or perhaps a consultant's flawed design, may need alteration to the designs, drawings, and specifications [4]which would be helpful for building professionals in assessing and taking proactive measures for reducing the adverse impact of variations. Design/methodology/approach - To achieve the study objectives, a questionnaire survey was carried out to collect information on potential effects of variations. Responses from 28 professionals working for a developer organization (a government agency. Variation may occur for a variety of reasons, both predictable and unpredictable [5]. While some alterations in design, drawing, and specifications are the inevitable result of changing circumstances, others are the result of the project team's negligence. Unquestionably, there will be natural calamities like earthquakes, landslides, diseases, and political unrest like strikes, etc. This could involve a workers' strike, a lack of labor, lack of equipment, or materials, and may be among other things [7].

In terms of brick-laying operations, the construction industry in Nepal is similar to that in other parts of the world. Mostly, construction projects experience brick-laying operations may be little or significant. Karnali province is experiencing rapid growth and transformation in the construction sector, mainly after the provincial system was executed. There is speedy growth of the province in the building sector. This situation is good for the provincial development but since the building sector is just starting to grow, it is clear and concise that hiring inexperienced consultants, contractors, and even an understaffed engineering client has resulted in design flaws that have required several modifications to plans, specifications, and contractual obligations. It has been experienced that lesser labor productivity has caused a decrease in project performance in projects in Karnali province. The performance has been adverse concerning time and quality. Whenever a project is delayed, it is difficult to agree on the additional time and the costs associated with such delay. Disputes and

claims arise when neither party agrees on the extra time and cost. This all eventually contributes to the poor performance of any construction project [8]. The provincial system is not so mature in our context. In addition to this, Karnali province is situated remotely having geographical challenges and even the organizations do not have fulfilled manpower because of hesitation to work in the remote places. Connectivity is a major challenge in this province and it is sad to know that two districts Humla and Dolpa are still not fully connected to the national road network & almost every district of Karnali province lacks fully available heavy motorable roads. In a situation like this, projects need to be planned and executed properly with a pre-estimated count and quality of manpower from the laborer level to the managerial level. This is also related to the resources available as the provinces are allocated limited resources by the federal government. Karnali province has been experiencing RCC buildings and brick masonry buildings for almost 20 years. So, the brick-laying operation is almost new to the manpower available here although the building construction projects are crucial for the province.

There have been very few studies regarding the causes and impacts of degrading labor productivity in brick-laying operations in building projects in Nepal and almost none in Karnali province. So, there is a need to study the causes and impacts of labor productivity in the context of the Nepalese building sector in Karnali Province in particular. Therefore, the need for research in this field is very important to document the causes and factors affecting labor productivity in bricklaying operations in Nepalese construction projects. The study aims for the following objectives:

- To identify different factors that affect labor productivity.
- To predict the influencing factors that affect labor productivity using the Artificial Neural Network (ANN) model.

2. Literature Review

Productivity means “how much and how well we produce from the resources used,” or “how one entity uses its resources to produce outputs from inputs,” and is also defined as “how one entity uses its resources to produce outputs from inputs.” Since its inception, measuring productivity in the construction sector has been a difficult undertaking due to the presence of numerous stochastic variables, including labor-intensive tasks, distinctive characteristics, and uncertainties [9]. Regardless of how different authors define productivity, it is typically understood to be the amount of output generated for each unit of inputted resources. Work efficiency can be gauged using an index known as labor productivity.

In short-term projects, the cost of materials and equipment is frequently disregarded because it is less likely to vary, while labor productivity can vary greatly, raising managerial worries. They stated that the two most important factors affecting labor productivity are the effectiveness with which labor is utilized during the construction process and the relative competence of labor in terms of its ability to perform tasks at a specified time and location. Though there are several definitions and interpretations, all refer to labor productivity as a comparison of input and output. According to [10] the following factors will greatly affect the productivity of bricklaying operations.

- Methods of delivery of brick, including delivery times and intervals.
- Since the ease or difficulty of placing new brick will rely on both the condition of the fresh brick and as well as the shape and dimensions of the brick and levels, it is important to consider the shape and size of the brick.
- The availability of machinery for the bricklaying. They can determine the speed at which laying can progress. This has a direct impact on the productivity of bricklaying.

Expectancy theory suggests that employees constantly predict likely future rewards for completing tasks, and if the rewards seem attractive, people become motivated to do the job to get expected rewards and suggests

that the opposite is true as well. This theory finds extensive application in designing incentive schemes.

Construction projects are labor-intensive and labor costs are a substantial percentage of the total budget. Impaired labor productivity causes an increase in construction project schedules. One of the most commonly discussed subjects is labor productivity in the construction industry, and modeling labor productivity by utilizing different techniques has been the major concern of adoption. It is a challenging task as it requires identifying the influencing factors as well as considering the associated interdependencies [11].

The allocation of factors that affect labor productivity falls under the following factors:

- Resource/Material-related factors
- Manpower-related factors
- Leadership-related factors
- Other factors

The degradation of labor productivity relies on the following causes:

1. Unavailability of materials at the time of work
2. Delayed material delivery by the supplier
3. Unsuitability of material storage location
4. Congestive work area within the project site
5. Absenteeism of craftsmen
6. Use of PPE
7. Wages (Poor Pay)
8. Incentives (Payment for extra work)

Expectations out of labor performance

9. Labor poor behavior and thinking
10. Level of experience and skill of craftsmen
11. Percentage composition of permanent workers out of total workers
12. Communication problems among the different ethnical groups working together (Language Barrier)
13. Level of familiarity with current job nature, environment, and conditions
14. Facilities provided to labor
15. Error in drawings
16. Change indrawing and specifications
17. Improper project coordination and communication
18. Poor project planning and scheduling
19. Level of motivation and commitment through seminars, meetings, and training
20. Improvement in bricklaying methods
21. Inspection Delays (Supervisor Absenteeism)

22. Poor Leadership quality of project manager
23. Level of bureaucracy
24. Structural design complexity
25. Misunderstanding between the agency and the contractor
26. Level of relationship between the workforce and the site supervisor
27. Strikes called by political parties
28. Accident frequency
29. Social environment
30. Improper ventilation for sufficient light & fresh air
31. Change in floor area
32. Floor Height
33. Labor disruption
34. Access to site

The impacts of degrading or neutral labor productivity as identified from these studies are listed below:

a. Time overruns
b. Cost Overruns
c. Unable to achieve predefined quality

3. Research Methodology

This research consists of four phases: First phase topic was selected along with identifying the problems, establishment of research objectives, and development of the research plan. The second phase was focused on the literature review regarding the topic selected. The third phase involved a questionnaire survey to assess the factors and causes that have a direct impact on labor productivity in brick-laying operations and the measures to improve labor productivity in construction projects. The consultant, client, and contractor will be the target group. The fourth and last phase of the research was concluded and recommended accordingly.

The research area is the province headquarters of Karnali Province, Birendranagar Municipality, Surkhet. Four types of respondents were considered in this study. The first respondents were at the managerial level as they are involved in so many projects. The second type of respondents were officer level, the third type of respondents were the proprietor level and the fourth type of respondents were manpower level. This kind of population selection helped to understand the different perspectives as well.

AS per (Salkind, 2010), sample size, "ss" for infinite population is calculated as follows:

$$ss = \frac{Z^2 * p * (1-p)}{e^2}$$

Where:

ss= Sample size required

Z= Level of confidence considering 95 % = 1.96

p = percentage of chances that the questionnaire depicts the issues of

implementation in different phases, expressed as decimal = 0.05

q=1-p

e = Sampling error which shows precision taken 5 percent.

The sample size for the finite population is calculated using the correction as follows:

New ss = $\frac{ss}{1+\frac{ss-1}{pop}}$

Where: -

ss = previous sample size

Pop = population = N

Table 1: Sample Size Calculation

S.N.	Parameters	Projects / Respondents
1	Population Size (N)	49
2	Degree of Confidence (Z)	95%
3	Population Proportion (p)	0.5
4	Error (e)	5%
5	Sample Size Calculation	29.56
6	Required Sample Size	30

The software tools for the analysis were Microsoft Excel and SPSS. The data were analyzed to find frequency distributions, means, standard deviation, etc.

Statistics was used in data analysis. Statistical tests and methods as listed below were done in analysis.

- Relative importance Index
- Frequency Index
- Mean Value Analysis
- Reliability Analysis
- Root Mean Square Error (RMSE) and Sensitivity Analysis were analyzed using ANN

ANNs are mathematical non-parametric models made up of a network of "neurons," or interconnected processing units, that are adaptable, trainable, and include experiential information. As the human brain does, the interconnected components that make up artificial neural networks (ANNs) are known as neurons that are capable of learning, pattern recognition, and categorization. According to [12], the networks learn from data and store that knowledge in a system of synaptic strengths or weights, which measure the strength of neuron connections. Compared to common statistical prediction models and mathematical expressions of output amount based on input data (e.g., sigmoid function, hyperbolic function).

4 . Results and discussions

4.1. General Characteristics

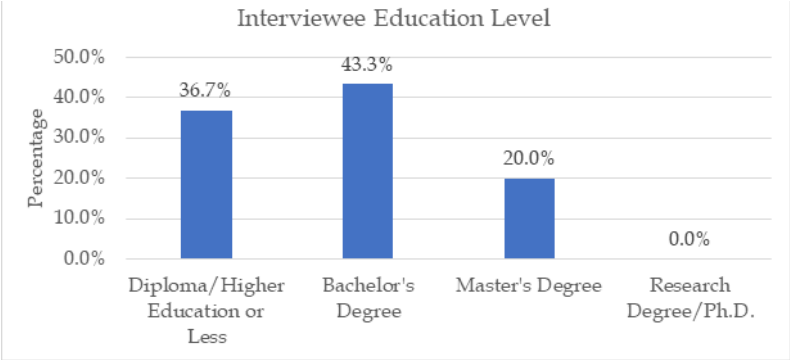


Figure 1: Interviewee Education Level

Figure 1 shows that the majority of interviewees were Bachelor's degree which was 43.3%, Diploma or less qualified degree holder respondents 36.7%, the remaining 20% of interviewees were master's degree holders and zero score respondents with research-level degrees (Ph.D.).

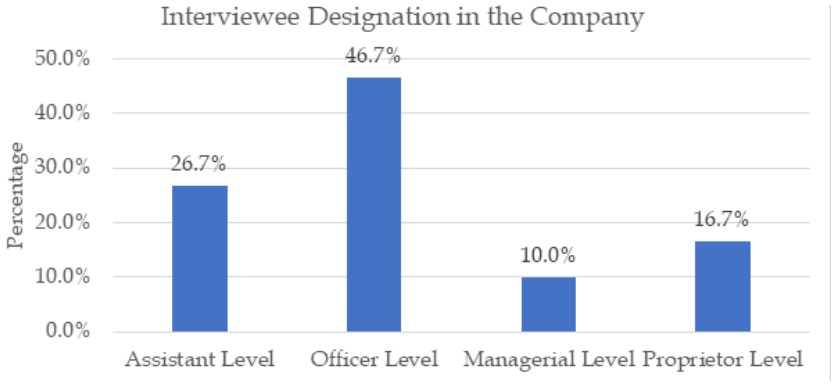


Figure 2: Interviewee Designation in the Company

Figure 2 shows that the majority of respondents were officer level which was calculated to be 46.7%, 26.7% of respondents were found to be assistant level, 16.7 % of respondents were found to be 16.7% and the remaining 10% of all respondents were found to be proprietor level.

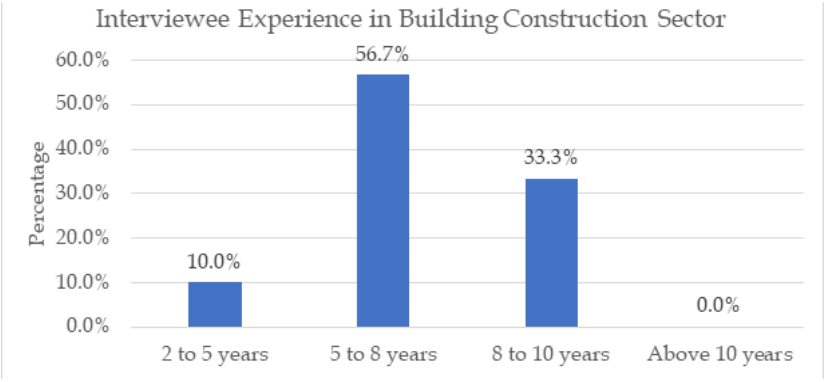


Figure 3: Interviewee Experience in Building Construction Sector

Figure 3 shows that the majority of respondents, i.e., 56.7 % of respondents have had experience of 5-8 years, 33.3 % of respondents were found to have experience of 8-10 years, rest of the respondents i.e., 10% of respondents were found to have 2-5 years of experience and above 10 years of experience scored zero value among respondents' field of building constructions.

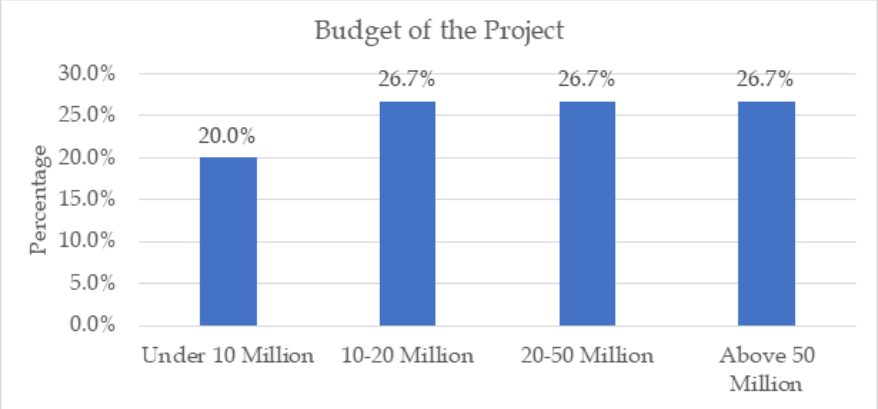


Figure 4: Budget of the Project

Figure 4 shows that 26.7% of the projects are found to be 10-20 million, 20-50 million, and above 50 million each and the remaining 20% of projects are under 10 million of budget.

4.2. **Objective One: Factors Affecting Labor Productivity**

To find out the factors that affect labor productivity in Birendranagar, Surkhet was the main objective of the study. Questionnaires were used to understand and determine the factors. 30 respondents were asked to fill out the questionnaires. The frequency of the scores received by each factor based on the Likert scale was recorded. The relative importance index (RII) and mean value response (MVR) have been assessed and ranked as per their value.

4.2.1. **Relative Importance Index (RII)**

Table 2: Ranking Resource/Material-Related Factors

SN	Statement	RII	Rank
A	Resource / Material Related Factors		
1	Unavailability of materials at the time of work	0.69	4
2	Delayed material delivery by the supplier	0.69	3
3	Unsuitability of material storage location	0.74	1
4	Congestive work area within the project site	0.73	2

From the table and graph, the unsuitability of material storage location with RII score of 0.74 and the Congestive work area within the project site with RII score of 0.73 are considered as the most influencing resource-related factors affecting labor productivity in brick-laying operations with RII score above 0.70.

Table 3: Ranking Manpower-Related Factors

SN	Statement	RII	Rank
B	Manpower Related Factors		
1	Absenteeism of craftsmen	0.63	9
2	Use of PPE	0.81	2
3	Wages (Poor Pay)	0.78	4
4	Incentives (Payment for extra work)	0.81	1
5	Expectations of labor performance	0.80	3
6	Labor poor behavior and thinking	0.67	7

7	Level of experience and skill of craftsmen	0.74	5
8	Percentage composition of permanent workers out of total workers	0.67	7
9	Communication problems among the different ethnical groups working together (Language Barrier)	0.53	11
10	Level of familiarity with current job nature, environment, and conditions	0.58	10
11	Facilities provided for labor	0.69	6

From the table and graph presented, the use of PPE with RII score of 0.81, wages (Poor Pay) with RII score of 0.78, incentives (payment for extra work) with RII score of 0.81, expectations out of labor performance with RII score of 0.80 and level of experience and skill of craftsmen with RII score of 0.74 are the most influencing Manpower related factors affecting labor productivity with RII score above 0.70.

Most significant factor

- Use of PPE (RII score 0.81)
- Incentives (RII score 0.81)
- Expectations out of labor performance (RII score 0.80)

Table 4: Ranking Leadership-Related Factors

SN	Statement	RII	Rank
C	Leadership Related Factors		
1	Error in drawings	0.62	12
2	Change indrawing and specifications	0.66	10
3	Improper project coordination and communication	0.70	6
4	Poor project planning and scheduling	0.77	2
5	Level of motivation and commitment through seminars, meetings, and training	0.78	1
6	Improvement in bricklaying methods	0.67	9
7	Inspection Delays (Supervisor Absenteeism)	0.69	7
8	The poor Leadership quality of the project manager	0.73	5
9	Level of bureaucracy	0.68	8
10	Structural design complexity	0.76	4
11	Misunderstanding between the agency and the contractor	0.65	11
12	Level of relationship between the workforce and the site supervisor	0.77	2

Most significant factors (with RII score above 0.70):

- Poor project planning and scheduling
- Level of motivation and commitment through seminars, meetings, and training
- Poor Leadership quality of project manager
- Structural design complexity
- Level of relationship between the workforce and the site supervisor
- Improper project coordination and communication

Table 5: Ranking Other Factors

SN	Statement	RII	Rank
D	**Other Factors**		
1	Strikes called by political parties	0.57	6
2	Accident frequency	0.51	8
3	Social environment	0.63	4
4	Improper ventilation for sufficient light & fresh air	0.57	6
5	Change in floor area	0.65	3
6	Floor Height	0.68	1
7	Labor disruption	0.67	2
8	Access to site	0.62	5

Since all the factors resemble the RII value lesser than 0.70, the above-examined factors show less effect on labor productivity in brick-laying operations. Social environment, change in floor area, floor height, and labor disruption seem to be the top four factors affecting labor productivity.

4.2.2. Mean Response Analysis (MRA)

Based on ranking score values starting from 1 to 5, the weightage for each response is calculated for analysis and is given by:

Table 6: Weightage of responses (Mean Value Responses)

Responses	Weightage (Mean Value of Responses)
Very Low	1.00-1.80
Low	1.81-2.60
Neutral	2.61-3.40
High	3.41-4.20
Very High	4.21-5.00

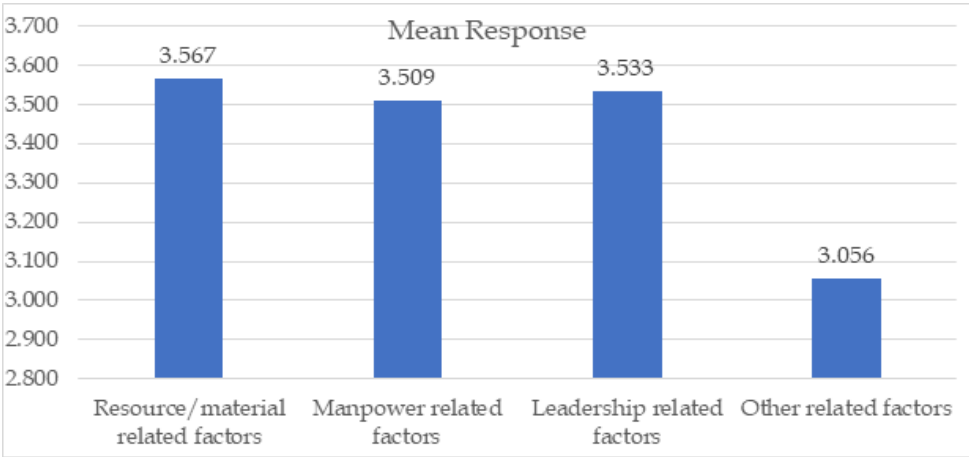


Figure 5: Mean Value Response of each factor

Figure 5 shows that the effect of resource-related factors, manpower-related factors, and leadership-related

factors is high on the labor productivity in bricklaying operations in building constructions in Birendranagar whereas the effect of other factors is neutral on labor productivity.

Each cause of material-related factors (group A factors) has a high effect on the labor productivity in brick-laying operations in Birendranagar Surkhet and the overall effect of resource-related factors on Labor Productivity is high.

"The effect of absenteeism of craftsmen, labor poor behavior and thinking, incentives (payment for extra work), expectations out of labor performance, level of experience and skill of craftsmen and facilities provided to labor" appears to have a high effect on the labor productivity in bricklaying operations in construction projects. The overall effect of manpower-related factors on Labor Productivity is high.

"The error in drawings, change indrawing and specifications, improvement in bricklaying methods, level of bureaucracy and misunderstanding between the agency and the contractor " appears to have a neutral effect on LP. Whereas, "improper project coordination and communication, poor project planning and scheduling, level of motivations and commitment through seminar, meetings and training, inspection delays (supervisor absenteeism), poor leadership quality of project manager, structural design complexity and level of relationship between the workforce and the site supervisor" shows the high effect on labor productivity. Overall, leadership-related factors appear to have a high effect on labor productivity in brick-laying operations in construction projects.

The "accident frequency" appears to have a low effect on labor productivity whereas "the Strikes called by political parties, social environment, improper ventilation for sufficient light & fresh air, improper ventilation for sufficient light & fresh air, floor height, labor disruption and access to the site" indicates to have a neutral effect on labor productivity. Overall, the group D factors indicate a neutral effect on labor productivity in brick-laying operations in construction projects.

4.3. **Objective Two: Predicting influencing factors that affect labor productivity using the ANN model**

4.3.1. Reliability of Data

Questionnaire survey and site observation were used to acquire 30 sets of data from active building construction sites in Birendranagar, Surkhet, to assess the significance of input factors using Artificial Neural Networks (ANNs). With a Cronbach's alpha rating of 0.976, the research and data collection are more reliable.

Table 7: Reliability Test

Reliability Statistics	
Cronbach's Alpha	**No. of Items**
.976	35

4.3.2. Artificial Neural Network (ANN) Analysis:

To identify the elements affecting labor productivity, the ANN model for better analysis was used. The causes were divided into four primary categories: factors related to materials, factors related to labor, factors related to leadership, and other factors. Additionally, the mean response analysis of these factors was chosen as the input variable for the model, and the output of the model was chosen to be the labor productivity.

Since it is more precise, powerful, and adaptable than other software options, IBM SPSS version 26 was chosen to create ANN with a multilayer perception model. By the demands of the multilayer perception model, 70% are used for training and the remaining 30% are used for testing. One hidden layer was used in the model's development, and all other parameters remained the same.

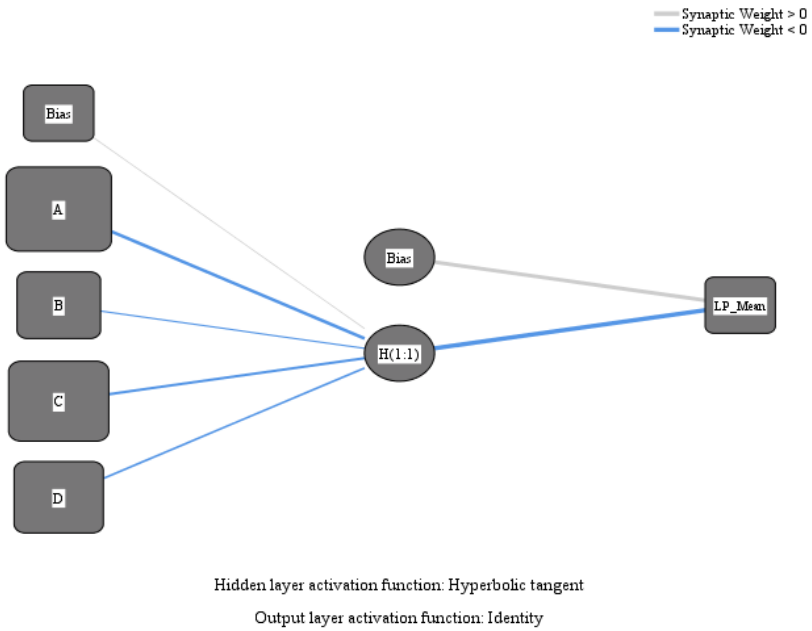
Table 8: Case Processing Summary

		N	Percent
Sample	Training	19	63.3%
	Testing	11	36.7%
Valid		30	100.0%
Excluded		0	
Total		30	

Table 9: Network Information

Input Layer	Covariates	1	Material-related factors (A)
		2	Manpower-related factors (B)
		3	Leadership-related factors (C)
		4	Other related factors (D)
	Number of Units[a]		4
	Rescaling Method for Covariates		Standardized
Hidden Layer(s)	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1[a]		1
	Activation Function		Hyperbolic tangent
Output Layer	Dependent Variables	1	LP_Mean
	Number of Units		1
	Rescaling Method for Scale Dependents		Standardized
	Activation Function		Identity
	Error Function		Sum of Squares
a. Excluding the bias unit			

Figure 6: Artificial Neural Network Diagram



4.3.3. RMSE Values

ANN analysis was done 10 times from which the sum of square errors (SSEs) was gained and root mean square of errors (RMSE) was calculated [13]the adoption rate has not been encouraging. Interestingly, existing research work on past information technology and system models have so far focused primarily on organizational context and adopted specifically for work. Furthermore, past antecedents were mainly constructed using electronic commerce literatures which do not reflect the actual mobile environment. In contrast SCC is mainly adopted voluntarily by mobile users and for personal purposes. Thus this leads to the difficulty in drawing meaningful conclusion. The study addresses these limitations by proposing a new mobile technology acceptance model (MTAM.

Table 10: RMSE Values

Training			**Testing**			
N	**SSE**	**RMSE**	**N**	**SSE**	**RMSE**	**Total Samples**
19	0.008	0.021	11	0.026	0.049	30
21	0.014	0.026	9	0.005	0.024	30
25	0.015	0.024	5	0.002	0.020	30
18	0.011	0.025	12	0.013	0.033	30
22	0.037	0.041	8	0.021	0.051	30
18	0.015	0.029	12	0.016	0.037	30
22	0.025	0.034	8	0.012	0.039	30
21	0.011	0.023	9	0.010	0.033	30
22	0.011	0.022	8	0.017	0.046	30
20	0.023	0.034	10	0.002	0.014	30
Mean	0.017	0.028	Mean	0.012	0.035	
Standard Deviation	0.009	0.006	Standard Deviation	0.008	0.012	

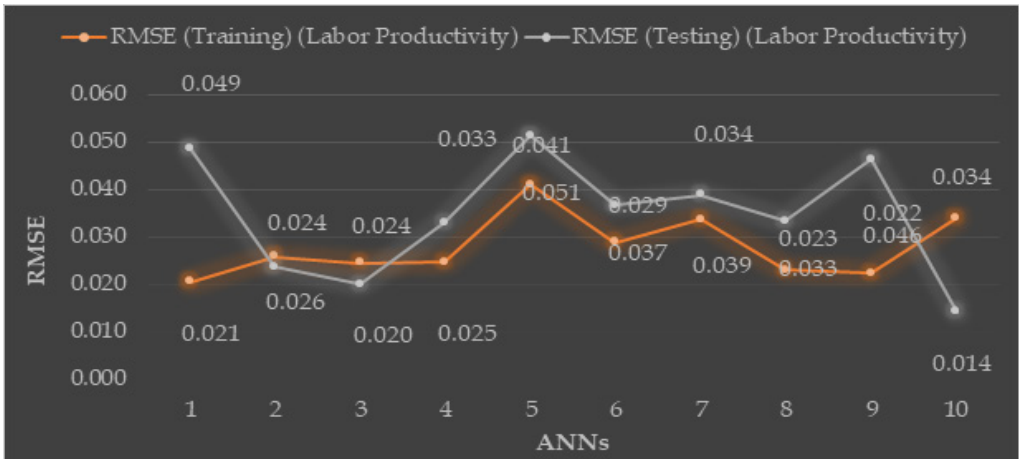


Figure 7: RMSE Training vs. RMSE Testing

Table 10 demonstrates that the training and testing processes' average RMSE values are simply 0.028 and 0.035, respectively. As a result, we can testify to the good model fit.

4.3.4. Sensitivity Analysis

Sensitivity analysis was carried out to determine the normalized relevance of these neurons by dividing their relative value by the maximum importance to determine the strengths of every input neuron's ability to forecast [14].

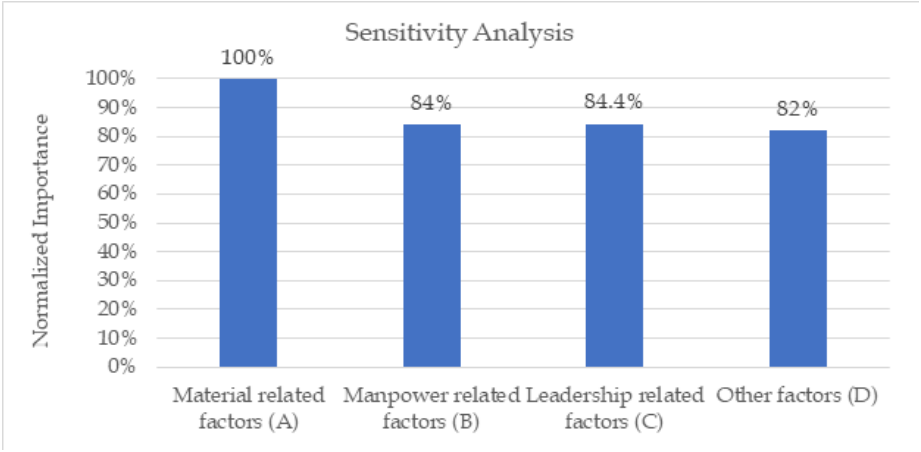


Figure 8: Sensitivity Analysis for Factors Affecting Labor Productivity

Figure 8 shows that materials-related factors have the most influence (100% influence) on labor productivity followed by leadership-related factors (84.4% influence), manpower-related factors (84% influence), and at last other factors (82% influence).

5. Conclusion and Recommendations

5.1. Conclusions

5.1.1. Objective I: To identify different factors that affect the Labor Productivity

Based on the study and questionnaire survey, it can be concluded that:

Each cause of material-related factors (group A factors) has a high effect on the labor productivity in brick-laying operations in Birendranagar Surkhet and the overall effect of resource-related factors on Labor Productivity is high. From the study and calculation of RII Value from different 4 respondents' labor, officer, manager, and proprietor regarding resource-related factors, it was found that all 4 parties suggested the 'unavailability of materials at the time of work (RII 0.69) and the delay of material delivery by the supplier (RII 0.69) are most important factors to be minimized with &' Unsuitability of material storage location (RII 0.74), Congestive work area within the project site (RII 0.73)' are the most influencing material related factors.

"The effect of absenteeism of craftsmen, labor poor behavior and thinking, incentives (payment for extra work), expectations out of labor performance, level of experience and skill of craftsmen and facilities provided to labor" appears to have a high effect on the labor productivity in bricklaying operations in construction projects. The overall effect of manpower-related factors on Labor Productivity is high. From the study and calculation of RII Value from different 4 respondents' labor, officer, manager, and proprietor regarding manpower-related factors, it was found that all four parties suggested 'Incentives (Payment for extra work) with RII score 0.81', 'expectations out of labor performance with RII score 0.80', 'Wages (Poor Pay) with RII score 0.78', 'level of experience and skill of craftsmen with RII score 0.74' & use of PPE with RII score 0.81' are the most influencing material related factors.

"The error in drawings, change indrawing and specifications, improvement in bricklaying methods, level of bureaucracy and misunderstanding between the agency and the contractor " appears to have a neutral effect

on LP. Whereas, "improper project coordination and communication, poor project planning and scheduling, level of motivations and commitment through seminar, meetings, and training, inspection delays (supervisor absenteeism), poor leadership quality of project manager, structural design complexity and level of relationship between the workforce and the site supervisor" shows the high effect on labor productivity. Overall, leadership-related factors appear to have a high effect on labor productivity in brick-laying operations in construction projects. From the study and calculation of RII Value from different 4 respondents' labor, officer, manager, and proprietor regarding leadership-related factors, it was found that all four parties suggested a 'level of motivation and commitment through seminars, meetings, and training with RII 0.78', 'poor project planning and scheduling with RII 0.77', 'level of relationship between the workforce and the site supervisor with RII 0.77', 'structural design complexity with RII 0.76', 'Poor Leadership quality of project manager with RII 0.73' are the most influencing leadership related factors.

The "accident frequency" appears to have a low effect on labor productivity whereas "the Strikes called by political parties, social environment, improper ventilation for sufficient light & fresh air, improper ventilation for sufficient light & fresh air, floor height, labor disruption and access to the site" indicates to have a neutral effect on labor productivity. Overall, the group D factors indicate a neutral effect on labor productivity in brick-laying operations in construction projects. From the study and calculation of RII Value from different 4 respondents' labor, officer, manager, and proprietor regarding other factors, it was found that all 4 parties suggested the 'change in floor area, labor disruption, and floor height' with RII score below 0.70 are factors influencing labor productivity.

5.1.2 Objective II: To predict labor productivity during bricklaying operation using Artificial Neural Network (ANN) model

IBM SPSS software was chosen to create ANN with a multilayer perception model. ANN analysis was done 10 times from which the sum of square errors (SSEs) was gained and root mean square of errors (RMSE) was calculated as 0.028 and 0.035, respectively. As a result, we were able to testify to the good model fit.

Sensitivity analysis shows that materials-related factors have the most influence (100% influence) on labor productivity followed by leadership-related factors (84.4% influence), manpower-related factors (84% influence), and at last other factors (82% influence).

From the study, we can conclude that the results obtained from the relative importance index (RII), mean response analysis (MRA), and sensitivity analysis through Artificial Neural Network (ANN) meet the same conclusion as the highest influencing factor affecting labor productivity are ranked as below:

- Material-related factors
- Leadership-related factors
- Manpower-related factors
- Other factors

5.2. Recommendation

Based on the study and questionnaire survey, it can be concluded that the labor productivity in brick-laying operations can be estimated using the ANN model.

The recommendations for improvement of labor productivity in bricklaying operations in construction projects implemented in Birendranagar, Surkhet are discussed below;

From the study and calculation of RII Value from different 4 respondents' labor, officer, manager, and proprietor regarding resource-related factors, it was found that all 4 parties suggested the 'unavailability of materials at the time of work (RII 0.69) and the delay of material delivery by the supplier (RII 0.69) are most important factors to be minimized with &' Unsuitability of material storage location (RII 0.74), Congestive

work area within the project site (RII 0.73)' are the most influencing material related factors to be mitigated to improve labor productivity in bricklaying operations. A suitable area for storing materials should be made for a convenient work supply.

From the study and calculation of RII Value from different 4 respondents' labor, officer, manager, and proprietor regarding manpower-related factors, it was found that all four parties suggested 'Incentives (Payment for extra work) with RII score 0.81', 'expectations out of labor performance with RII score 0.80', 'Wages (Poor Pay) with RII score 0.78', 'level of experience and skill of craftsmen with RII score 0.74' & use of PPE with RII score 0.81' are the most influencing material related factors. Incentives, wages, and bonuses should be provided to the workers from time to time and experienced manpower should be appointed to work to improve labor productivity.

From the study and calculation of RII Value from different 4 respondents' labor, officer, manager and proprietor regarding leadership-related factors, it was found that all four parties suggested 'level of motivation and commitment through seminars, meetings, and training with RII 0.78', 'poor project planning and scheduling with RII 0.77', 'level of relationship between the workforce and the site supervisor with RII 0.77', 'structural design complexity with RII 0.76', 'Poor Leadership quality of project manager with RII 0.73' are the most influencing leadership related factors. The leadership quality, workmanship, skills, and knowledge of work schedule should be given to all the co-workers from top to bottom level of the workforce through seminars, meetings, training, and motivation from time to time to improve labor productivity.

From the study and calculation of RII Value from different 4 respondents' labor, officer, manager, and proprietor regarding other factors, it was found that all 4 parties suggested the 'change in floor area, labor disruption, and floor height' with RII score below 0.70 are factors influencing labor productivity. The above factors can either be mitigated or be made aware of preliminary.

5.3. Recommendation for Further Study

The Recommendations for further study are discussed below;

- Building projects implemented in Birendranagar, Surkhet were only considered for the study. A similar study can be carried out on building projects implemented in the whole Karnali province of Nepal.
- Time and resources were limited.
- Detailed engineering report of the projects was not analyzed.

Conflict of interest

No conflict of interest.

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