ASSESSMENT OF ENVIRONMENT CONSCIENCE CONSTRUCTION PRACTICES IN PAKISTAN USING SIGNAL TO NOISE RATIO

Sikandar Bilal Khattak[1*], and Iftikhar Hussain[1]

ABSTRACT

Construction sector contribution to global and national Gross Domestic Product (GDP) is significant. However, it is a source of carbon emissions and solid waste as well. The positive impact is more of a community or region based, whereas its contribution to climate change has a global spread. For years, environment-friendly construction, green buildings, lean construction, and sustainable construction has been portrayed as a possible alternative. However, the success factors for environment conscience construction differs in different regions. Identification of these factor is the first step towards achieving it. However, no all-inclusive study exists for a developing and terror hit country like Pakistan. This paper identifies and quantifies the environmental conscience factors, respectively. The data is then analyzed through Taguchi Signal to Noise Ratio (SNR) to rank the factors. The results indicate that factors such as type of soil, which has some economic benefits or factors such as clean water, which are client requirements, are mostly considered, whereas factors such as recyclable products, renewable energy, and carbon emissions are least considered.

KEYWORDS: *Construction, Environment, Green Construction, Sustainable Construction, Signal to Noise Ratio*

INTRODUCTION

Construction contributes around 10 % of the total global Gross Domestic Product (GDP) (Yun and Jung, 2017) and engages around 9.9 million human resources ((ECIF), 2010). In developing countries, construction has been a significant source of employment and economic development (Goel et al., 2019). However, this economic and social impact results in resource depletion and environmental degradation. The myth that the construction industry has unlimited resources has eroded (Ong, 2017). The construction activities, especially the buildings, consume around 17 percent, 25 percent, and 50 percent of water, wood, and extracted minerals/stones respectively (IEA, 2011).

Integrating sustainability with construction has been a complicated issue for decades. The complexity such as fragmentation (Myers, 2005), dependency on other sectors (Meng, 2012), technology variation (Gunatilake, 2013), and social integration makes sustainable construction a much more challenging and complicated issue. Construction is the translation of the design into reality (Roger Flanagan, 1993), whereas sustainability is the ability to sustain or maintain itself. Integrating construction with sustainability results in the translation of the design into reality, which is cost-effective, environment-friendly, and socially acceptable.

Although construction does have a definite link with society, it is also responsible for carbon emissions, air pollution, resource depletion, and other environmental degradation propositions (Augenbroe et al., 1998). In Pakistan, due to the fast urbanization (Arif and Hamid, 2009) and China Pakistan Economic Corridor (CPEC) (Rauf, 2019), the construction sector saw an increase in growth from 4 % in 2014-15 to 9 % in 2015-16 (Wasti, 2016).

Although no new cities were developed over the years, the housing societies over the last decades have seen a mushroom-like growth. This growth typically has been observed in Islamabad, Lahore, Karachi, and Peshawar, but is not limited to these cities only. This fast urbanization has consumed orchards, farms, and agriculture land at an alarming rate. Such expansion has forced the governments both at the federal and provincial levels to start infrastructure projects and mass transit systems, which has added more calamity to the available situation.

Approximately four thousands trees were uprooted for Rawalpindi-Islamabad Metro (Khattak, 2014), thirty nine hundred for Lahore Metro (Hussain, 2016), and nine hundred and sixty for Islamabad Metro (Anwar, 2017).

1 Department of Industrial Engineering University of Engineering and Technology Peshawar
**Corresponding author: sikandarbilal@uetpeshawar.edu.pk*

Moreover, these infrastructure developments have ignored carbon footprint, groundwater level, renewable energy, and plantation, which has brought Pakistan under severe climate adversity. The heat strokes in Karachi, smog at Lahore, and flooding in Khyber Pakhtunkhwa have been a typical headline in both print and electronic media.

As sustainability success factors varies (Gan et al., 2015), several research articles (Powmya and Abidin, 2014, Ametepey et al., 2015, Yılmaz and Bakış, 2015) related to identification of factors, barriers, and challenges are available for specific regions, and countries. The broader study of the authors, considers the sustainability is totality. However, this paper covers the environmental aspect only.

A comprehensive literature review was carried out to identify the challenges, barriers, and factors associated with sustainable construction. The terms sustainable construction, sustainable development, green buildings, and sustainability, are not synonymous. Sustainability is an economic, social, and environment viable activity (Aarseth et al., 2017), whereas sustainable development is more of utilizing the resources keeping in view the future generation (Kates et al., 2005). Green buildings shields the natural environment for future generations (Circo, 2007), whereas sustainable construction takes care of the society, economy along with environment (Ortiz et al., 2009).

The literature review also indicates that although the world is moving from zero-carbon footprint to negative carbon footprint (Salazar and Meil, 2009). Pakistan construction sector has yet to assess itself to start reducing the carbon footprints. Moreover, there is no comprehensive study or research article available, which remotely discusses the environmental conscience construction of Pakistan.

METHODOLOGY

With the announcement of Sustainable Development Goals (SDGs) by the United Nations in 2015 (United Nations, 2017). Several standards, such as Global Reporting Index (GRI), P5, and ISO 21929, emerged and got acceptance. The GRI and P5 target sustainability in general, whereas ISO 21929 targets sustainable buildings in particular. Factors from these standards were extracted. Similar factors were merged, and the remaining factors were shared with five individuals (3 professionals, 2 academicians) having more than 25 years' experience. A total of nineteen environmental factors were finalized in the discussion session. The finalized factors are shown in the second column of Table 1. Column 3 show the respective references.

Articles related to sustainability mostly uses questionnaire/discussion sessions to analyze different factors (Banihashemi et al., 2017, Kivilä et al., 2017). The same approach is adopted for this research. In the light of the factors identified through literature review, a questionnaire was designed and distributed to five experts, two academicians, and three construction practitioners for content and face validity. The changes and suggestions were incorporated. The questions were framed to assess how much these environmental factors are considered in Pakistan construction industry. The final version of the questionnaire had a Likert scale (1-5), where 1 represents "Very Low", 2 represents "Low", 3 represents "Moderate", 4 represents "High" and 5 represents "Very High".

The construction industry has a meager response rate (Bamgbade et al., 2019). Researchers such as (Bertaux, 1981) consider a sample of 15 to be more than enough. (Banihashemi et al., 2017) while analyzing sustainable construction has used the sample size of 16. For this research, with a population of 100,000 and error 0.1, the Slovin's formula calculated an acceptable sample size of 99. The questionnaire was distributed through google form, emails, by hand, and through mail with more than 170 potential respondents. 115 responses were received, out of which 100 were complete, whereas 15 of them were incomplete. The respondents were mostly engineers, contractors, project engineers, consultants, and project managers. All of the respondents were having more than 5 years' experience and have served in different areas of Pakistan.

The data, once received, was subjected to reliability tests. The calculated values for Bartlett's test, Kaiser-Mayer-Olkin (KMO), and Cronbach alpha test are 0.000, 0.879, and 0.933. These calculated values satisfy the acceptability condition. Hence the data is concluded to be reliable.

Table 1: Factors identification and literature review

S.No	Factors	References							
		(Banihashemi et al., 2017)	(Martens and Carvalho, 2016)	(Kivilä et al., 2017)	(Tam et al., 2006)	(Persson, 2009)	ISO 21929	P5	GRI
i.	Water Waste		✓		✓			✓	
ii.	Water Quality							✓	
iii.	Type of Soil						✓		
iv.	Surrounding Buildings					✓			
v.	Solid Waste	✓		✓	✓		✓	✓	
vi.	Roof Top and Wall Plantation						✓		
vii.	Renewable Energy Sources		✓				✓	✓	
viii.	Recyclable Products/Material							✓	
ix.	Noise Pollution	✓		✓	✓				
x.	Natural Resources		✓		✓				
xi.	Natural Disasters (Earthquake and Floods etc.)		✓						
xii.	Local Environment/Bio-Diversity		✓		✓				
xiii.	Green Areas						✓		
xiv.	Environmental Laws	✓	✓						
xv.	Environment-Friendly Material	✓							
xvi.	Digital Communication	✓							
xvii.	Clean Water		✓	✓			✓	✓	
xviii.	Carbon Emissions							✓	
xix.	Air Quality						✓		

Other than these statistical reliability tests, some factors were tested for discriminant validity. It helped in verifying the respondent's attentiveness and authenticity. Fig. 1 shows the measures for the factors asked in more than one question. The mode and median numbers are similar, whereas there is a slight deviation in the mean. Hence, Table 1 and Fig. 1 concludes the reliability and fitness of data.

The data was then subjected to Taguchi Signal to Noise (S/N) Ratio. The Taguchi S/N ratio is a quality tool, which typically relies on customer satisfaction and dissatisfaction (Ho et al., 2014). It typically generates two signals which are added via Equation 1. Equation 2 and Equation 3 generate the two signals referred to as disagree signal and agree signal respectively. These signals are generated with the help of Equation 4 and Equation 5. As shown in Equation 5, the agree signal combines the Likert scale value of "high (4)" and "very high (5), whereas the disagree signal as shown in Equation

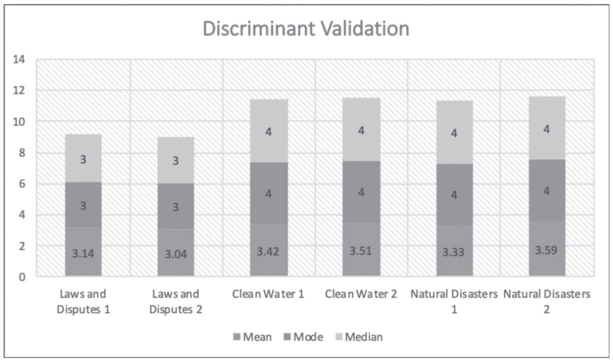

Fig. 1: Different questions with similar factors

4 combines the "low (2)" and "very low (1)" values.

$$S/N_{ti} = S/N_{di} + S/N_{ai} \quad (1)$$

$$S/N_{di} = -10\log\left(\frac{p_{di}}{1-p_{di}}\right) \quad (2)$$

$$S/N_{ai} = -10\log\left(\frac{1-p_{ai}}{p_{ai}}\right) \quad (3)$$

$$p_{di} = \frac{(Y_{i1}+Y_{i2})}{Y_t} \quad (4)$$

$$p_{ai} = \frac{(Y_{i4}+Y_{i5})}{Y_t} \quad (5)$$

Where is the larger the better attribute, and is smaller the better attribute, the greater shows, the greater is better, which indicates that most of the customers agree that these factors are practiced more, smaller represents lower is better; namely customers agree that these factors are practiced least (Lee et al., 2008). combines the signals, where higher values represent better quality (most practiced), and lower values represent the poor quality (least practiced) (Ho et al., 2014).

Data Analysis

All the factors have been graded on a five-point Likert Scale. Fig. 2 shows the Likert Scale input data for each factor. The following data is the input to be used in Equation 4 and 5.

Table 2 shows the S/N ratio calculations. Column 3 shows the calculations for Column 4 shows the calculations for, and Column 5 shows the calculations for.

As per the S/N ratio calculations, the factors with a value of less than 1 is considered to be Noise. As shown in Table 2, the and signals have four noise factors, each. However, as shown in Fig. 3, when both the signals are combined, only three factors that are biodiversity, solid waste, and environmental laws are categorized as noise factors.

RESULTS AND DISCUSSION

The ranks, as shown in Table 3, are as per the signal quality, the bottom rank represents least practiced factors whereas top rank represents the most practiced factors. As shown in Fig. 4, the factor "rooftop and wall plantation" is least considered, whereas "type of soil" is the most considered factor. The reason for this is that the type of soil is associated with economic benefits. The excavation cost typically depends on the type of soil or rock. On the other hand, Pakistan laws and regulations do not have any benefits to motivate practitioners for rooftop and wall plantation. The practitioners also report that wall plantations reduce the life of the wall, which increases the maintenance cost.

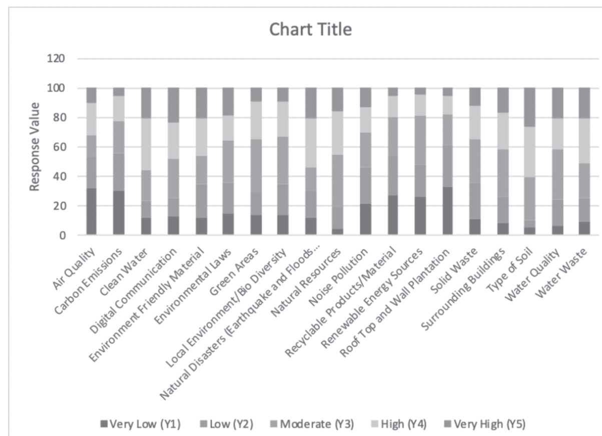

Fig. 2: Taguchi signal to noise ratio input data

Furthermore, Pakistan is facing the brunt of climate change; the floods and heavy rains have been the headlines of newspapers for the last decade. The construction industry is a significant contributor to carbon emissions. However, there is neither enforcement nor motivation to reduce carbon emissions. Moreover, there is no motivation for the practitioners to use recyclable products and renewable energy. Hence, these factors are reported to be least practiced in Pakistan.

The barricading or fencing of the construction site

Table 2: Taguchi calculations

S.No	Factors	Low Signal (S/N_{di})	High Signal (S/N_{ai})	Low + High (S/N_{ti})
i.	Roof Top and Wall Plantation	-1.9426523	-6.5854135	-8.5280658
ii.	Carbon Emissions	-1.0473535	-5.2476289	-6.2949824
iii.	Recyclable Products/Material	-0.6963593	-6.0205999	-6.7169592
iv.	Air Quality	-0.5217801	-3.2735893	-3.7953695
v.	Renewable Energy Sources	0.34762106	-6.2973142	-5.9496931
vi.	Noise Pollution	0.69635928	-3.6797679	-2.9834086
vii.	Solid Waste	2.49877473	-2.6884531	-0.1896784
viii.	Environmental Laws	2.49877473	-2.4987747	0
ix.	Local Environment/Bio-Diversity	2.68845312	-3.0756086	-0.3871555
x.	Environment-Friendly Material	2.68845312	-0.6963593	1.99209384
xi.	Natural Disasters	3.67976785	0.69635928	4.37612713
xii.	Green Areas	3.88860351	-2.6884531	1.20015039
xiii.	Surrounding Buildings	4.54258372	-1.401787	3.14079669
xiv.	Water Waste	4.77121255	0.17374096	4.94495351
xv.	Digital Communication	4.77121255	-0.3476211	4.42359148
xvi.	Water Quality	5.00602351	-1.401787	3.60423647
xvii.	Clean Water	5.24762889	1.04735351	6.2949824
xviii.	Natural Resources	6.29731418	-0.8715018	5.42581242
xix.	Type of Soil	9.54242509	1.94265228	11.4850774

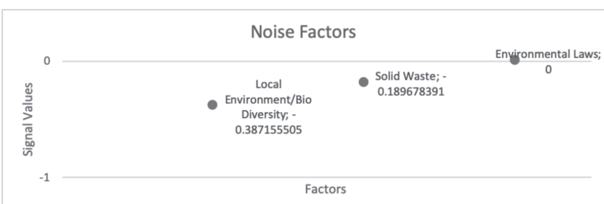

Fig. 3: Noise identification

is hardly seen in Pakistan. The poor air quality and noise pollution damage the ecosystem and biodiversity. The air quality in Pakistan's cities is very much on the lower side. Moreover, wildlife sanctuaries in Pakistan have been severely affected due to the different types of pollution caused by construction activities.

The essence of sustainability is to reuse and recycle. However, construction activities result in waste that cannot be reused or recycled. Globally, these types of wastes end up in landfills under strict environmental compliance. However, in Pakistan, the disposal of solid waste is the least considered factor. As reported, the disposal mechanism and its location are evaluated in terms of monetary benefits, and no environmental implications are considered during the decision-making process.

As shown in Table 3 and Fig. 4, the factors related to water, such as water quality, water waste, and clean water, are considered in most of the projects. One of the reasons is the demand of the end-user, and secondly, it is client requirement as per the project documents. Moreover, water waste can limit the movement of workers and equipment and can cause damage to structures as well. Hence, these factors are more practiced.

Similarly, the work in the process is hardly insured, and the one-year mandatory maintenance clause in the tender documents forces the practitioners to consider natural resources and natural disasters such as earthquakes and floods in all the projects. However, the results indicate that the practitioners consider these factors in half of the projects only. The number of projects opting for such projects equals to the number of projects not opting for these factors.

In synopsis, the contractors and consultants in Pakistan are not adhering to environment conscience practices used

Table 3: Ranking of environmental factors

S. No	Factors	Variables	Disagree Rank	Agree Rank	Combine Rank
i.	Type of Soil	Env17	1	1	1
ii.	Clean Water	Env3	3	2	2
iii.	Natural Resources	Env10	2	7	3
iv.	Water Waste	Env19	5	4	4
v.	Digital Communication	Env4	5	5	5
vi.	Natural Disasters	Env9	9	3	6
vii.	Water Quality	Env18	4	8	7
viii.	Surrounding Buildings	Env16	7	8	8
ix.	Environment-Friendly Material	Env5	10	6	9
x.	Green Areas	Env7	8	11	10
xi.	Environmental Laws	Env6	12	10	11
xii.	Solid Waste	Env15	12	11	12
xiii.	Local Environment/Bio-Diversity	Env8	10	13	13
xiv.	Noise Pollution	Env11	14	15	14
xv.	Air Quality	Env1	16	14	15
xvi.	Renewable Energy Sources	Env13	15	18	16
xvii.	Carbon Emissions	Env2	18	16	17
xviii.	Recyclable Products/Material	Env12	17	17	18
xix.	Roof Top and Wall Plantation	Env14	19	19	19

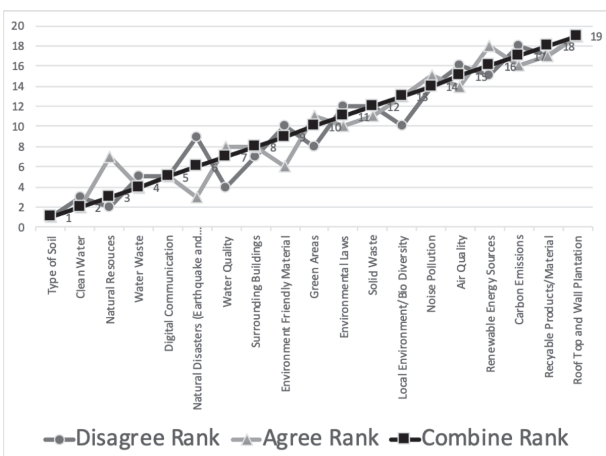

Fig. 4: Most and least practiced factors

worldwide. The government can enforce the factors by incorporating the identified factors into tender documents, laws and regulations. Such initiatives will push practitioners to look for alternative and innovative initiatives. Moreover, the government needs to facilitate these initiatives by offering incentives, benefits, and tax rebates.

CONCLUSION

Infrastructure development and other construction activities are significant for the socio-economic development of a community and country. However, these activities are also responsible for environmental degradation. An environment-friendly construction can reduce its impacts. However, success factors for environment-friendly construction vary from region to region. It is concluded, that factors that have an economic impact or some enforcement are practiced more in Pakistan, whereas factors that have high severity but no benefits or motivation are least practiced. Carbon emissions, air quality, recyclable products, biodiversity, renewable energy, and noise pollution are not considered in a developing country like Pakistan, whereas factors such as clean water, type of soil, water waste, natural resources, and water quality are mostly considered due to client demand or economic benefit.

Furthermore, the research can be further extended by having target values for the respective factors. Internal and external benchmarking can help the practitioners and government to develop an educated construction policy.

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