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WORKERS' BEHAVIOUR TOWARDS NOISE POLLUTION CONTROL ON CONSTRUCTION SITES

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ABSTRACT

Noise pollution is a noticeable hazard in construction sites, which can cause severe damage to the health and safety of workers and the neighbouring community. Number of studies have investigated control measures for noise pollution, majority proposing regulatory and engineering control, which are expensive and mostly ineffective. While behavioural changes of workers could contribute to effective noise control, very few past studies have dealt with behaviour of construction workers. To fill this knowledge gap, this study used a questionnaire survey and analysed the responses using structural equation modelling by testing several hypotheses developed using the Norm Activation Model that investigates the relationship between attitudes and behaviour of construction workers. The sample belonged to a wide range of worker categories of major construction firms in Colombo, Sri Lanka. Results revealed that a positive relationship exists between personal norms and environmental behaviour. Furthermore, these personal norms are significantly informed by the awareness of consequences and a sense of responsibility to act to mitigate noise pollution in their sites. Thus, while workers are aware of the negative consequences of noise pollution and are responsible to act, an increase in environmental behaviour will occur via the activation of personal norms. Hence, workers tend to alter their behaviour when having altruistic moral norms. As a practical implication arising out of this research, these worker attributes could be strategically used by construction companies to create a conducive work environment where workers themselves take initiatives to deal with environmental destruction caused by construction activities.

***Keywords**: Construction projects; Health Issues; Noise Pollution; Norm Activation Model.*

1. INTRODUCTION

Noise is the most serious acoustic pollutant (Ballesteros *et al*., 2010) and is defined as 'undesired sound,' which is enough to cause damage to the environmental and health of people exposed to it (Golmohammadi *et al*., 2013). The environmental noise can be illustrated using simple measures such as the overall sound pressure level and fluctuation of levels with time and frequency of sound (Hamoda, 2008). Researchers have identified different sources of noise pollution on construction sites such as site traffic (Geetha and Ambika, 2015), noisy tools and equipment (Geetha and Ambika, 2015; Hamoda, 2008), and construction activities, which directly involve machinery with high noise level, particularly, earthworks consisting of site clearance, excavation, cutting, filling, and

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compaction (Haron *et al*., 2012). According to Ballesteros *et al*. (2010), excavation is the noisiest stage, mainly due to noise from engines of machinery and the peak levels caused by hoe loading. Several studies have attempted to identify noise emission levels from construction site sources (Thalheimer, 2000; Waddington *et al*., 2000; Fang *et al*., 2009). However, it is difficult to estimate the environmental impacts of noise due to size of the project, complex interactions between noise levels, types of construction equipment used, distance from the noise source, and duration of the construction stage (Hamoda, 2008). To mitigate environmental impacts of noise pollution, regulatory and environmental measures are the most popular in construction sites. However, their effectiveness is questionable. In addition, engineering control measures are very expensive to implement. Therefore, researchers and practitioners are now resorting to behavioural changes among workers to ameliorate environmental pollution on construction sites. Fuertes *et al*. (2013) emphasized that environmental behaviour (EB) of workers of construction projects can attain changes by eliminating negative environmental impacts. Thus, EB should address the necessity of collaboration of main roles among project participants to ensure it yields positive environmental effects on both the product and project outcomes (Weston, 2011). However, very little research has been undertaken on EB of construction workers towards noise pollution and its control. Past research on noise pollution has mainly focused on regulatory and engineering control methods. Hence, this study aims to investigate workers' behaviour towards noise pollution on construction sites, which causes severe health impacts on the workers and society if not properly managed.

2. LITERATURE REVIEW

2.1 IMPACT AND CONTROL OF NOISE ON CONSTRUCTION SITES

The most prevalent irreversible occupational hazard due to construction industry is identified as noise-induced hearing impairment, which has caused hearing difficulties to over 120 million people worldwide (Hamoda, 2008). The World Health Organization (WHO) has classified it as having specific effects psycho-physiological wellbeing, interference with speech communication and intended activities, mental health effects, disturbance to sleep, annoyance, effects on domestic behaviour, and diminished performance (WHO, 1990; Golmohammadi *et al*., 2013). Moreover, the National Institute for Occupational Safety and Health of US (NIOSH) (1990) stated hundred-thousands of construction workers are at risk of developing hypertension due to exposure to high levels of noise emission. The effect of noise may not be pronounced instantaneously, but its exposure duration will help decide the social, psychic, and physical detriments on people (Fernandez *et al*., 2009).

Removal of excessive noise is not just a legal responsivity of a construction firm, but also a moral and ethical responsibility. Table 1 highlights the solutions and practices identified in the existing body of literature for noise pollution control at construction sites. These practices help a safer and healthier workplace and further subject to cost savings through high performance and lesser absenteeism and accidents.

Table 1: Solutions and practices for controlling noise pollution at construction sites

Solutions and practices	Source of references
Comply with international standards such as ISO 1996 and 1999	Ballesteros *et al*. (2010)
Designing temporary facilities in each construction phase including strategic positioning of noisy equipment; Acoustic treatments; Monitoring sound level during construction activities; Maintain a good neighbourhood policy and better response regarding complaints	Thomas and Costa (2017)
Noise mitigation plans and assessment revised during construction stage; Use prefabricated and industrialized equipment; Favour equipment with lower noise and vibration emissions; Training and awareness programmes about sound pollution	Thomas and Costa (2017) Fernandez *et al*. (2009)
Keep equipment in good condition; Characterize activities that emit noise	Thomas and Costa (2017) Hamoda (2008)
Periodically conducting medical hearing check-ups for workers; Provide personal hearing devices for workers	Fernandez, *et al*. (2009)
Limit access to noisy zones and isolation of noisy procedures; Breakdown the noise propagation path through barriers and sound enclosures; Use of absorbent materials to reduce sound reflections; Transmit noise and vibration through floating floors; Divide noisy tasks into a limited number of workers to prevent exposure to noise	ISO (1996)
Involve Environmental Impact Assessment (EIA) practitioners during the planning stage of a project	Haron *et al*. (2012) Geetha and Ambika (2015)

2.2 BEHAVIOURAL CHANGES

When considering the characteristics of construction projects, every activity of a project has a direct interaction with the environment. Thus, the behaviour of workers of a project from the commencement of construction to the completion can make a considerable impact on the environment (Yusof *et al*., 2015). Positive environmental behaviour could accompany solutions to the negative impacts that construction activities have on the quality of air, water, land, resources exploitation, ecology, energy consumption, workers' and public health, and sustainability (Shen *et al*., 2011). Gradually the negative impacts from construction projects on the environment can be mitigated through these positive behaviours throughout the design (not only workers but also designers adopting such behaviour) and construction phases of the project (Mora, 2007; Yusof *et al*., 2015).

Environmental and social psychologists demonstrated behaviour is influenced through the attitudes, beliefs, and values of persons (Murray, 2013). Continuously, values, beliefs, and behaviours are rooted through generations and stabilized over the years by sharing the practices and experiences (Braungart, 2013). Thus, a quick change is difficult to achieve. According to Braungart (2013)'s point of view, the construction industry needs a holistic approach encompassing a cultural shift of behaviours and attitudes of various project participants to overcome endemic environmental issues. Further, Robin and Poon (2009) have interpreted "changes of attitudes and practices" is the sixth principle promulgated by the World Conservation Strategy of 1991 to originate a sustainable society. Therefore, the complete transformation of actions and mindsets can be achieved from changes happening in practices and behaviours (Udawatta *et al*., 2015). Wong and Yip (2004) highlighted that behavioural and attitudinal changes of contractors is more significant than adopting new technologies.

Environmental researchers have tried to investigate the relationship between attitudes and behaviours through which some theories have emerged. Most prominent among those theories which are used by many environmental researchers are the Norm Activation Model (NAM) and the Theory of Planned Behaviour (TPB) (Ajzen, 1993; Schwartz, 1977). Schwartz's norm-activation model (NAM) asserts that pro-environmental behaviour depends on directly the activation of altruistic moral norms rather than general environmental concern (Park and Ha, 2014). A person feels a sense of moral obligation if he is responsible for ameliorating consequences and if he expects serious negative outcomes for others. Thus, Schwartz explained the acceptance of personal responsibility and the intensity of awareness of consequences lead to the activation of personal norms (Onwezen *et al*., 2013). The TPB is a modified version of Theory of Reasoned Action (TRA) model, and it consists of a new variable, perceived behaviour control other than the variables of attitude, subjective norm, and intention (Kurisu, 2015).

3. MODEL CONCEPTUALISATION AND HYPOTHESIS DEVELOPMENT

Out of the theories discussed in the literature reviews, NAM is more suitable for this research because it is about intervention behaviour, which applies to when the events are already in place that someone believes will lead to harmful consequences for others and oneself collectively (Cordano *et al*., 2011). The relationship between independent latent variables and the latent dependent variable considered under this study is illustrated in Figure 1 as the conceptual model of NAM.

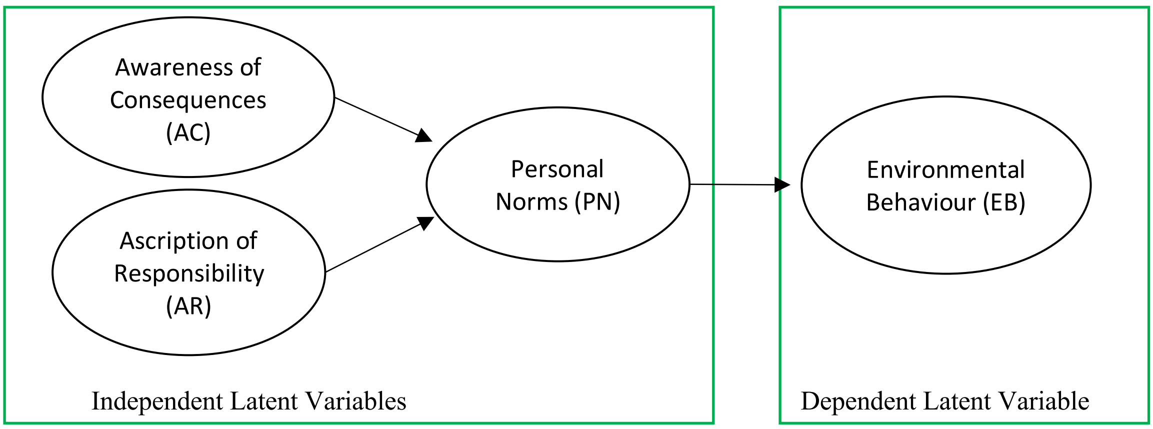

Figure 1: Conceptual model used for this study

Personal Norms (PN) is referred to as the feeling of "moral obligation to perform or refrain from specific actions" (Schwartz and Howard, 1981, p. 191). Thus, the following hypothesis is developed:

H1: Personal Norms significantly and positively affect environmental behaviour.

Awareness of Consequences (AC) is defined as the awareness of negative consequences for others when not taking pro-social actions (De Groot and Steg, 2009). Thus, the following hypothesis is developed:

H2: Awareness of consequences significantly and positively affect personal norms.

Ascription of Responsibility (AR) is described as the feeling of responsibility when not acting pro-socially for the negative consequences (De Groot and Steg, 2009). Thus, the following hypothesis is developed:

H3: Ascription of responsibility significantly and positively affects personal norms.

4. RESEARCH METHOD

A survey is a systematic way of collecting primary data, which can be efficiently utilized to suggest possible reasons for relationships in a model comprised of key variables (Saunders *et al*., 2009).

4.1 PROCEDURE

The questionnaire survey expects to investigate the environmental behaviour of construction workers towards noise pollution control in construction sites. The sample was selected from the SC1- and SC2-graded registered contracting firms in Construction Industry Development Authority (CIDA) in Sri Lanka, using purposive convenience sampling technique. The respondents consisted of tradesmen, plant operators, and unskilled workers. When selecting the sample size, the study considered the rules of thumb of Partial Least Squares Structural Equation Modelling (PLS-SEM). For the application of analysing tool of PLS-SEM, the minimum sample size should be equal to ten times the largest number of formative indicators used to measure one latent construct. Thus, 100 respondents were determined for the sample. Table 2 presents the response rates of each worker category. Female representation of the sample was around 2% of the total respondents.

Table 2: Profile of the construction workers according to the role and work experience

		Profession			Number of respondents	Experience of respondents
		Tradesmen	*Plant operator*	*Unskilled workers*		
Working Experience (years)	Less than 5	6	12	5	23	24%
	5 to 10	14	4	12	30	32%
	11 to 20	12	2	17	31	33%
	More than 20	4	-	6	10	11%
Number of respondents		36	18	40	94	94%
Response rate		38%	19%	43%	94%	

The mean of the descriptive analysis helped to analyse perceptions with a scale that has been employed in the study of Kazaz and Ulubeyli (2007). Accordingly, a difference of 1(strongly disagree) - 5 (strongly agree) of the Likert scale and intervals with 0.8 was developed to determine the degree of central tendency based on following categorizations; 1.00 ≤ "Strongly disagree" ≤ 1.80; 1.80 < "Disagree" ≤ 2.60; 2.60 < "Neutral" ≤ 3.40; 3.40 < "Agree" ≤ 4.20; and 4.20 < "Strongly agree" ≤ 5.00.

Kazaz and Ulubeyli (2007) have also used a similar approach that comprises intervals of the study for investigating the drivers of productivity among construction workers. The rank defined, when there are two or more variables, having same mean values, the priority is assigned for the variables according to the descending order of standard deviation or coefficient of variation (COV) (Kumaraswamy and Chan, 1998).

4.2 MEASURE OF CONSTRUCT

The questionnaire comprised of general information, demographics, and variables of environmental behaviour. The items were developed using literature and variable definitions to ensure content validity. Three items were developed to measure the awareness of consequences, one for ascription of responsibility, four for personal norms, and two for environmental behaviour of construction workers regarding the noise pollution on construction sites.

5. RESULTS

5.1 WORKERS' VIEW ON THEIR RESPONSIBLE BEHAVIOUR

As shown in Table 3, the overall mean scores for the ten (10) constructs used to measure the latent variables affecting noise pollution control behaviour ranges from 4.00 to 5.00. Out of them, six (06) constructs were rated as 'strongly agree', which consists of one each from awareness of consequences, personal norms, and environmental behaviour. The rest of the constructs were rated as 'agreed'.

Table 3: Statistical measures of the items of noise pollution

Code	Items	Min	Max	Mean	Std. Dev	COV (%)
AC-1	The noise pollution in construction sites causes serious health impacts to workers	1	5	4.64	0.80	17.24
AC-2	I am aware of the negative influence of noise pollution on my site on the society	1	5	4.25	0.85	20.00
AC-3	The noise pollution in construction sites causes nuisance and discomfort to the neighbourhood	1	5	4.15	1.03	24.82
AR-1	I feel I am jointly responsible for the consequences of noise pollution of my site on workers' health and safety	1	5	4.18	0.92	22.01
PN-1	It would be against my moral principles not to act against noise pollution issues in my site	1	5	4.49	0.87	19.38
PN-2	I have a moral obligation to protect the environment from noise pollution arising from my site	1	5	4.61	0.83	18.00
PN-3	I would feel guilty about not acting against noise pollution arising from my site	1	5	4.01	0.97	24.19
PN-4	I feel obliged to protect the environment from noise pollution from my site	1	5	4.19	0.72	17.18

Code	Items	Min	Max	Mean	Std. Dev	COV (%)
EB-1	I help reduce noise pollution in my site	2	5	4.45	0.74	16.63
EB-2	I am very concerned not to generate noise in my work; If it is unavoidable, I take precautions to minimize it	1	5	4.55	0.69	15.16

5.2 MODEL VALIDATION

Past studies have employed Structural Equation Modelling (SEM) (e.g., Zailani *et al*., 2015; Abdullah *et al*., 2016) considering its capability to perform a full test of concepts and theories (Rigdon, 1998). Two techniques have been used under SEM that are variance-based partial least squares (PLS-SEM) and covariance-based techniques (CB-SEM). However, the technique will depend on the research objectives, characteristics of data, and model structure (Gefen *et al*., 2011). Hair *et al*. (2013) suggested that PLS-SEM is superior to CB-SEM for exploratory studies. Thus, PLS-SEM was selected for this study since the study is exploratory in nature as the effect of awareness of consequences and ascription of responsibility on the environmental behaviour of construction workers has not previously tested. Notably, this technique was employed using the software SmartPLS 3.0. The model testing involved a two-step approach followed by Hair *et al*. (2013) to evaluate the reliability and validity of the indicators before validating the structural relationship of the model. The first step was analysing measurement model, followed by analysing structural relationships among the latent constructs using the structural model as the second step.

5.2.1 Evaluation of Measurement Model

The internal consistency reliability and validity of constructs were assessed. Table 4 presents a summary of factor loadings, Composite Reliability (CR), and Average Variance Extracted (AVE) of all indicators.

Table 4: The factor loadings, CR, and AVE of the PLS algorithm

Construct	Indicators	Factor Loadings	CR	AVE
Awareness of Consequences	AC-1	0.640	0.815	0.598
	AC-2	0.811		
	AC-3	0.852		
Ascription of Responsibility	AR-4	1.000	1.000	1.000
Personal Norms	PN-5	0.844	0.931	0.773
	PN-6	0.955		
	PN-7	0.872		
	PN-8	0.841		
Environmental Behaviour	EB-9	0.972	0.971	0.944
	EB-10	0.972		

The loadings of all indicators were above 0.7, signifying satisfactory indicator reliability (Hair *et al*., 2011). The AC-Noise 1 was retained, based on the contribution to content validity. The internal consistency reliability of all constructs, which were evaluated using CR, was above 0.7, and the convergent validity of constructs, evaluated using AVE was above 0.5; thus, the results satisfy a sufficient degree of rule-of-thumb according to Hair *et al*. (2011). The discriminant validity was assessed using two approaches. First, the cross-loadings were examined to validate that the opposing constructs are higher than loads of indicators. Second, Table 5 shows, in accordance with the Fornell and Larcker criteria, the discriminant validity of each latent construct is higher than the construct's highest squared correlation with other constructs of the model.

Table 5: Construct correlations versus square root of AVE

	AR	AC	EB	PN
AR	**1.000**			
AC	0.533	**0.773**		
EB	0.438	0.291	**0.972**	
PN	0.678	0.723	0.384	**0.879**

Note: Diagonals represent the square root of the AVE.

Thus, both analyses confirm the discriminant validity of all constructs.

5.2.2 Evaluation of Structural Model

The explanatory power of the research model was assessed using the Coefficient of determination (R2). The predictive relevance (Q2) value (0.127), larger than zero, indicates that the model has satisfactory predictive relevance (Hair *et al*., 2011). The bootstrapping with 5,000 bootstrap samples were applied to assess the path coefficients' significance. Table 6 represents the path coefficient and bootstrapping results of the structural model. The results indicate that the effect of AR (β=0.409, $p<0.001$) and AC (β=0.505, $p<0.001$) on PN and PN (β=0.384, $p<0.001$) on EB are significant and positive, thereby supporting H1, H2, and H3.

6. DISCUSSION

The model was conceptualised to ascertain whether the awareness of consequences, the ascription of responsibility, and personal norms influence the environmental behaviour of construction employees when making decisions about their behaviour towards the environmental impacts. Three (03) hypothesis were tested, as depicted in Table 6. From the first hypothesis, the results established that the relationship between PN and EB is positive and significant. This proves PN is a latent variable of EB and, workers who have high altruistic PN are more likely to control noise in their sites. Thus, an increase in EB can happen while increasing PN of a person. It further indicates that employees tend to control noise emission in their work as personal norm dictates that it is the right thing to do.

Table 6: The path coefficients and bootstrapping results of the structural model

Hypothesis	Relationship	Path coefficient	Decision
H1	Personal Norms → environmental behaviour	0.384^{***}	Supported
H2	Awareness of consequences → personal norms	0.505^{***}	Supported
H3	Ascription of responsibility → personal norms	0.409^{***}	Supported

$^{***}p<0.001$

The second hypothesis of the model claimed that awareness of consequences significantly and positively affects personal norms. The output of the PLS analysis confirmed this hypothesis. This relationship was tested concerning the noise pollution caused from construction sites and could be interpreted as the generation of moral obligation to act towards noise pollution which is influenced by the awareness of negative consequences of noise pollution. Moreover, it illustrates that when workers are aware of the severe health impacts on workers and community due to noise emitted by site activities, a change in behaviour could occur by the activation of personal norms. Similarly, the third hypothesis confirms the relationship between PN and AR being positive and significant. Hence, personal norms can be activated by assigning responsibility of the action. This reveals that when a person feels jointly responsible for the consequences of noise pollution of their site on workers' health and safety, it generates moral obligations to protect the workers from noise pollution. Thus, the model postulating the significant and positive relationship between EB and PN was confirmed from the PLS-SEM statistical analysis. Furthermore, the model confirms this relationship is moderated by both AC and AR. The relationship between PN and EB become positively strong when employees are aware of the seriousness of the negative outcomes of noise pollution for others and feel self-responsible for the consequences of their behaviour. In contrast, employees have successfully neutralised moral obligation on their behaviour while they are less aware of the negative consequences and denying the responsibility of consequences. Hence, well-established altruistic moral norms willingly alter the behaviour of someone, and this concept should be cleverly utilised between sites to obtain a significant reduction in environmental pollution that emerges from many construction activities.

7. CONCLUSIONS

This study aimed to investigate the environmental behaviour of workers towards noise pollution control in the construction industry. The findings confirmed that the awareness of the negative consequences of noise pollutions and a feeling of self-responsibility could affect the environmental behaviour of construction employees via the activation of personal norms. The study revealed a significant fact to the theory that other than the environmental ethics, environmental behaviour could be changed by normative concerns. The study provides several practical implications for construction companies, where some of the worker attributes identified could be used to change worker behaviour and mitigate a considerable portion of noise pollution arising out of construction activities. There are many strategies proposed in the past literature that could be used to enhance pro-environmental attitudes and behaviour of workers. Further research is needed to test which of those strategies are suitable for construction workers, especially regarding attitude and behaviour on noise pollution.

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