Highway sustainability construction: reducing carbon emissions using process management.

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HIGHWAY SUSTAINABILITY CONSTRUCTION: REDUCING CARBON EMISSIONS USING PROCESS MANAGEMENT

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Carbon emission is a critical issue in infrastructure development, in which the highway construction industry is inclusive. Previous studies suggest that continuous carbon emission across the highway projects is due to the use of different types of construction equipment, and their inherent activities. Several research studies focused on arbitrary evaluation in order to reduce carbon emission using simulation, life-cycle analysis, and multi-criteria optimisation. The general lack of methodological rigours questions the effectiveness of those carbon reduction methods. In addition, some of those studies do not show subtle improvement in carbon reduction, and some of the findings are restricted for use. The study aims to develop an integrated technique and a better understanding of using process management in reducing carbon emissions in highway construction projects. A unique approach using the literature review as the mode of enquiry is used, which enables the use of secondary information as inputs to the analytical hierarchy process. The result shows that 'Strategy' has the highest weight score. The pattern of results indicates that a new paradigm shift is required in the use of strategic process management approach in highway carbon reduction. Two contributions are made: firstly, early decision-making, to include carbon reduction strategy during the highway feasibility study and tender phases. Secondly, to use the proposed strategic process management framework in determining realistic carbon reduction strategies across the highway construction sector.

Keywords: carbon-management, climate emergency, sustainability, infrastructure

INTRODUCTION

Carbon emission depletion has been an issue of great interest in a wide range of fields. The research constitutes relatively a new area, which emerged from a need to reduce carbon emissions during the highway construction projects. Kellogg (1978) revealed that in the past four decades, scientists and international communities had raised the alarm on the threat posed as a result of human-induced anthropogenic activities. Ripple *et al.,* (2017) warned that the risks associated with carbon emissions continue to rise dramatically. The identified perils due to carbon emissions are global warming, change in landscapes, sea-level rising and coastal flooding. The pre-industrial values of carbon emission were fewer than 300 parts per million (ppm), and

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the post-industrial values of carbon emission currently stands at 420 (ppm). The International Panel on Climate Change (IPCC) stressed that if anthropogenic human-induced activities continue to increase exponentially, that will result in continuous carbon emission, then by 2250, the atmosphere will get to a startling carbon saturation level of 2000 (ppm). As Huang *et al.,* (2018) noted that the construction industry is a contributory sector to carbon emissions, and the highway construction projects are encompassed (Wang *et al.,* 2015). There are several cross-sectional studies which suggest that carbon emissions continually emit as a result of construction equipment and attendant activities (Kim *et al.,* 2012; Cass and Mukherjee, 2011). The vast majority of the studies on carbon reduction focused on arbitrary evaluating emission using the life-cycle assessments, simulation, and multi-criteria optimisation.

Currently, there have been various arguments among the scholars on what methods and approaches that are appropriate in reducing carbon emissions in highway construction. The general lack of methodological rigours brings doubt in the various carbon emissions methods. However, most of the studies are short-term, which do not necessarily show subtle improvement in carbon reductions. Some research findings across this field are restricted to limited comparison, and some are descriptive. The vast majority of the studies have not considered the need to use process management as an approach to reduce carbon emissions in highway construction.

This, therefore, the paper aims to develop a better understanding of using a process management technique for reducing carbon emission in highway construction projects. The specific question which drives this study is focused on the significance of using process management to reduce carbon emission in the highway projects. The objective of the study is to investigate how decision-making helps in identifying the criteria needed in reducing carbon emissions. Information for this study was collected using a literature review as the mode of enquiry. The utilised technique is the analytical hierarchy process for decision-making, which is used in deciding on an appropriate protocol.

The present study fills a gap in the literature by providing insights into using process management approach in carbon reduction across the entire life cycle of a highway project. This study, therefore, provides an exciting opportunity to advance in knowledge using process management to reduce carbon emissions.

It is beyond the scope of this study to examine in detail the various rigorous processes, tools, techniques and outputs for each phase for the developed strategic framework. The reader should bear in mind that this study is based on literature review; thus, extensive primary data and development of the processes is an essential factor for future research. Another potential limitation is that the scope is too broad, and any future study should consider study boundary restrictions. The paper is structured in five sections; foremost is the summary literature, methods, results and discussion, and findings. We conclude with concise suggestions on the need to adopt process management in carbon reduction across phases of the highway construction.

LITERATURE REVIEW

Carbon Emission in Highway Construction:

Burgos *et al.,* (2015) claimed that anthropogenic greenhouse gases are emissions produced either through natural or human-induced activities. Approach and assertions in determining carbon emission have passionately been opposed in recent years by some scholars. Many experts argued that the use of life-cycle assessments (LCA) in carbon reduction approach is consistent and wide-ranging, (Cass and Mukherjee, 2011; Duan *et al.,* 2015). Life-cycle assessments provides a practical framework in assessing potential environmental impacts due to human-induced anthropogenic activities. Cass and Mukherjee's study are of considerable significance, as it marks an attempt to examine carbon emissions associated with different pavement design and construction using LCA. The study method used construction data, which is a form of inputs of data across the life-cycle in determining carbon emissions. A significant concern with this method, is uncertainty in a change to the design and construction processes, which equally affect the data associated with the carbon reduction assessments. There are evident difficulties in accepting the reliability of the data collection as an input in carbon reduction. For instance, highway construction projects are overwhelmed with extensive data and paper trails, which may not be consistent considering deficient record modifications, lack of communications, design changes and materials substitutions which sometimes are not correctly archive.

Some study investigation focused on the empirical methods and multi-criteria optimisation to calculate and reduce carbon emission in highway construction (Wang *et al.,* 2015; Lidicker *et al.,* 2013). The empirical method estimates the carbon emitted in a project using budget sheets, and material records, which serve as an input to the construction materials, fuel and energy used across the phases of the projects. The multi-criteria optimisation is the concept of minimising life-cycle costing to reflect on the reduction of greenhouse gas emissions, which is vaguely comprehended.

The shortcoming of some of the carbon reduction methods is the arbitrary inputs and outputs of data, which sometimes are subjective. In most studies, the carbon life-cycle analysis omits and fails to follow the International Standard Organisation (ISO) guideline 14044:2006, and ISO 14040:2006 in calculating carbon emissions, and these undermine the usefulness of the study. Notwithstanding the subjective approach to some study, there are vastly available methods used in calculating the carbon emissions in highway construction projects. Cass and Mukherjee (2011) identified a method of using data inputs in determining carbon reductions. Though the authors suggested that, the carbon emissions results will continue to differ across research outcome, this is due to the use of non-prototype strategies. Ma *et al.,* (2016) shared the same sentiments that no universal criteria are acceptable for the evaluation of carbon emissions in asphalt pavement construction. The difference is the variable emission carbon data, which globally has different methods, inputs statistics, and assumptions. Apparently, in comparing some of the suggestions from past studies, most are considered short-term, which did not show a definite improvement in carbon reduction. Invariably, these studies indicate a restriction to limited comparisons, and some are illustrative, as a new paradigm is required in reducing carbon emission in highway construction.

METHODS AND MATERIALS

Many researchers have utilised life-cycle analysis (LCA) to measure carbon emissions in highway construction. The LCA method is particularly useful in studying carbon reduction and emissions if only a systematic approach is used following the guideline of ISO 14040 and 14044. However, there are certain drawbacks associated with the use of these carbon emission methods. The LCA methodology shortcomings are variation in different modelling approach and missing inventory inputs. The main disadvantage of carbon reduction simulation models is that it focuses more on uncertainties, no standardised approach is used, and it is challenging to validate the results, so there are high scepticism and variations. Some studies evaluated the carbon reduction life-cycle analysis arbitrarily across phases of the highway projects.

The research questions, aims and objectives support the choice of research strategy. Figure-1 represents an overall methodology and pathway design for the study. The literature review is the mode of enquiry which enables the use of secondary data as inputs to the analytical hierarchy process (AHP). The reason for choosing literature method is that it forms a significant foundation for all type of research (Snyder, 2019).

In this study, primary data are absent, so the literature review using secondary data information serves as the basis of knowledge development. Creswell (2014) suggested that no particular method has an advantage over others, but several decisions need to be made, such as the identification of strategies of inquiry. The advantage of the analytical hierarchy process is in two folds for this study:

(1) It is used to determine competing decision-making criteria, used in deciding on the appropriate protocol in developing a process management approach.

(2) The AHP calculates the pairwise comparison to determine the consistency of the chosen sub-criteria in Figure-2 level-2.

The sub-criteria are contained in two subsets to enable the selection of appropriate decision protocol. Handfield *et al. (*2002) mentioned that AHP will not be clear substitute thinking for the decision-maker, but it organises thoughts and inputs for the development of process and procedures.

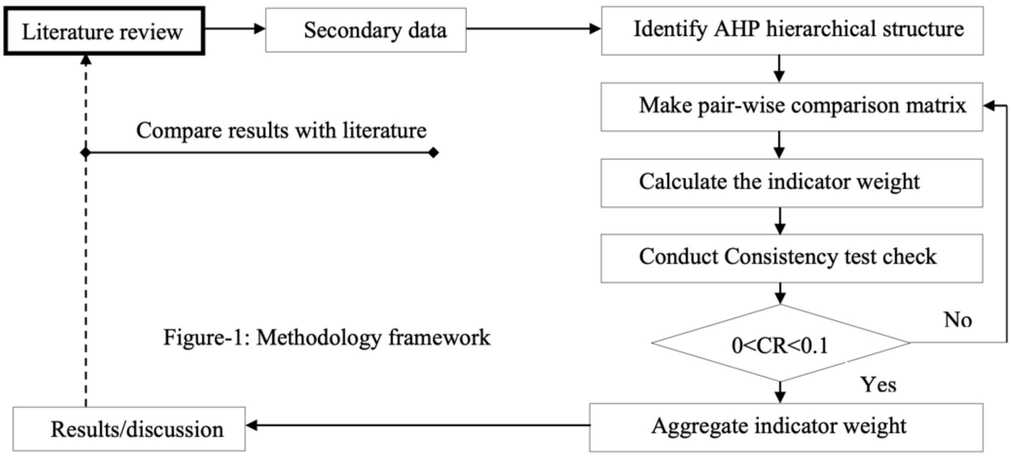

Figure 1: Schematic of AHP development

The following section depicts the AHP systematic development for the study as summarised and presented in a schematic form in Figure-1.

Analytical Hierarchy Process (AHP)

The process evaluation is categorised in five distinct parts: Develop AHP hierarchical structure (Figure-2); develop pairwise comparison matrix (Table 3-5 and 12-13); calculate the pairwise comparison to determine weight-score (Table 5-7 and Table 13-15); conduct Saaty's (1980) Consistency test check (Table-11 and Table - 18); and aggregate criteria weights-score (Figure-2).

Develop an AHP Hierarchical Structure

The AHP structure (Figure 2) is categorised from level-0 to level-3. The overall 'Goal' is level-0, decomposed to level-1 having two subsets. The next level-2 is sub-criteria from the literature review in Table 2. The aim is to determine most likely sub-criteria the AHP will select to develop a framework in carbon reduction. The level-3 is a result of highest weight-score from level-2.

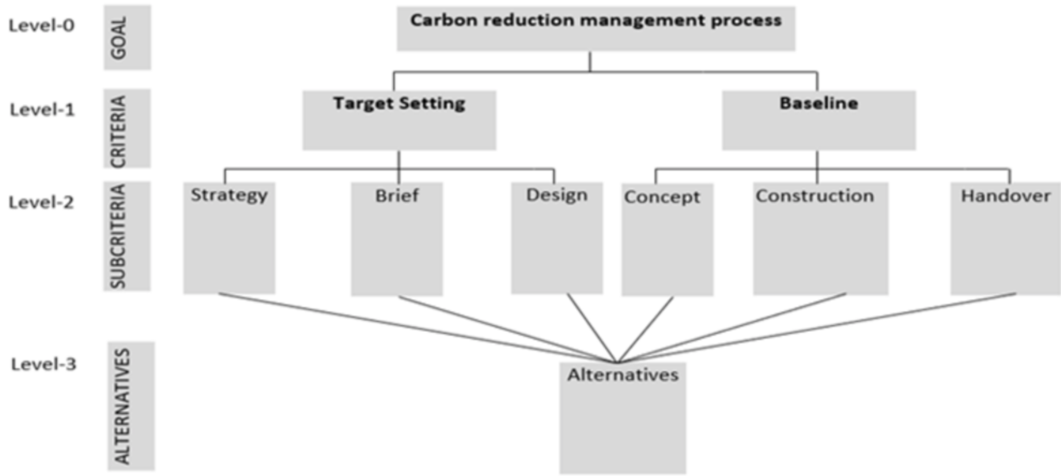

Figure 2: AHP Hierarchical Structure

Develop a Pairwise Comparison Matrix

In order to help decision-makers to develop the pairwise comparison matrix, Saaty (1980) created a nine-point "scale of relative importance" (Table-1). In past studies, the "scale of relative importance" is assigned based on subjective expert assessment (Handfield *et al.,* 2001).

That is a sensitive assertion, as the decision-maker may have a subjective bias in assigning appropriate scale of relative importance to the sub-criteria identified in level-2. In order to bridge the noted gap from past research. The current study conducted a literature review to identify frequencies and how many times carbon emission is measured across the highway project phases. The summary is displayed in Table-2, which aided in assigning of Saaty's scale of relative importance from the Table-1, to the respective pairwise comparison tables.

Table 1: Saaty's scale of relative importance

Numerical rating	1	2	3	4	5	6	7	8	9
Scale importance	Equal	Weak	Moderate	Moderate-plus	Strong	Strong-plus	Very strong	Very, very strong	Extreme
Reciprocal	1	1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9

The objective assessment of Table-2 and Table-1 helped to assign unbiased scale of relative importance to the upper right corner of Table 3, which are {4: 8: 5}. 'Strategy' is given 'very-very-strong' than 'Design', which was assigned with value '8' from Table-1. Again, 'Strategy' is moderately-plus preferred than 'Brief' which is assigned '4' from Table 1, and "Brief" given '5' which is considered 'Strong' than the 'Design'. In completing the upper right-hand corner of Table-3, the next allocation is the lower left-hand corner of Table 3. Foremost, '1' is assigned to the entire diagonal in Table 3, as each sub-criterion against itself is 'equal' to 1 from Table-1. The lower-left corner of Table 3 is assigned 'Reciprocal', as stated in Table 1. Formerly from Table-3, 'Strategy' in the first row, and 'Design' in the third column is assigned '8'. Then, therefore, from the Table-1, the reciprocal is assigned in Table-4 as 1/8 in the third-row, first column. The same approach follows for other criteria in Table-4, and Table-12 for subset 'Baseline' respectively.

Calculate the Pairwise Comparison to Determine Weight Score

The pairwise comparison matrix is converted to decimals to make it easier to work with. The Table-4 is converted to decimals in Table 5, and the summation values of each three respective column yield: {1.38, 5.20, 14.00}. The values in Table-6 are attained by dividing each column criteria with its total summation in Table 5; say (1/1.38 = 0.727, 0.250/1.38 = 0.182……. n). The concept in Table 6 is that each column summation must total equal to one: (1.00: 1.00: 1.00). The Table 7 is the average of each row in Table 6 to yield the weight score for each determined criterion in level 2: (Strategy = 0.689: Brief = 0.244: Design = 0.067). Similar pairwise comparison calculation applies to Table 12 - 15 for the subset 'Baseline.'

Table 2: Frequencies of carbon reduction in highway projects at different stages (Authors)

Phases of carbon estimation and reduction opinion in highway projects

SNO		Strategy	Brief	Design	Concept	Construction	Handover
1	*Cass &Mukherjee et al. (2010)*	✓	✓	✓	✓	✓	-
2	*Ma et al. (2016)*	✓	-	✓	✓	✓	-
3	*GschÖsser (2012)*	✓	✓	✓	✓	✓	-
4	*Ehn et al. (2010)*	✓	✓	-	✓	-	-
5	*Wang et al. (2015)*	✓	-	-	-	✓	-
6	*Huang et al. (2018)*	-	-	-	✓	✓	-
7	*Kim et al. (2012)*	✓	✓	-	✓	✓	-
8	*ADB India (2010)*	✓	✓	-	✓	-	✓
9	*Seo and Kim (2013)*	✓	-	-	✓	-	-
	Frequencies	**8**	**5**	**3**	**8**	**6**	**1**

Conduct Saaty's Consistency Test Check

The AHP decision tool is based on relative judgment. Unfortunately, the tool suffers from discrepancies. Saaty's Consistency Ratio (CR) is used to check the consistency of weight-score achieved in Table 7 and Table 15, respectively. The process of calculating Consistency Ratio (CR) is:

Determine Consistency Index (CI) = (λ - N) / (N - 1) ………….......... Equation (1).

Tables 3-11: Analytical Hierarchy Process analysis method (Target setting subset)

AHP N=3

Table-3

Target setting	Strategy	Brief	Design
Strategy	1	4	8
Brief		1	5
Design			1

Table-4

Target setting	Strategy	Brief	Design
Strategy	1	4	8
Brief	1/4*	1	5
Design	1/8*	1/5*	1

Table-5

Target setting	Strategy	Brief	Design
Strategy	1	4	8
Brief	0.250	1	5
Design	0.125	0.200	1
Total	1.38	5.20	14.00

Table-6

Target setting	Strategy	Brief	Design
Strategy	0.727	0.769	0.571
Brief	0.182	0.192	0.357
Design	0.091	0.038	0.071
Total	**1.00**	**1.00**	**1.00**

Table-7

Target setting	Strategy	Brief	Design	
Strategy	0.727	0.769	0.571	**0.689**
Brief	0.182	0.192	0.357	**0.244**
Design	0.091	0.038	0.071	**0.067**
				1.000

Table-8

Saaty's RI

N	**RI**
2	0.00
3	0.58
4	0.90

Table-9

Target setting				
Strategy	0.689	0.976	0.536	**2.201**
Brief	0.172	0.244	0.335	**0.751**
Design	0.086	0.049	0.067	**0.202**

Table-10

Target setting	
Strategy	**3.19**
Brief	**3.08**
Design	**3.02**
λ	3.10

Table-11

Lambda	3.10
CI	0.05
CR	0.09

Tables 12-18: Analytical Hierarchy Process analysis method (Baseline subset).

Table-12 (AHP, N=3)

Baseline	Concept	Construction	Handover
Concept	1	8	5
Construction	1/8*	1	6
Handover	1/5*	1/6*	1

Table-13

Baseline	Concept	Construction	Handover
Concept	1.00	8	5
Construction	0.125	1	6
Handover	0.200	0.167	1
	1.33	**9.17**	**12.00**

Table-14

Baseline	Concept	Construction	Handover
Concept	0.755	0.873	0.417
Construction	0.094	0.109	0.500
Handover	0.151	0.018	0.083
	1.000	**1.000**	**1.000**

Table-15

	Concept	Construction	Handover	
Concept	0.755	0.873	0.417	**0.681**
Construction	0.094	0.109	0.500	**0.631**
Handover	0.151	0.018	0.083	**0.252**
				1.565

Table-16

Baseline	Concept	Construction	Handover
Concept	0.681	5.046	1.262
Construction	0.085	0.631	1.515
Handover	0.136	0.105	0.252

Table-17

6.99		**10.26**
2.23		**3.54**
0.49		**1.96**
	λ	**15.75**

Table-18

Lambda	15.75
CI	7.38
CR	12.72

Lambda (λ) from Table 10. Therefore, use Equation-1; λ = (3.10 - 3) / (3-1) = 0.05

Consistency Ratio (CR) = CI / RI: where (RI) is Saaty's Random Index from Table 8, and RI is 0.58; Thus; CR = 0.05 / 0.58 = 0.09

Therefore, CR = 0.09 in Table 11; (0 < 0.09 < 0.10) ……Satisfactory. A look at Table 18, the "CR" for the subset "Baseline is unsatisfactory" {12.72 > 0.10}.

RESULTS

The purpose of the analytical hierarchy process in this study is to determine competing decision-making across the sub-criteria, which is required in deciding on the appropriate protocol in developing a process management approach. A look at Figure-3, the aggregate weight of sub-criteria revealed a positive indication at level-1, with 'Baseline' subset weight score of 1.565. The reason for such a high score is that carbon emission reduction is most likely to occur during the concept design and construction phases, but less likely to occur during the handover phase. A look at level-1 in Figure 3, 'Target subset' weight scores 1.000, which is less than the other subset by 0.565. Although, the selection for the decision making is based on sub-criteria with the highest weight score, and the Saaty's Consistency Ratio is fulfilled. 'Strategy' scored 0.689, and Consistency Ratio for the subset is 0.09 ≤ 0.10, which is satisfactory.

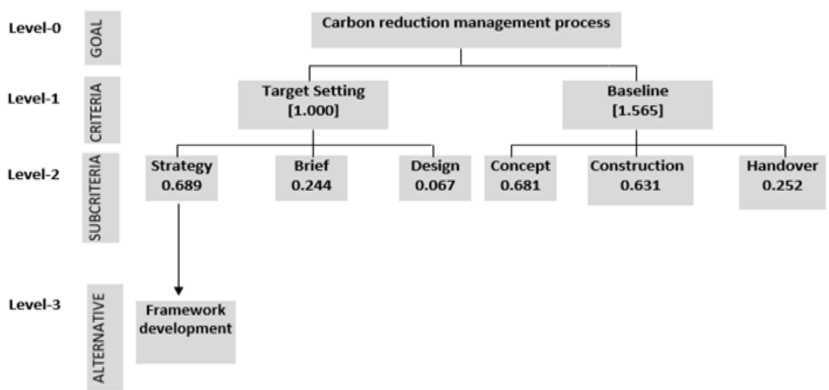

Figure 3: Aggregate weight of sub-criteria in decision-making

The level-1 subset 'Baseline' when compared with Saaty's Consistency Ratio, is unsatisfactory with 12.72 > 0.10. The result is, therefore, rejected. Although, there are noticeable differences from the results obtained from both subsets, the surprising and striking result to emerge from the analysis is "Strategy". It is a bit awkward, but expected, as that will play a vital role in establishing a strategic framework during the feasibility stage, and across various phases of highway construction in carbon reduction.

DISCUSSION AND FINDINGS

This study was designed to develop a better understanding of using a process management approach in reducing carbon emission in highway construction. Emphasis was to determine at what phase it is appropriate to implement carbon emission reductions, using process management framework.

The prominent finding that emerged from the study is the use of the analytical hierarchy process in using pairwise comparison calculation to select 'Strategy' from sets of sub-criteria. Maleka (2014, p.6) defined 'strategy' as a process of integrating activities and the allocation of scarce resources to meet objectives. Some scholars expressed their views in discussing strategy; (Mintzberg, 1994) considers strategy as a pattern in a stream of decisions. (McKeown, 2011) debates that, a strategy is about shaping the future to get desirable results. Subsequently, Maleka's model for the Strategic Management Process is adopted. The model resulted in the development of Figure 4, the Strategic Process Management Approach for Carbon reduction. The objectives of the developed framework are to enable systematic goal setting in the use of strategic process management in reducing carbon emissions, starting from the tender phase of a project. Every project is unique, and relevant project factors must be put into consideration in reducing carbon emissions.

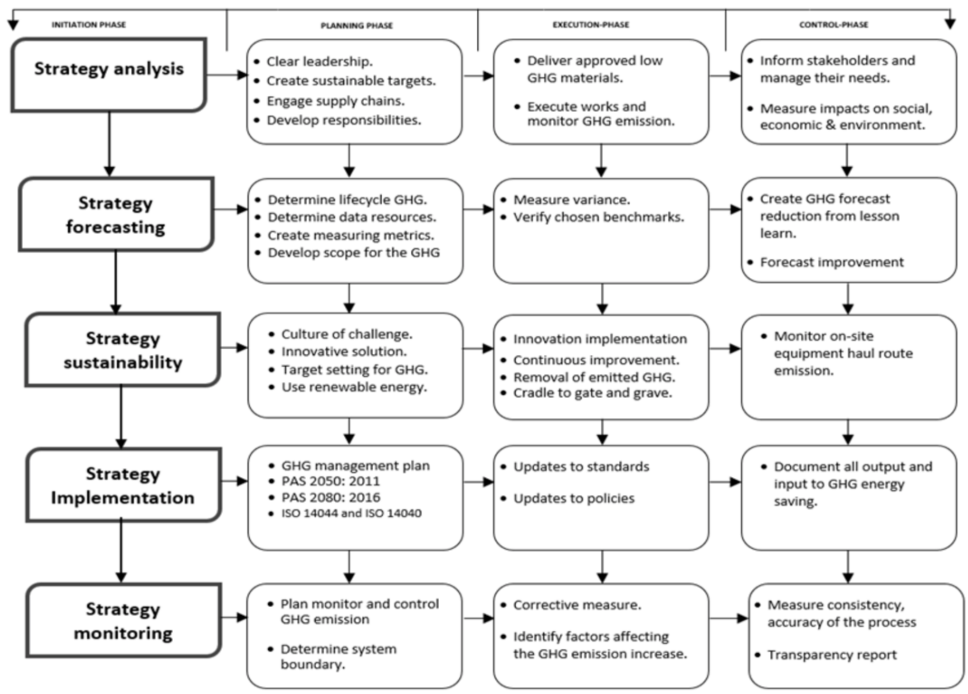

Figure 4: Strategic Process Management Approach for Carbon reduction

The research findings of this study is unique in that, "Strategy" scored higher when compared with the other sub-criterion, most notably the construction phase. Considering the fact that the construction stage is the most common period at which carbon reductions are implemented during highway construction. This pattern of result indicates that a new paradigm shift is required. Although, this result has not previously been described. In comparing the result with other past studies, dissimilarities are revealed. Notably, past studies adopted a non-prototype strategy in determining carbon emission reduction. Generally, the life-cycle analysis methods are arbitrarily used to calculate the carbon emission reduction, and the result outputs undermine the usefulness. Moreover, no standard or universal criteria are globally established, hence different methods, inputs and outputs.

There are still several questions that remain unanswered. It is beyond the scope of this study to examine and develop in detail the various processes, tools and techniques and other outputs for each phase of the Strategic Management Process Framework. The present study used a literature-based data source. It is suggested that extensive primary data is required as an essential factor for future research. Another potential limitation is that, the scope is too broad, and any future study should consider a limited scope. It is also significant to consider the limitations of this study, in prioritising to assign the Saaty's relative scale of importance. Future research suggestions are made to utilise analytical brainstorming, using a knowledge base for assigning scale of importance to sub-criterions. Despite the promising results, the Strategic Process Management Approach in carbon reduction has its limitation; the process is dense and needs to develop robust processes, tools, techniques and outputs for each phase.

CONCLUSION

This study set out to gain a better understanding of carbon reduction across highway projects. These findings raised critical issues on how carbon emissions are arbitrarily determined across phases of highway construction projects. In most cases, the results from past studies have insufficient information to enable future decision-making in new projects. On the contrary, this study is an attempt to systematically examine and identify carbon reductions using a Process Management Approach. This paper presents two contributions. Firstly, is the early decision-making to include carbon reduction strategy during the highway feasibility phase. Secondly, to adopt the proposed Strategic Process Management Framework, in determining a realistic carbon reduction across the highway construction sector.

REFERENCES

Ahn, C, Pan, W, Lee, S and Peña-Mora, F A (2010) *Lessons Learned from Utilising Discrete-Event Simulation Modelling for Quantifying Construction Emissions in Pre-Planning Phase*, Paper presented at the Proceedings of the 2010 Winter Simulation Conference, 3170-3176.

Burgos, M, Sierra, A, Ortega, T and Forja, J M (2015) Anthropogenic effects on greenhouse gas (CH4 and N2O) emissions in the Guadalete river estuary (SW Spain), *Science of the Total Environment*, **503-504**, 179-189.

Cass, D and Mukherjee, A (2011) Calculation of greenhouse gas emissions for highway construction operations by using a hybrid life-cycle assessment approach: Case study for pavement operations, *Journal of Construction Engineering and Management*, **137**(11), 1015-1025.

Creswell, J W (2014) *The Selection of a Research Approach Research Design: Qualitative, Quantitative and Mixed Methods Approaches*, Thousand Oaks, CA: Sage 3-24.

Gschösser, F, Wallbaum, H and Boesch, M E (2012) Life-cycle assessment of the production of swiss road materials, *Journal of Materials in Civil Engineering*, **24**(2), 168-176.

Handfield, R, Walton, S V, Sroufe, R and Melnyk, S A (2002) Applying environmental criteria to supplier assessment: A study in the application of the analytical hierarchy process, *European Journal of Operational Research*, **141**(1), 70-87.

Huang, L, Krigsvoll, G, Johansen, F, Liu, Y and Zhang, X (2018) Carbon emission of global construction sector, *Renewable and Sustainable Energy Reviews*, **81**, 1906-1916.

Huang, Y, Ning, Y, Zhang, T and Wu, J (2016b) Measuring carbon emissions of pavement construction in china, *Sustainability*, **8**(8), 723.

Huang, Y, Hakim, B and Zammataro, S (2013) Measuring the carbon footprint of road construction using CHANGER, *International Journal of Pavement Engineering*, **14**(6), 590-600.

Kellogg, W W (2019) *Climate Change and Society: Consequences of Increasing Atmospheric Carbon Dioxide*, London: Routledge.

Kim, B, Lee, H, Park, H and Kim, H (2012) Greenhouse gas emissions from onsite equipment usage in road construction, *Journal of Construction Engineering and Management*, **138**(8), 982-990.

Lidicker, J, Sathaye, N, Madanat, S and Horvath, A (2013) Pavement resurfacing policy for minimisation of life-cycle costs and greenhouse gas emissions, *Journal of Infrastructure Systems*, **19**(2), 129-137.

Ma, F, Sha, A, Yang, P and Huang, Y (2016) The greenhouse gas emission from Portland cement concrete pavement construction in china, *International Journal of Environmental Research and Public Health*, **13**(7), 632.

Ripple, W J, Wolf, C, Newsome, T M, Galetti, M, Alamgir, M, Crist, E and 15, 364 scientist signatories from 184 countries (2017) World scientists warning to humanity: A second notice, *Bioscience*, **67**(12), 1026-1028.

Saaty, T L (2008) Decision making with the analytic hierarchy process, *International Journal of Services Sciences*, **1**(1), 83-98.

Seo, Y and Kim, S (2013) Estimation of materials-induced CO2 emission from road construction in Korea, *Renewable and Sustainable Energy Reviews*, **26**, 625-631.

Snyder, H (2019) Literature review as a research methodology: An overview and guidelines, *Journal of Business Research*, **104**, 333-339.

Wang, X, Duan, Z, Wu, L and Yang, D (2015) Estimation of carbon dioxide emission in highway construction: A case study in southwest region of china, *Journal of Cleaner Production*, **103**, 705-714.