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Intelligent Decision Support Model Towards Mapping the Performance of Brick Vendor's Industries: A Construction Management Approach

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A B S T R A C T

Brick suppliers are one of the most significant agents, which help to develop the infrastructure of our India nation. Nowadays, brick suppliers broadly participate in the construction sectors at global platform also. Brick supplier/manufacturers are continuously looked after the demand of construction sectors. The demand of brick vendor's industries is highly found due to establishment of new colonizers in today's era. In order to respond these, many colonizers have perceived the necessity to rapid and balance the production system of their colonies. Timely delivery of brick helps the colonizers to speed up their colony production and hose selling supply chain. Therefore, there is need to emphasize the decision making scenario of brick supplier supply chain. Today, most Multi Criteria Decision Making (MCDM) problems in line of construction management such as evaluation of brick supplier. In MCDM, the problem is consisted of alternative evaluation against aspects (or dimensions). MCDM models with intelligent techniques are called as intelligent Decision Model (IDM). In the presented research work, a 2nd second level hierarchical G-F-A-L-R supply chain model has been constructed by literature survey in addressing the challenges of current brick vendor's industries. To simulate the presented model, a 'VIKOR with FMF' MCDM method applied with generalized trapezoidal fuzzy set. The ratings performance of brick vendor's industries is evaluated under current Green-Flexible-Agile-Lean-Resilient (G-F-A-L-R) SC strategies. An empirical case research of a company exists in the Chhattisgarh, Bilaspur is assumed and presented. The results are shown in results and discussion section.

Keywords: Multi-Criteria Decision Making (MCDM), Benchmarking, G-F-A-L-R (Green Flexibility-Agility-Leanness-Resilient) Supply Chain, Performance Measurement (PM), Construction management, Brick

1.CONSTRUCTION MANAGEMENT:

Construction management deals with managing the starting and finishing activities associated with construction such as colonies, highways, tunnels, bridges, pipelines, drainage systems and sewage treatment plants. Most of these projects are publicly owned and therefore financed either through bonds or taxes. This category of construction is characterized by a high degree of mechanization, which has gradually replaced some labor intensive operations. The engineers and builders engaged in infrastructure construction are usually highly specialized. However, demands for different segments of infrastructure and heavy construction may shift with saturation in some segments. For example, as the available highway construction projects are declining, some heavy construction contractors quickly move their work force and equipment into the field of mining where jobs are available Chen et al. (2007), Hsu and Hu (2008), Simpson and Samson (2008), Huiyu and Weiwei (2010); Samantra (2013).

2. BRICK:

A brick is building material used to make walls, pavements and other elements in masonry construction. Traditionally, the term brick referred to a unit composed of red mud, but it is now used to denote any rectangular units lay in mortar. A brick can be composed of red mud-bearing soil, sand, and lime, or concrete materials. Bricks are produced in numerous classes, types, materials, and sizes which vary with region and time period, and are produced in bulk quantities. Red brick supplier election is considered as key goal in regional planning and negative social, economic and environmental impacts and consequences. So many factors i.e. economic, social and environmental impacts of environmentally sustainable industries must be considered simultaneously. Therefore, appropriate brick supplier, has significant importance in management decisions. Since inappropriate brick supplier only has no economic and social profits, but will cause catastrophic environmental problems. In recent years and by increasing knowledge, efficient criteria for scientific brick supplier election problem were developed from various aspects and accompanied with decreasing environmental problems (Christopher 1998); (Chan 2003); (Gunasekaran 1999), (Green et al., 1998), (Garvin 1993), (Hult et al., 2007), (Huiyu and Weiwei 2010), (Hsu and Hu 2008), (Kainumaa and Tawara 2006), (Kurien and Qureshi 2011), (Lin et al., 2006), (Min and Galle 1997).

3. SUPPLY CHAIN MANAGEMENT (SCM):

Supply chain management is described as the procedure of mapping, executing, and managing the supply chain in efficient potential way. Samantra (2013), Mohanty & Mahapatra (2014), Sahu et al. (2015a), Sahu et al. (2016a).Performance measurement (mapping) is considered as the fundamental ingredient of effectual forecast and scheming with decision making. Green (Environment) Supply Chain is related to the execution of a green ethical and thoughts in traditional SC system. Green Supply Chain deals with concerned of environments sources, need to be addressed up to delivery of products to the end users. Green supply chain management is a way to control the pollution of environment.Supply chain flexibility measured as great response towards growing vagueness. Supply chain flexibility has become so imperative in responding to the global competition and deal with the capability of industry to react well to unpredictable variations in purchaser's necessity and challenger action. Samantra (2013), Mohanty & Mahapatra (2014). Agile supply chain is related to service of firm against service to customers i.e. responding to the client demands, technical advancements and unbalanced business environment (Samantra, 2013; Li 2009; Chong and David 2010; 2012; 2013).The Lean is a dynamic method to advance the technology/approach/path for eliminating the invaluable added activities or misuse by industrial processes Chen et al. (2007), Hsu and Hu (2008), Simpson and Samson (2008), Huiyu and Weiwei (2010), Toke et al. (2010), Nambirajan and Ganeshkumar (2010), Samantra (2013), Mohanty & Mahapatra (2014).Resilience SC is concerned to address the turbulence and discontinuities. From the managerial perspective, resilience SC has been explained in terms of modification to capability or aptitude. (Chen et al., 2006), (Amid et al., 2006).MCDM (Multi Criteria Decision Making) has aim to find optimal choice under several (conflicting) criterion, which are to be achieved Wang et al. (2021), Bag et al. (2021b), Bag et al., (2021a). Group Decision Making: Opinionated voting/ Goods selection/ Project evaluation helps the brick industries for making decision.

4. SUPPLY CHAIN PERFORMANCE MEASUREMENT (SCPM):

Performance measurement (mapping) overcame the managers' implication and assisted them in mapping the performance of their firms at the platform of SC actions.The performance mapping split up into two types such as *Objective and Subjective measurement.*

5. LITERATURE SURVEY:

The relevant literature survey is conducted to determine the research gaps, are cited only.
Garvin (1993) Min and Galle (1997), Panizzolo (1998), Greeen et al. (1998), Gunasekaran (1999), Sharifi and Zhang (1999), Meredith and Francis (2000), Sharifi and Zhang (2001), Arbos (2002), Shah and Ward (2003), Neely (2005), Kainumaa and Tawara (2006a), Kainuma and Tawara (2006b), Amida et al. (2006), Chen et al. (2006), Lin et al. (2006), Hult et al. (2007), Srivastava (2007), Chen et al. (2007), Hsu and Hu (2008), Simpson and Samson (2008), Huiyu and Weiwei (2010), Toke et al. (2010), Nambirajan and Ganeshkumar (2010), Samantra (2013), Mohanty & Mahapatra (2014), Sahu et al. (2015a), Sahu et al. (2016a), Sahu et al. (2016b), Sahu et al. (2017 a, b and 2018), Pancino et al. (2019), Abualfaraa et al. (2020), Zhang et al. (2020a), Zhang et al. (2020b), Bu et al. (2020), Wang et al. (2021),Bag et al. (2021b).

6. RESEARCH GAPS and OBJECTIVES:

After conducting the literature survey in the context of modern SC strategies applications in the construction management. It is observed that no one researchers till now has proposed the as Green-Flexible-Agile-Lean-Resilient (G-F-A-L-R) idea for performance mapping or materialize the overall efficiency and effectiveness of any material supplier. Furthermore, it is also realized the necessity to propose an in centre of 'centroid' technique with the fuzzy number or set with double or reliable MCDM techniques to calculate the performance of brick supplier industries. *Aforesaid research gaps are transformed into research objectives.*

7. INTELLIGENT TECHNIQUES and MODEL DEVELOPMENT:

Fuzzy sets are influential arithmetical technique, which is adopted for modelling vague schemes. A fuzzy set is a crisp set. A crisp set solely permits total participation or non-participation, though fuzzy sets permit incomplete participation Chen (1985), Beamon (1999), Chongand David (2010), Chong and David (2012), Christopher (1998), Chan et al. (2003), Cabral et al. (2012), Kurien and Qureshi, Sahu et al.(2012), Sahu et al. (2017a,b), Sayadi, et al. (2009), Tavana et al. (2016), Abualfaraa et al. (2020), Srivastava (2007), Chen et al. (2007),Hsu and Hu (2008), Simpson and Samson (2008), Huiyu and Weiwei (2010), Toke et al. (2010), Nambirajan and Ganeshkumar (2010),Samantra (2013), Mohanty & Mahapatra (2014), Sahu et al. (2015a), Sahu et al. (2016a), Sahu et al.2016b), Sahu et al. (2017 a, b and 2018), Pancino et al. (2019), Abualfaraa et al. (2020), Zhang et al. (2020a), Zhang et al. (2020b), Bu et al. (2020), Wang et al. (2021), Bag et al. (2021b), Bag et al., (2021a). Zadeh (1965) employed the arithmetic operations of triangular fuzzy numbers based on the extension principle. It is affirmed by present thesis study that to extract fruitful information from fuzzy set and to resolve the decision making problem under the subjective or objective information with the help of fuzzy sets; defuzzification is required, which figure out the crisp value for comparison. The present thesis has utilized the centroid method, which is presented by for defuzzification and to transform the triangular fuzzy set

$\left[\alpha,\beta,\eta\right]$ into crisp value. Let, $\tilde{\Omega}_1=\left[\alpha_1,\beta_1,\eta_1,w_{\tilde{\Omega}_1}\right]$ and $\tilde{\Omega}_2=\left[\alpha_2,\beta_2,\eta_2,w_{\tilde{\Omega}_1}\right]$ are triangular fuzzy numbers such that $\alpha\le\beta\le\eta$ and $w_{\tilde{\Omega}}\in 1$, then fuzzy numbers $\tilde{\Omega}_1$ and $\tilde{\Omega}_2$ can be operated as:

$$\tilde{\Omega}_1\oplus\tilde{\Omega}_2=\left[\alpha_1,\beta_1,\eta_1,w_{\tilde{\Omega}_1}\right]\oplus\left[\alpha_2,\beta_2,\eta_2,w_{\tilde{\Omega}_1}\right]$$

$$=\left[\alpha_1\oplus\alpha_2,\beta_1\oplus\beta_2,\eta_1\oplus\eta_2;\ \min\left(w_{\tilde{\Omega}_1},w_{\tilde{\Omega}_2}\right)\right] \quad \text{.......... (2)}$$

$$\tilde{\Omega}_1-\tilde{\Omega}_2=\left[\alpha_1,\beta_1,\eta_1,w_{\tilde{\Omega}_1}\right]-\left[\alpha_2,\beta_2,\eta_2,w_{\tilde{\Omega}_1}\right]$$

$$=\left[\alpha_1-\alpha_2,\beta_1-\beta_2,\eta_1-\eta_2;\ \min\left(w_{\tilde{\Omega}_1},w_{\tilde{\Omega}_2}\right)\right] \quad \text{.......... (3)}$$

$$\tilde{\Omega}_1\otimes\tilde{\Omega}_2=\left[\alpha_1,\beta_1,\eta_1,w_{\tilde{\Omega}_1}\right]\otimes\left[\alpha_2,\beta_2,\eta_2,w_{\tilde{\Omega}_1}\right]$$

$$=\left[\alpha_1\otimes\alpha_2,\beta_1\otimes\beta_2,\eta_1\otimes\eta_2;\ \min\left(w_{\tilde{\Omega}_1},w_{\tilde{\Omega}_2}\right)\right] \quad \text{.......... (4)}$$

$$\tilde{\Omega}_1/\tilde{\Omega}_2=\left[\alpha_1,\beta_1,\eta_1,w_{\tilde{\Omega}_1}\right]/\left[\alpha_2,\beta_2,\eta_2,w_{\tilde{\Omega}_1}\right]$$

$$=\left[\alpha_1/\eta_2,\beta_1/\beta_2,\eta_1/\alpha_2;\min\left(w_{\tilde{\Omega}_1},w_{\tilde{\Omega}_2}\right)\right] \quad \text{.......... (5)}$$

Let $DMi=\left\{DM1,DM2,...,DMq\right\}$ are the decision makers in the group decision making proces $Ai=\left\{A1,A2,...,Am\right\}$, are the alternatives, and $Cij=\left\{C11,C12,...,Cmn\right\}$ are the criterions and if $\tilde{\Omega}_{ijk}=\left[\alpha_{ijk},\beta_{ijk},\eta_{ijk}\right]$, is the criterion value given by decision maker DMk, where $\tilde{\Omega}_{ijk}$ is the triangular fuzzy number for the alternative Ai with respect to the criterion (Cij). Moreover, let $\tilde{w}_{ijk}=\left[w\alpha_{ijk},w\beta_{ijk},w\eta_{ijk}\right]$ is the criterion weight given by the decision maker DMk, where $\tilde{w}_{ijk}$ is also represents triangular fuzzy number, then, the aggregated fuzzy rating, $\tilde{\tilde{\Omega}}_{ijk}=\left[\alpha_{ij},\beta_{ij},\eta_{ij}\right]$ and weight, $\tilde{\tilde{w}}_{ijk}=\left[w\alpha_{ij},w\beta_{ij},w\eta_{ij}\right]$ of alternatives with respect to each criterion can be calculated by below mentioned Equations

$$\alpha_{ij}=\frac{1}{K}\sum_{k=1}^{K}\alpha_{ijk},\ \ \beta_{ij}=\frac{1}{K}\sum_{k=1}^{K}\beta_{ijk},\ \ \eta_{ij}=\frac{1}{K}\sum_{k=1}^{K}\eta_{ijk} \quad \text{.......... (6)}$$

$$w\alpha_{ij}=\frac{1}{K}\sum_{k=1}^{K}w\alpha_{ijk},\ \ w\beta_{ij}=\frac{1}{K}\sum_{k=1}^{K}w\beta_{ijk},\ \ w\eta_{ij}=\frac{1}{K}\sum_{k=1}^{K}w\eta_{ijk} \quad \text{.......... (7)}$$

8. CRISP VALUE:

A defuzzification formula is proposed is used for transforming fuzzy value into crisp or single value.

(a,b, c,d) is a trapezoidal fuzzy set, then can be converted into crisp value by using

(a+2*b+2*c+d)/6……………………………………………………………………………………….(8)

9. VIKOR TECHNIQUE:

VIKOR stand for Višekriterijumsko kompromisno rangiranje, which assists the decision maker's (DM_S) in judging the status of the parameters in a decision making process under a range of user data Mohanty and Mahapatra (2014). The VIKOR technique is a multi-criteria optimization technique that can be used to solve complex dilemmas under decision making process. The technique determines the compromise ranking list and the compromise solution from the initial weights values. The technique would be employ for ranking and selecting best alternative from a set of available alternatives in the presence of non commensurable and conflicting criteria Tavana et al. (2016). The VIKOR methodology deals with the following steps and equations:

(a) Formulation of the decision-making problem
(b) Normalization of decision-making information
(c) Construction of weighted decision-making matrix
(d) Determination of the positive ideal solution and the negative ideal solution of the evaluated objects

For benefit attributes:

$$\tilde{\tilde{V}}^{+} = \left[\tilde{\tilde{v}}_j^{+}\right]_{1\times n}, \tilde{\tilde{V}}^{-} = \left[\tilde{\tilde{v}}_j^{-}\right]_{1\times n} \quad \text{.......... (9)}$$

For cost attributes:

$$\tilde{\tilde{V}}^{+} = \left[\tilde{\tilde{v}}_j^{-}\right]_{1\times n}, \tilde{\tilde{V}}^{-} = \left[\tilde{\tilde{v}}_j^{+}\right]_{1\times n} \quad \text{.......... (10)}$$

Computation of the indexed values such that, $i = 1, 2, ..., m$

$$S_i = \sum_{j=1}^{n} w_{ij} \left(\frac{d\left(\tilde{\tilde{v}}_j^{+}, \tilde{\tilde{v}}_{ij}\right)}{d\left(\tilde{\tilde{v}}_j^{+}, \tilde{\tilde{v}}_j^{-}\right)} \right) \quad \text{.......... (11)}$$

$$R_i = \max_j \left[w_{ij} \left(\frac{d\left(\tilde{\tilde{v}}_j^{+}, \tilde{\tilde{v}}_{ij}\right)}{d\left(\tilde{\tilde{v}}_j^{+}, \tilde{\tilde{v}}_j^{-}\right)} \right) \right] \quad \text{.......... (12)}$$

Computation of the overall response (Q_i), $i = 1, 2, ..., m$

$$Q_i = v \frac{\left(S_i - S^{*}\right)}{\left(S^{-} - S^{*}\right)} + (1-v) \frac{\left(R_i - R^{*}\right)}{\left(R^{-} - R^{*}\right)} \quad \text{.......... (13)}$$

Where v is defined as importance given to the computed score of S_i, R_i or the maximum group utility and $S^{-} and\ S^{*}$ are the maximum and minimum values of S_i. The ranking of the alternatives is performed by sorting the values of Q_i in ascending order.

10.FMF-TECHNIQUE:

It is Full Multiplicative Form was proposed by **Sahu et al. (2017a).** It combined the maximization as well as minimization of utility functions, where overall utility of i_{th} option is expressed as dimension-less number, w_j is considered as priority weight:

$$U_i^{'} = \frac{A_i}{B_i} \quad \text{.......... (14)}$$

Here, $A_i = \prod_{j=1}^{g} x_{ij}; i = 1, 2, ..., m$; denotes the multification of positive parameters of the i_{th} option to be maximized with $g = 1, 2, ..., n$ being the number of parameters to be maximized and $B_i = \prod_{j=g+1}^{n} x_{ij}; i = 1, 2, ..., m$; denotes the multification of negative parameters of the i_{th} option to be minimized with $n - g$ being the number of parameters to be minimized.

11. MODEL DEVELOPMENT:

In this paper, a universal G-F- A-L-R criteria based theoretical model to quantify the value of brick vendor industries is presented. The presented model is build by bending the crucial and significant measures and their interrelated metrics of each Green-Flexible-Agile-Lean-Resilient (G-F-A-L-R). Model is build by following the shown research documents (Bag et al., (2021a), Bag et al., (2021b), the Wang et al., (2021), Zhang et al., (2020b), Sahu et al., (2016a), (Sahu et al., 2015), Samantra (2013) and Toke et al., (2010). Decision support model towards mapping the performance of brick vendor's industries is set as goal of model. Greenness, C1, Flexibility, C2, Agile,C3, Lean ,C4, Resilient, C5 are set at 1st level. Green services & execution, (C1,1), Green material & purchasing,(C1,2), Green equipments and machines ,(C1,3), Volume flexibility,(C2,1), Responsiveness,(C2,1), Delivery time flexibility by suppliers, (C2,3), Logistics Agility, (C3,1), Agility in complain processing, (C3,2), Managerial working agility, (C3,3), Waste evaluation and reduction provisions, (C4,1), Value streams, (C4,2), Process perfections, (C4,3), Financial condition, (C5,1), New supplier development, (C5,2), Team experience, (C5,3) are set at 2nd level metrics. The crucial measures and their interrelated metrics of model can be tackled the expert or verbal information (fuzzy data). The model is applicable for mapping the performance of brick vendor industries. Table. 1 showed the model.

12. EMPIRICAL CASE STUDY:

This is an empirical case study (assumed) at bilaspur Chhattisgarh, India to find the validation of Table: 1. G-F- A-L-R theoretical model to evaluate the priority rating of brick vendor supplier. In this case study, a colonizer, which is developing colony is assume accompanied with its four of brick vendor suppliers. In this case study, the colonizer has finalized the four brick vendor suppliers closer to colony. The model is built by following the shown research documents (Bag et al., (2021a), Bag et al., (2021b), the Wang et al., (2021), Zhang et al., (2020b), Sahu et al., (2016a), (Sahu et al., 2015), Samantra (2013) and Toke et al., (2010). Decision support model towards mapping the performance of brick vendor's industries is set as goal of model.

The model is established corresponding to four alternatives brick vendor's firm. Later, the crucial measures and their interrelated metrics of model is tackled the expert or verbal information (fuzzy data). The model is applicable is used for mapping the performance of four brick vendor industries A1, A2, A3 and A4.

The further steps related to evaluation of results are shown below.

Step 1:

Construction of a cluster of expert's panel for assessing the overall Green-Flexible-Agile-Lean-Resilient (G-F-A-L-R) performances of four brick vendor industries A1, A2, A3 and A4.

Step 2:

Election of suitable linguistic scale in terms of ratings and importance grades against evaluation criteria is shown in the Table. 2.

Step 3:

Evaluation of performance ratings as well as weights against criteria associated with model up to 1-2nd level hierarchy corresponding to four brick vendor industries A1, A2, A3 and A4, is shown in Table. 3 and Table.4 .

Step 4:

An assigned linguistic variable in the terms of ratings and weights against 1 to 2nd level hierarchy is aggregated as a single fuzzy set is shown in Table. 5. Then aggregated rating and weights is converts into single responses by using Equation, is shown in Table 6.

Step 5:

Applied the VIKOR technique (Equation. 5) calculate the overall performance of four brick vendor industries using expert panel information under Green-Flexible-Agile-Lean-Resilient (G-F-A-L-R).

Step 6:

Applied the FMF technique (Equation. 5) calculate the overall performance of four brick vendor industries using expert panel information under Green-Flexible-Agile-Lean-Resilient (G-F-A-L-R).

Step 7:

The comparative analysis is carried out to find the reliable ranks. After evaluating the results from VIKOR and FMF techniques, the results are compared to obtain the reliable and robust decision. The comparative results are shown such as A2 is found the best alternative brick vendor's industry out of A1, A3, A4. The colonizer is suggested to choose A2 under (G-F-A-L-R) SC practices and their interrelated metrics to speed up own colony production. The results are shown by Table.7 and 8.

Table: 1. G-F-A-L-R theoretical model

(Bag et al., (2021a), Bag et al., (2021b), the Wang et al., (2021), Zhang et al., (2020b), Sahu et al., (2016a), (Sahu et al., 2015), Samantra (2013) and Toke et al., (2010)

Goal	*1st level Measures*	*2nd level metrics*
Decision support model towards mapping the performance of brick vendor's industries	*Greenness, C_1*	*Green services & execution, ($C_{1,1}$)*
		Green material & purchasing,($C_{1,2}$)
		Green equipments and machines ,($C_{1,3}$)
	Flexibility, C_2	*Volume flexibility,($C_{2,1}$)*
		Responsiveness,($C_{2,1}$)
		Delivery time flexibility by suppliers, ($C_{2,3}$)
	Agile,C_3	*Logistics Agility, ($C_{3,1}$)*
		Agility in complain processing, ($C_{3,2}$)
		Managerial working agility, ($C_{3,3}$)
	Lean ,C_4	*Waste evaluation and reduction provisions, ($C_{4,1}$)*
		Value streams, ($C_{4,2}$)
		Process perfections, ($C_{4,3}$)
	Resilient, C_5	*Financial condition, ($C_{5,1}$)*
		New supplier development, ($C_{5,2}$)
		Team experience, ($C_{5,3}$)

Table 2 Fuzzy scale for capturing ratings and weights

Attribute scale (rating)	Attribute scale (weight)	Triangular fuzzy numbers
Very Poor (VP)	Very Low (VL)	(0,0,0.167)
Poor (P)	Low (L)	(0,0.167,0.333)
Moderately Poor (MP)	Medium Low (ML)	(0.167,0.333,0.5)
Fair (F)	Medium (M)	(0.333,0.5,0.668)
Moderately Good (MG)	Medium High (MH)	(0.5,0.668,0.835)
Good (G)	High (H)	(0.668,0.835,1)
Very Good (VG)	Very High (VH)	(0.835,1,1)

Table 3 Ratings assigned for alternatives

Indicators	Alternatives (Ai)	Decision makers assessment					
		DM1	DM2	DM3	DM4	DM5	DM6
$C1,1$	$A1$	F	MG	MG	F	MG	MG
	$A2$	MG	VG	MG	MG	VG	MG
	$A3$	F	MG	MG	F	MG	MG
	$A4$	VG	F	G	VG	F	G
$C1,2$	$A1$	G	MP	VG	G	MP	VG
	$A2$	P	F	G	P	F	G
	$A3$	G	MP	MG	G	MP	MG
	$A4$	MG	VG	F	MG	VG	F
$C1,3$	$A1$	G	MP	MG	G	MP	MG
	$A2$	G	F	G	G	F	G
	$A3$	G	MP	MG	G	MP	MG
	$A4$	F	F	MP	F	F	MP
$C2,1$	$A1$	G	G	MG	G	G	MG
	$A2$	F	VP	MG	F	VP	MG
	$A3$	G	G	MG	G	G	MG
	$A4$	MP	P	F	MP	P	F
$C2,2$	$A1$	G	VG	G	G	VG	G

	$A2$	VG	F	G	VG	F	G
	$A3$	VG	VG	G	VG	VG	G
	$A4$	F	G	VG	F	G	VG
$C2,3$	$A1$	G	MP	F	G	MP	F
	$A2$	G	G	F	G	G	F
	$A3$	F	MP	F	F	MP	F
	$A4$	F	F	F	F	F	F
$C3,1$	$A1$	MG	MG	F	MG	MG	F
	$A2$	G	G	G	G	G	G
	$A3$	MG	MG	F	MG	MG	F
	$A4$	MP	MP	VG	MP	MP	VG
$C3,2$	$A1$	VG	VG	MP	VG	VG	MP
	$A2$	MP	MG	F	MP	MG	F
	$A3$	VG	MG	MP	VG	MG	MP
	$A4$	F	G	F	F	G	F
$C3,3$	$A1$	VP	G	MP	VP	G	MP
	$A2$	F	P	F	F	P	F
	$A3$	VG	G	MP	VG	G	MP
	$A4$	G	MG	VG	G	MG	VG
$C4,1$	$A1$	VG	MG	F	VG	MG	F
	$A2$	VG	MG	MG	VG	MG	MG
	$A3$	G	MG	F	G	MG	F
	$A4$	VG	G	VG	VG	G	VG
$C4,2$	$A1$	G	MP	MG	G	MP	MG
	$A2$	G	F	MG	G	F	MG
	$A3$	G	MP	MG	G	MP	MG
	$A4$	VG	F	F	VG	F	F
$C4,3$	$A1$	VG	VG	MG	VG	VG	MG
	$A2$	VG	G	MG	VG	G	MG
	$A3$	G	VG	MG	G	VG	MG
	$A4$	VG	VG	G	VG	VG	G
$C5,1$	$A1$	G	VP	VG	G	VP	VG
	$A2$	VG	F	G	VG	F	G
	$A3$	VG	VG	MG	VG	VG	MG
	$A4$	MG	G	F	MG	G	F
$C5,2$	$A1$	G	MP	MG	G	MP	MG
	$A2$	VG	G	G	VG	G	G
	$A3$	G	G	MG	G	G	MG
	$A4$	MG	MG	MP	MG	MG	MP
$C5,3$	$A1$	F	F	MG	F	F	MG
	$A2$	G	MP	MG	G	MP	MG
	$A3$	F	F	MG	F	F	MG
	$A4$	VG	P	F	VG	P	F

Table 4 Weights assigned for alternatives

Cij	Experts Assessment					
$C1,1$	MH	VH	M	VH	M	MH
$C1,2$	H	L	H	L	H	H
$C1,3$	M	MH	M	MH	M	M
$C2,1$	M	VH	H	VH	H	M
$C2,2$	H	H	M	H	M	H
$C2,3$	VH	MH	VH	MH	VH	VH
$C3,1$	L	L	ML	L	ML	L
$C3,2$	M	M	L	M	L	M
$C3,3$	VH	M	H	M	H	VH
$C4,1$	H	MH	VH	MH	VH	H
$C4,2$	M	ML	ML	ML	ML	M
$C4,3$	H	ML	M	ML	M	H
$C5,1$	MH	H	H	H	H	MH
$C5,2$	M	MH	M	MH	M	M
$C5,3$	VH	VH	H	VH	H	VH

Table 5 Aggregated fuzzy ratings and weights

Cij	$A1$	$A2$	$A3$	$A4$	*weights*
$C1,1$	(0.444,0.612,0.779)	(0.612,0.779,0.890)	(0.444,0.612,0.779)	(0.612,0.778,0.889)	(0.556,0.723,0.834)
$C1,2$	(0.557,0.723,0.833)	(0.334,0.501,0.667)	(0.445,0.612,0.778)	(0.556,0.723,0.834)	(0.445,0.612,0.778)
$C1,3$	(0.445,0.612,0.778)	(0.556,0.723,0.889)	(0.445,0.612,0.778)	(0.278,0.444,0.612)	(0.389,0.556,0.724)
$C2,1$	(0.612,0.779,0.945)	(0.278,0.389,0.557)	(0.612,0.779,0.945)	(0.167,0.333,0.500)	(0.612,0.778,0.889)
$C2,2$	(0.724,0.890,1.000)	(0.612,0.778,0.889)	(0.779,0.945,1.000)	(0.612,0.778,0.889)	(0.556,0.723,0.889)
$C2,3$	(0.389,0.556,0.723)	(0.556,0.723,0.889)	(0.278,0.444,0.612)	(0.333,0.500,0.668)	(0.723,0.889,0.945)
$C3,1$	(0.444,0.612,0.779)	(0.668,0.835,1.000)	(0.444,0.612,0.779)	(0.390,0.555,0.667)	(0.056,0.222,0.389)
$C3,2$	(0.612,0.778,0.833)	(0.333,0.500,0.668)	(0.501,0.667,0.778)	(0.445,0.612,0.779)	(0.222,0.389,0.556)
$C3,3$	(0.278,0.389,0.556)	(0.222,0.389,0.556)	(0.557,0.723,0.833)	(0.668,0.834,0.945)	(0.612,0.778,0.889)
$C4,1$	(0.556,0.723,0.834)	(0.612,0.779,0.890)	(0.500,0.668,0.834)	(0.779,0.945,1.000)	(0.668,0.834,0.945)
$C4,2$	(0.445,0.612,0.778)	(0.500,0.668,0.834)	(0.445,0.612,0.778)	(0.500,0.667,0.779)	(0.222,0.389,0.556)
$C4,3$	(0.723,0.889,0.945)	(0.668,0.834,0.945)	(0.668,0.834,0.945)	(0.779,0.945,1.000)	(0.389,0.556,0.723)
$C5,1$	(0.501,0.612,0.722	(0.612,0.778,0.889)	(0.723,0.889,0.945)	(0.500,0.668,0.834)	(0.612,0.779,0.945)
$C5,2$	(0.445,0.612,0.778)	(0.724,0.890,1.000)	(0.612,0.779,0.945)	(0.389,0.556,0.723)	(0.389,0.556,0.724)
$C5,3$	(0.389,0.556,0.724)	(0.445,0.612,0.778)	(0.389,0.556,0.724)	(0.389,0.556,0.667)	(0.779,0.945,1.000)

Table 6 Normalized matrix and the aggregated crisp weights (VIKOR)

Cij	$A1$	$A2$	$A3$	$A4$	Aggregated weight
$C1,1$	0.612	0.769	0.612	0.769	0.714
$C1,2$	0.713	0.501	0.612	0.714	0.612
$C1,3$	0.612	0.723	0.612	0.445	0.556
$C2,1$	0.779	0.399	0.779	0.333	0.769
$C2,2$	0.881	0.769	0.927	0.769	0.723
$C2,3$	0.556	0.723	0.445	0.500	0.871
$C3,1$	0.612	0.835	0.612	0.546	0.222
$C3,2$	0.759	0.500	0.658	0.612	0.389
$C3,3$	0.399	0.389	0.713	0.825	0.769
$C4,1$	0.714	0.769	0.668	0.927	0.825
$C4,2$	0.612	0.668	0.612	0.658	0.389
$C4,3$	0.871	0.825	0.825	0.927	0.556
$C5,1$	0.612	0.769	0.871	0.668	0.779
$C5,2$	0.612	0.881	0.779	0.556	0.556
$C5,3$	0.556	0.612	0.556	0.547	0.927

Table 7 Ranking (VIKOR approach)

Alternatives	*Si*	*Ri*	*VIKOR (Qi)*			Ranking order
			$(\nu = 0)$	$(\nu = 0.5)$	$(\nu = 1)$	
$A1$	5.996	0.791	0.140	0.570	1.000	4
$A2$	4.513	0.769	0.000	0.000	0.000	1
$A3$	5.355	0.871	0.647	0.607	0.568	3
$A4$	5.354	0.927	1.000	0.784	0.567	2

Table 8 Ranking (FMF approach)

A1	A2	A3	A4
0.00000084	0.00000151	0.00000099	0.00000055
Ranking			
3	1	2	4

RESULTS AND DISCUSSION:

By computing the results from VIKOR technique, the result states that A2 is the best alternative brick vendor's industry out of A1, A3, A4. The colonizer is advised to select the A2 under (G-F-A-L-R) SC practices and their interrelated metrics to speed up own colony production. By computing the results from FMF technique, the result state that A2 is found the best alternative brick vendor's industry out of A1, A3, A4. The colonizer is advised to prefer A2 alternative brick vendor's industry under (G-F-A-L-R) SC practices and their interrelated metrics to ramp up own colony production. It is finally concluded by conducting the comparative analysis on the results evaluated from VIKOR and FMF techniques. The comparative analysis clarified the ranks and stated that A2 is the best alternative brick vendor's industry out of A1, A3 and A4. The colonizer is directed to choose A2 under (G-F-A-L-R) SC practices and their interrelated metrics to speed up own colony production.

CONCLUSIONS and FUTURE SCOPE:

The proposed intelligent decision support model is built and proposed towards mapping the performance (efficiency as well as effectiveness) of brick vendor's industries. In the presented work, the constructed model fuzzy-VIKOR and FMF technique is used to rank the brick vendor's industries under expert information. After evaluating the results from VIKOR and FMF techniques, A2 is found as the best alternative brick vendor's industry out of A1, A3, A4. The colonizer is suggested to choose A2 under (G-F-A-L-R) SC practices and their interrelated metrics to speed up own colony production. The presented work aids the novel/forthcoming researchers to solve other construction management problems under linguistic information. The proposed work has the aptitude to overcome the problems in relation to appraise the overall performance of many colonizer firms under the considered model. Furthermore, the model is acceptable by global researchers to resolve aforesaid problem, however the IDM parameter model is found flexible in nature. It can solve the many problems such as evaluation of other type of brick suppliers under different subjective information. In the context of future scope, the implementation of proposed MCDM technique is not constrained to solve only performance measurement problems of evaluation of brick vendor's industries. It is also found valid to solve the several real-life problems on replacement of measures of constructed model. In future, many such as DSS can be constituted by exploring the same technique accompanied with model to solve below said problems of different disciplines such as selection of project design, Material handling equipments evaluation for a given engineering application, Selection of choice product's designs, Evaluation of contemporary machining techniques etc,.

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