QUALITATIVE AND QUALITATIVE MODELING OF RED BRICK MANUFACTURING FIRMS UNDER GREEN AND TRADITIONAL SUPPLY CHAIN USING RPA

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ABSTRACT

Brick firm is one of the most efficient employs the materials to produce a product. Brick plants are typically located close to raw material sources. Brick not meeting standards after firing are culled from the process and ground to be used as grog in manufacturing brick or crushed to be used as landscaping material. There is virtually no waste of raw materials in manufacturing brick. Brick manufacturing uses readily available raw materials, including some waste products. The primary ingredient is red mud. The red brick industry's goal is to reduce resources used in the manufacturing process. Although, water is used in brick manufacturing, it is not chemically altered but is evaporated into the atmosphere. Brick manufacturers are continuously looked for the way to diminish pollution by evaluating the green cum traditional supply chain performance red brick supplier firms. In the presented research work, the authors have proposed a DSS (consist of implementation of reference point approach implementation on constructed module. to benchmark the alternatives.

Keywords: Multi-Criterion Decision Making (MCDM), Benchmarking, Performance Measurement (PM), Fuzzy.

I. INTRODUCTION AND LITERATURES:

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. Two basic categories of bricks are fired and non-fired bricks. The fundamentals of brick manufacturing have not changed over time. However, technological advancements have made contemporary brick plants substantially more efficient and have improved the overall quality of the products. A more complete knowledge of raw materials and their properties, better control of firing, improved kiln designs and more advanced mechanization have all contributed to advancing the brick industry. Red muds must have plasticity, which permits them to be shaped or molded when mixed with water; they must have sufficient wet and air-dried strength to maintain their shape after forming. Also, when subjected to appropriate temperatures, the red mud particles must fuse together [1-5].

Apart from considering the technical features, the role of green supply chain to diminish pollution by evaluating the green cum traditional supply chain performance of firm is realized. MCDM selects the red brick supplier as per criteria. The advantage of MCDM is that it gives a balanced view of how suitable any option is, and helps to take emotion out of the equation. It also stops any one factor from overshadowing others. One of its disadvantages is that it is possible for a critical criterion to be obscured in the overall score. Other problems include that a simple multiplication of the score times the weighting may be too simple a calculation, and that putting all of the criteria together fails to differentiate between logical, objective measurements and emotional, subjective judgments. MCDM problems are widespread all the time, MCDM as a discipline only has a relatively short history of about 30 years. The development of the MCDM discipline is closely related to the advancement of computer technology. In one hand, the rapid development of computer technology in recent years has made it possible to conduct systematic analysis of complex MCDM problems. On the other hand, the MCDM increasingly important and useful in supporting business decision making.

II. RED BRICK SUPPLY CHAIN MANAGEMENT

Nowadays, natural resources and environmental issues were considered as important matter for sustainable development. These limitations caused decision making agents to choose appropriate red brick supplier, which would cause least environmental damages. 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 red brick supplier, has significant importance in management decisions. Since inappropriate red 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 red brick supplier election problem were developed from various aspects and accompanied with decreasing environmental problems. Therefore since red brick supplier is multi-criteria decision which affects various indexes in order to decision making. It seems that use of multi-criteria decision making methods could be effective in decision making process and preparing optimum pattern from environmental management viewpoint. TOPSIS model must be developed and evaluated for weighing of effective criteria in environmental decision making, developmental actions according to accurate and deep investigation of internal and external (environmental) factors effective on environment considering to its wide application among multi-criteria decision making models due to options ranking. For this purpose, cooperation of environmental protection organization and other policy maker organizations for developmental actions of establishing TOPSIS model in developmental actions of environmental decision making processes must be considered. SAW decision making model for ranking of effective indexes in environmental decision making in developmental actions must be evaluated and developed considering to acquiring more realistic results in analyzing and prioritizing criteria and effects. Joint utilization of SMCE, TOPSIS and SAW strategies in spatial evaluation of developmental projects in order to use of capabilities and removing their limitations and potential tool in environmental management in comprehensive and accurate decision making must be considered by developmental actions policy-maker organizations.

III. EXPERT DECISION MAKING

Decision-making can be regarded as a problem-solving activity terminated by a solution deemed to be optimal, or at least satisfactory **[5-7].**

It is therefore a process which can be more or less rational or irrational and can be based on explicit or tacit knowledge and beliefs. Experts are a unique population of reliable, consistent, accurate decision makers, which makes them worthy of study. It is the possession of expertise that defines people as an experts, and it is their expertise that we need to study to be informed about experts decision making processes. The individuals in a group may be demographically similar or quite diverse. Decision-making groups may be relatively informal in nature, or formally designated and charged with a specific goal. The process used to arrive at decisions may be unstructured or structured. The nature and composition of groups, their size, demographic makeup, structure, and purpose, all affect their functioning to some degree. The external contingencies faced by groups (time pressure and conflicting goals) impact the development and effectiveness of decision-making groups.

IV. FUZZY SET THEORY

Prof. Zadeh proposed the concept of fuzzy logic in 1965. Fuzzy logic theory is a control tool and technique, which encompasses the data by allowing partial set membership rather than crisp set membership or non-membership.

Fuzzy logic deals with the concept of partial truth, where the truth value may range between completely true and completely false. Fuzzy logic found their application where the valuable information is neither completely true nor completely false, or which are partly true and partly false [1-3].

V. THE REFERENCE POINT APPROACH (RPA) METHOD

Reference point approach [36-39] chooses the maximal objective reference point (vector) is found according to ratios found by employing Equ.1. The j_{th} coordinate of the reference point can be described as ($r_j = \max M_{x_1 x_2 \ldots x_{(i-1)}}$) in case of maximization. $r_j = \min M_{x_1 x_2 \ldots x_{(i-1)}}$ in case of minimization Every coordinate of this vector represents maximum or minimum of certain objective (indicator). Then every element of normalized response matrix is recalculated and final rank is given according to deviation from the reference point and the Min-Max Metric of Tchebycheff:

$$R_{x_1 x_2 \ldots x_{(i-1)}} = \min\left(\max\left| r - M_{x_1 x_2 \ldots x_{(i-1)}} \right| \right) \quad \ldots\ldots(1)$$

VI. CASE STUDY

Procedural hierarchy: case application

This section considers the real case of a Colony Developer Company 'Rishabh Colonizer' situated in the Bhilai, Chhattisgarh, India; desire to place an order of red-brick to supplier firms (considered the Eco, S.K and Flypro red-brick manufacturers) up to that time until project does not complete via participating in global green issues as per various rule and regulations imposed by the government. The selection of best red brick supplier subjected with the consideration of the green cum traditional SC measures and their metrics against company's partners 'Eco, S.K and Flypro red-brick manufacturers' is considered as a challenging issue. Preliminary, Rishabh Colonizer conducted the brainstorming session and at last looked for three alternative industries i.e. Eco, S.K and Flypro red-brick manufacturers and searched the appropriate technique to choose the best alternative under green cum traditional SC.

Step 1: a fuzzy and non-fuzzy based red-brick supplier performance evaluation module/index is constructed, is given in Table 1, 2 and 3. A rating scale is given in Table 4.

Step 2: Later five decision makers of Rishabh Colonizer assessed the weights for 1st 2nd 3rd and 4th in term of linguistic, given in Table 5, 6 and 7. Later, five decision makers of Rishabh Colonizer assessed the rating for 4th, 3rd , 2nd in term of linguistic, given in Table 8, 9 and 10.

The authors applied the formulation of reference paper [2] to compute Defuzzified value and weighted normalized matrix, given in Table 11.

Step 3: The authors applied to [Equa. 1]; on weighted normalized matrix to compute rank of the alternatives has been computed, given in Table 12.

VIII. APPLICATION

Colonizer can use *proposed approach/method* for measuring the performance's scores of the clay brick supplier candidate. Presented approach/method is also found well for other industries in substituting measures and metrics (included in decision making hierarchical structural module) corresponding to fuzzy cum non fuzzy information under scope of considering alternatives i.e. red brick, coal refinery, refractive material refinery etc suppliers.

VIII.CONCLUSION

The presented work is valid for small to high scale construction companies i.e. colonies, hotels, hostels developers etc. The construction companies can avail the presented work to appraise the values of supplier candidate as per numeric and expert's panel information under green and traditional SCs of considered clay-brick suppliers. Moreover, applied ML-MCDM with RPA method can tackle numeric and expert's panel information corresponding to quantitative and qualitative measures and metrics, respectively for finding the effective decision.

In depicted DSS, is found active to undertake many industrial decision making problems in substituting the chain of architectures corresponding to fuzzy cum non fuzzy information under scope of considering alternatives.

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Table: 1 Green red brick supplier evaluation appraisement index for red-brick alternative A_1 **(**Eco red-brick manufacturer in Bhilai, C.G).

<table>
<tr><th>Goal (f_x)</th><th>Measures; (INR/Unit), f_{x_1}</th><th>Metrics; (INR/Unit), $f_{x_1x_2}$</th><th>Metrics; (INR/Unit), $f_{x_1x_2x_3}$</th><th>Metrics; (INR/Unit), C_{ijkl}</th></tr>
<tr><td rowspan="11">Green Red Brick Partner Evaluation Appraisement Index</td><td rowspan="3">Supply chain management, C_1</td><td>Supply in time, $C_{1,1}$</td><td>Quality, C_{111}</td><td>Credit, C_{1111}</td></tr>
<tr><td>Solving problems with suppliers, $C_{1,2}$</td><td>Complaint for product, C_{112}</td><td rowspan="10"></td></tr>
<tr><td>Communication with other companies, $C_{1,3}$</td><td rowspan="4"></td></tr>
<tr><td>Eco-design, C_2</td><td>Reuse of waste material, $C_{2,1}$</td></tr>
<tr><td>Operation management, C_3</td><td>Innovation of technique, $C_{3,1}$</td></tr>
<tr><td>Outside environmental management, C_4</td><td>Waste of water, $C_{4,1}$</td></tr>
<tr><td rowspan="5">Production cost, C_5</td><td rowspan="5">Material Procurement cost (loading and unloading material charge), $C_{5,1}$</td><td>Loading material labor charge from material supplier company;(0.02), C_{511}</td></tr>
<tr><td>Unloading material labor charge at brick making company;(0.02); C_{512}</td></tr>
<tr><td>Fuel consumption;(0.10), C_{513}</td></tr>
<tr><td>Truck hiring (cleaner and driver charge);(0.05), C_{514}</td></tr>
<tr><td>Documentation costs; (0.01), C_{515}</td></tr>
</table>

			Raw material cost;(0.10),C_{516}	
		Tempering;(0.04),$C_{5,2}$		
		Moulding;(0.10),$C_{5,3}$		
		Drying;(0.01),$C_{5,4}$		
		Firing; (0.03),$C_{5,5}$		
		Sorting;(0.1),$C_{5,6}$		
	Transportation cost, C_6	Loading finished brick’s labor charge at brick making company; (0.02),$C_{6,1}$		
		Unloading finished brick’s labor charge at rishabh colonizer;(0.02),$C_{6,2}$		
		Fuel consumption; (0.10),$C_{6,3}$		
		Truck hiring (cleaner and driver charge);(0.05),$C_{6,4}$		
		Documentation costs; (0.01),$C_{6,5}$		
	Water pollution treatment costs; (0.012), C_7			
	Energy consumption costs, C_8	Hydraulic machine power consumption cost;(0.12),$C_{8,1}$		
		Water supply motor power consumption cost;(0.05),$C_{8,2}$		
		Overall lighting and other appliance running cost;(0.03), $C_{8,3}$		
	Air pollution treatment costs;(0.020),C_9			
	Chemical waste treatment costs; (0.010),C_{10}			
	Solid waste treatment costs;(0.020),C_{11}			
	Other indirect expenses;(0.060),C_{12}			
	Staff salary; (0.080);C_{13}			

Table: 2 Green supplier evaluation appraisement index for red-brick alternative A_2 (S.K red-brick manufacturer in Bhilai, C.G).

Goal (f_x)	**Measures; (INR/Unit), f_{x_1}**	**Metrics; (INR/Unit), $f_{x_1x_2}$**	**Metrics; (INR/Unit), $f_{x_1x_2x_3}$**	**Metrics; (INR/Unit), C_{ijkl}**
Green Red Brick Partner Evaluation Appraisement Index	Supply chain management, C_1	Supply in time, $C_{1,1}$	Quality, C_{111}	Credit, C_{1111}
		Solving problems with suppliers, $C_{1,2}$	Complaint for product, C_{112}	
		Communication with other companies, $C_{1,3}$		
	Eco-design, C_2	Reuse of waste material, $C_{2,1}$		
	Operation management, C_3	Innovation of technique, $C_{3,1}$		
	Outside environmental management, C_4	Waste of water, $C_{4,1}$		
	Production cost, C_5	Material Procurement cost (loading and unloading material charge), $C_{5,1}$	Loading material labor charge from material supplier company;(0.02), C_{511}	
			Unloading material labor charge at brick making company;(0.02); C_{512}	
			Fuel consumption; (0.11), C_{513}	
			Truck hiring (cleaner and driver charge); (0.05), C_{514}	
			Documentation costs; (0.02), C_{515}	
			Raw material cost; (0.11), C_{516}	
		Tempering;(0.04), $C_{5,2}$		
		Moulding;(0.10), $C_{5,3}$		
		Drying;(0.01), $C_{5,4}$		
		Firing; (0.03), $C_{5,5}$		
		Sorting;(0.1), $C_{5,6}$		
	Transportation cost, C_6	Loading finished brick's labor charge at brick making company; (0.02), $C_{6,1}$		
		Unloading finished brick's labor charge at rishabh colonizer;(0.02), $C_{6,2}$		
		Fuel consumption; (0.12), $C_{6,3}$		
		Truck hiring (cleaner and driver charge); (0.04), $C_{6,4}$		
		Documentation costs; (0.01), $C_{6,5}$		

	Water pollution treatment costs; (0.012), C_7			
	Energy consumption costs, C_8	Hydraulic machine power consumption cost;(0.11),$C_{8,1}$		
		Water supply motor power consumption cost;(0.07),$C_{8,2}$		
		Overall lighting and other appliance running cost;(0.04), $C_{8,3}$		
	Air pollution treatment costs; (0.030),C_9			
	Chemical waste treatment costs; (0.010),C_{10}			
	Solid waste treatment costs; (0.030),C_{11}			
	Other indirect expenses; (0.080),C_{12}			
	Staff salary; (0.070);C_{13}			

Table: 3 Green supplier evaluation appraisement index for red-brick alternative A_3 **(**Flypro red-brick manufacturer in Bhilai, C.G)

Goal (f_x)	**Measures; (INR/Unit), f_{x_1}**	**Metrics; (INR/Unit), $f_{x_1x_2}$**	**Metrics; (INR/Unit), $f_{x_1x_2x_3}$**	**Metrics; (INR/Unit), C_{ijkl}**
Green Red Brick	Supply chain management,C_1	Supply in time, $C_{1,1}$	Quality, C_{111}	Credit, C_{1111}
		Solving problems with suppliers, $C_{1,2}$	Complaint for product,C_{112}	
		Communication with other companies, $C_{1,3}$		
	Eco-design, C_2	Reuse of waste material, $C_{2,1}$		
	Operation management, C_3	Innovation of technique, $C_{3,1}$		
	Outside environmental management, C_4	Waste of water, $C_{4,1}$		
	Production cost, C_5	Material Procurement cost (loading and unloading material charge),$C_{5,1}$	Loading material labor charge from material supplier company;(0.02) , C_{511}	
			Unloading material labor charge at brick making	

Partner Evaluation Appraisement Index			company;(0.02) ; C_{512}	
			Fuel consumption;(0.10), C_{513}	
			Truck hiring (cleaner and driver charge);(0.04), C_{514}	
			Documentation costs; (0.01),C_{515}	
			Raw material cost; (0.13),C_{516}	
		Tempering;(0.03),$C_{5,2}$		
		Moulding;(0.10),$C_{5,3}$		
		Drying;(0.02),$C_{5,4}$		
		Firing; (0.04),$C_{5,5}$		
		Sorting;(0.2),$C_{5,6}$		
	Transportation cost, C_6	Loading finished brick's labor charge at brick making company; (0.02),$C_{6,1}$		
		Unloading finished brick's labor charge at rishabh colonizer;(0.02),$C_{6,2}$		
		Fuel consumption; (0.12),$C_{6,3}$		
		Truck hiring (cleaner and driver charge); (0.06),$C_{6,4}$		
		Documentation costs; (0.01),$C_{6,5}$		
	Water pollution treatment costs; (0.012), C_7			
	Energy consumption costs, C_8	Hydraulic machine power consumption cost;(0.14),$C_{8,1}$		
		Water supply motor power consumption cost;(0.04),$C_{8,2}$		
		Overall lighting and other appliance running cost;(0.03), $C_{8,3}$		
	Air pollution treatment costs; (0.021),C_9			
	Chemical waste treatment costs; (0.011),C_{10}			
	Solid waste treatment costs; (0.022),C_{11}			
	Other indirect expenses; (0.061),C_{12}			
	Staff salary; (0.090);C_{13}			

Table 4: Linguistic scale

Linguistic Term (Appropriateness Rating)	Corresponding Fuzzy Numbers	Linguistic Term (Priority Weights)	Corresponding Fuzzy Numbers
Unsatisfactory (U)	(0,0,0.25)	Unimportant (UI)	(0,0.1,0.3)
Poor (P)	(0,0.25,0.5)	Slightly Important (SI)	(0,0.2,0.5)
Medium (M)	(0.25,0.5,0.75)	Fairly Important (FI)	(0.3,0.45,0.7)
Satisfactory (S)	(0.5,0.75,1)	Important (I)	(0.5,0.7,0.8)
Excellent (E)	(0.75,1,1)	Very Important (VI)	(0.7,0.9,1)

Table 5: Priority weights against 1st level indicators for alternative $\mathbf{A_1}$, $\mathbf{A_2}$ **and** $\mathbf{A_3}$

1st level indices	E_1	DM_2	DM_3	DM_4	DM_5
C_1	I	VI	VI	VI	VI
C_2	VI	I	I	FI	FI
C_3	VI	FI	I	I	I
C_4	VI	FI	VI	I	FI
C_5	VI	VI	VI	FI	VI
C_6	I	VI	VI	VI	VI
C_7	I	VI	VI	FI	VI
C_8	VI	VI	FI	FI	VI
C_9	VI	VI	VI	FI	SI
C_{10}	VI	VI	VI	FI	SI
C_{11}	VI	VI	VI	I	FI
C_{12}	I	UI	FI	I	FI
C_{13}	I	UI	FI	I	FI

Table 6: Priority weights against 2nd level indices for alternative $\mathbf{A_1}$, $\mathbf{A_2}$ **and** $\mathbf{A_3}$

2nd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
$C_{1,1}$	VI	VI	VI	I	FI
$C_{1,2}$	I	UI	FI	I	FI
$C_{1,3}$	I	UI	FI	I	FI
$C_{2,1}$	I	FI	FI	FI	FI
$C_{3,1}$	I	FI	FI	VI	SI
$C_{4,1}$	I	VI	FI	UI	SI
$C_{5,1}$	I	VI	FI	UI	VI
$C_{5,2}$	I	VI	VI	FI	VI
$C_{5,3}$	I	VI	UI	FI	VI
$C_{5,5}$	VI	I	UI	VI	VI
$C_{5,6}$	VI	FI	FI	VI	VI
$C_{6,1}$	VI	VI	FI	UI	VI
$C_{6,2}$	I	UI	VI	FI	FI
$C_{6,3}$	I	UI	VI	I	FI
$C_{6,4}$	I	FI	UI	FI	FI
$C_{6,5}$	I	FI	FI	FI	SI
$C_{8,1}$	I	VI	FI	SI	SI
$C_{8,2}$	I	VI	FI	SI	VI
$C_{8,3}$	I	UI	FI	I	FI

Table 7: Priority weights against 3rd and 4th level indices for alternative $\mathbf{A_1}$, $\mathbf{A_2}$ **and** $\mathbf{A_3}$

3rd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{111}	FI	FI	FI	VI	VI
C_{112}	FI	FI	FI	VI	VI
C_{511}	UI	UI	UI	UI	UI
C_{512}	FI	FI	FI	FI	FI
C_{513}	FI	FI	FI	FI	FI
C_{514}	VI	VI	VI	VI	VI
C_{515}	FI	FI	FI	VI	VI

C_{516}	FI	FI	FI	VI	VI
4th level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{1111}	FI	FI	FI	VI	VI

Table 8: Priority rating against 4th, 3rd and 2nd level indices for alternative $\mathbf{A_1}$

4th level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{1111}	S	M	M	M	P
3rd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{112}	S	M	E	M	P
2nd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
$C_{1,3}$	P	M	U	M	M
$C_{2,1}$	S	M	M	M	P
$C_{3,1}$	S	M	E	M	P
$C_{4,1}$	U	E	M	M	M

Table 9: Priority rating against 4th, 3rd and 2nd level indices for alternative $\mathbf{A_2}$

4th level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{1111}	E	U	M	M	E
3rd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{112}	E	M	U	E	E
2nd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
$C_{1,3}$	E	U	U	M	E
$C_{2,1}$	E	U	M	M	E
$C_{3,1}$	E	M	U	E	E
$C_{4,1}$	E	E	E	E	E

Table 10: Priority rating against 4th, 3rd and 2nd level indices for alternative $\mathbf{A_3}$

4th level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{1111}	U	M	M	M	M
3rd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{112}	S	E	E	E	P
2nd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
$C_{1,3}$	S	M	U	M	M
$C_{2,1}$	U	M	M	M	M
$C_{3,1}$	S	E	E	E	P
$C_{4,1}$	S	S	E	E	M

Table 11: Computed weighted normalized matrix ***(all the indices are beneficial)*** for alternatives A_1, A_2 and A_3

1st level indices	A_1	A_2	A_3
C_1	0.67	0.83	0.77
C_2	0.54	0.63	0.45
C_3	0.52	0.60	0.67
C_4	0.36	0.68	0.56
C_5	0.79	0.77	0.62
C_6	0.83	0.78	0.73
C_7	0.75	0.75	0.75
C_8	0.71	0.64	0.69
C_9	0.67	0.44	0.63
C_{10}	0.75	0.75	0.69

C_{11}	0.49	0.32	0.44
C_{12}	0.49	0.36	0.48
C_{13}	0.45	0.52	0.40
Reference point (max):	**0.83**	**0.83**	**0.77**

Table.12: Preference orders of **(**Eco, S.K and Flypro red-brick manufacturer in Bhilai, C.G) suppliers

Ai	*Performance score*	*Ranking*
(M_1)/A_1	0.280	2.000
(M_2)/A_2	0.120	**1.000**
(M_3)/A_3	0.297	3.000