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MODELING OF GREEN GLOBAL LOGISTICS STRATEGY SELECTION USING HYBRID GREY RELATIONAL ANALYSIS

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ABSTRACT

With the advancement in the standard of living of today's society, there has been an inevitable rise in the demands for product. Every consumer wants his order to be delivered as early as possible and scarcity of resources calls for effective utilization and recycling of resources wherever possible. Due to this, logistics is now a days a crucial and an important part of any business organization, but due to congestion problems on the roads as well as pollution in the environment, there has been an interest in developing green global logistics from the companies, government, and society. Similarly, as number of consumers in this field need aid expanding dramatically, particularly due to those ways that customary logistics can't meet those necessities about up to date social order. Also traditional logistics have an immense effect on the surroundings. Hence, there is a need to develop a model for green global logistics which we are going to suggest in this paper. In the present study, we selected few key concepts, which can contribute to the development of a green global logistics network. Furthermore, we created a model for best Green Global Logistics Strategy Selection and analyzed that model using a Hybrid Grey Relational Analysis methodology.

Keywords: *Analytical hierarchy process, Grey Relational Analysis, Green Logistics, MCDM, Strategy selection, Environment, Management.*

1. INTRODUCTION

Logistics can simply be defined as the commercial activity of transporting goods to the customers. It is an essential part of supply chain management. Densia (2015) considers logistics to be an element of distribution, which is focused on optimization of total distribution costs, as well as the quality of customer service, related to the whole process from placing the order, through storage, supply management and handling, to final shipment to the consumer [1]. In the present competitive scenario, customers have a lot of options available in the market and definitely they will choose the best one. If an organization wants to gain goodwill of their customers, they should focus on their satisfaction. So, in order to have supply chain profitability and to gain competitive advantage, an organization should apply suitable logistic strategy. Hence, for the betterment of the present and

future it is vital to additionally fuse those demands, prerequisites What's more necessities of customers, alongside those requirement which ensures the sustainability, through ceaselessly checking and assessing the effects and nature of the unique components of the entire logistics network.

While environmental issues have become critical concerns all over the world, organizations are constantly under pressure to develop environmentally responsible and friendly operations. Commitment to the natural environment has become an important variable [2]. And also at the same time every organization wants to expand his share in the global market means want to globalize his goods and services. Therefore, the interest in developing green global logistics from companies, government, and the public is increasing dramatically especially because traditional logistics cannot meet the requirements of modern society and has huge impact on the environment [3]. Logistics management considers the cost effective management of transportation of goods, green logistics may require a high initial cost but this concept has a very long term effect on the society. Because through concept of green we are making it sustainable, means it will be effective without exploiting the resources of future generation. Many researchers defined the green logistics differently, here the words may be different but the soul of the words is similar 'green logistics'.

In this paper, section 1 provides the introduction to the Green Global Logistics and section 2 provides the description of model and definition of the attributes which we have taken from the literature, section 3 provides application of analytical hierarchy process, section 4 grey relational analysis, section 5 provides discussion with future implications and finally section 6 provides the conclusion.

II. DESCRIPTION OF MODEL

This problem is formulated due to the demand of current scenario in logistics organizations, because the scenario has been changed from logistics to green logistics and then green logistics to green global logistics. Due to the competitive environment, every industry wants to globalize its firm and want to have a competitive advantage over others including green concepts in their goods and services. This problem is formulated based on literature survey. Literature helped us in defining 37 criterions. Out of 37 criterions 12 criterions were selected depending upon the requirement of the theme of the model. Then, these criterions were giving relative importance with the help of a group of experts. The definition of criterions and their references are discussed below.

Green Training (G.T):

As every organization spends on the training of their employees, there should be such strategy so that the training gives equal focus to enhance environmental consciousness of the employees. Denisa & Zdenka (2015) stated that enterprises are not interested in educating their employees in this field, which could, in our opinion, enable them to make the processes more effective [1].

Government Regulations (G.R):

For the environmental consciousness governmental rules, act or strategies should be imposed on the firms. Environmental acts of India should be followed, According to Section 2(a) of the Environmental Protection Act, 1986, 'Environment' includes

a) Water, air and land

b) The inter-relationship which exists among and between,

i) water, air, land, and

ii) human beings, other living creatures, plants, microorganisms and property [4].

Sathaye et.al. (2006) stated that pressure might be brought about in the form of government policies, litigation threats, or public perception to direct the consideration of firms toward sustainability [5].

Trade Barriers (T.B):

According to Bowersox and Closs (1996), while many forces facilitate borderless operations, some significant barriers continue to impede global logistics. Three barriers are significant: markets and competition, financial barriers, and distribution channels. Global logistics management must balance the cost of overcoming these barriers with the potential benefits of international trade to achieve the actual benefits of successful international operations [6].

Promotional Efforts (P.E):

Efforts towards achieving the goals, whether they are related to the economy or related to the sustainability should be promoted in order to increase enthusiasm of the related people. This is like giving honor to the deserving one. This strategy factor can act as a boost to the moral of personnel, which ultimately could help in improved effectiveness

Green Personnel (G.P):

Hire only those personnel that care about the environment and have an environment friendly mind set. Here green personnel indicate the attitude of employees within the organization. We should select such a strategy which emphasis on green personnel recruitment. As Denisa & Zdenka (2015) stated that If an organization wants to gain competitive advantage through green logistics he should have environmental conscious personnel furthermore, environmental conscious human resource [1].

Green Suppliers (G.S):

Here the term green suppliers means the suppliers should have very much concern about environment. Because it is the starting point of the logistics and has a high importance.

Reverse Logistics (R.L):

Reverse logistics is the process and management of flow of material from destination point for the reuse or the proper disposal. It is very necessary for green logistics and sometimes confused with it. The Fig.1 given below will clear the confusion between similitudes also contrast of reverse and green logistics [3].

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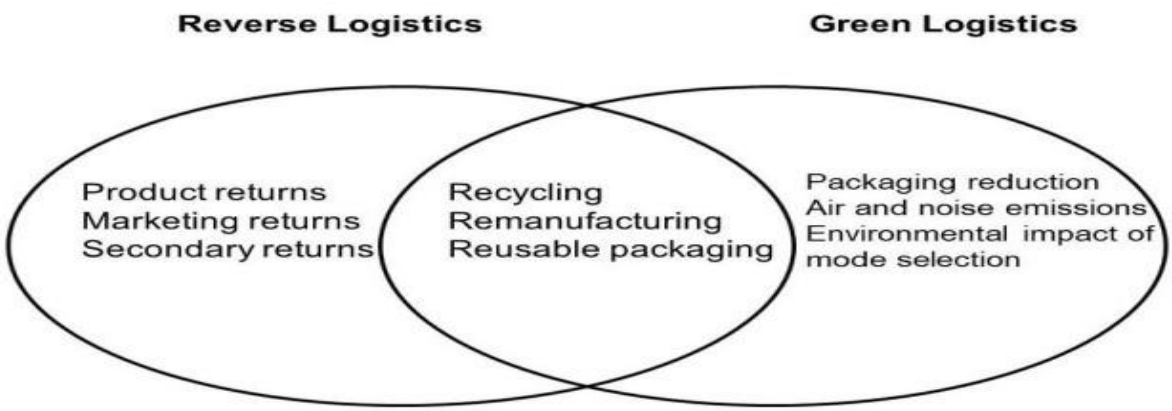

Figure 1 reverse logistics and green logistics. (Source: Stolka, 2014)

According to Wu and Dunn (1995) it is related to "a logistics system responsible for the environment, which not only includes forward logistics process from the acquisition of raw materials, production, packaging, transport, storage, to the delivery to end-users' hands, but also includes the reverse logistics dealing with waste recycling and disposal" [7]

Logistics Network (L.N):

According to the situations a logistics provider may be required to redesign logistics to enhance the effectiveness and productivity of the supply chain. Wu and Dunn (1995) states that besides technological innovation appropriate environmental sustainability strategies like adoption of IT tools and redesign of logistics is of utmost importance [7].

Vehicle Routing (V.R):

Vehicle routing is the process of finding best and shortest possible routes for the vehicles to reach from source to the destinations. Sbihi (2007) states vehicle routing models represent an approach which should indirectly produce less pollution because vehicles will tend to be directed away from congestion [8].

Decentralized Warehousing (D.W):

This system of warehousing although increases the administrative cost but is helpful for adding sustainability by reducing the total distance travelled by the vehicles. Cooper (1991) states that the only way to structurally reduce the emissions caused by one company is to decentralize warehousing and use fewer and larger transports [9].

Environmental Audits (E.A):

Environmental audit is a general term that can reflect various types of evaluations intended to identify environmental compliance and management system implementation gaps, along with related corrective actions. There are generally two different types of environmental audits: compliance audits and management systems audits. Environmental audit by SAI India is conducted within the broad framework of compliance and performance audit [10] Viegas et.al.(2013) stated Monitoring and auditing are regarded as essential activities for process control and follow up, which contribute to improving performance in organizations and provide a key role in preventing or reducing environmental harm [11].

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There should be a periodic inspection of the companies by the environmental regulating agencies, auditing whether these companies are complying with environmental regulation or not.

Improved Technology (I.T):

Rising prices of fuels are becoming the reason for the improved technology consideration, and this is automatically giving benefit to the environment and society. Improved technology may be very helpful in sustainability for example more fuel efficient truck or large Lorries, aerodynamic design of vehicles etc (Sashayed et al., 2006).

3. Application of Analytic Hierarchy Process (AHP)

In this problem we are using AHP process for weight calculation of all the attributes. We will use all the steps as discussed below

Step 1 Hierarchy model of the problem is constructed as shown in Fig. 2.

Step 2 Pair-wise comparison matrix is formed as green training (G.T) is equally important to green training and green training is 0.333 times important to government regulations (G.R), complete comparison is shown in Table 1.

Step 3 Column sum of each column is represented in last row of Table 1, obtained by using eq. (1),

$$\text{column sum} = \sum_{i=1}^{m} C_{ij}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

C_{ij}, is the element of Pair-wise Comparison Matrix. Here, for first column of Table 1

Column Sum=1+3+3+1+3+1+7.003+7.003+5+5+3+3=42.007

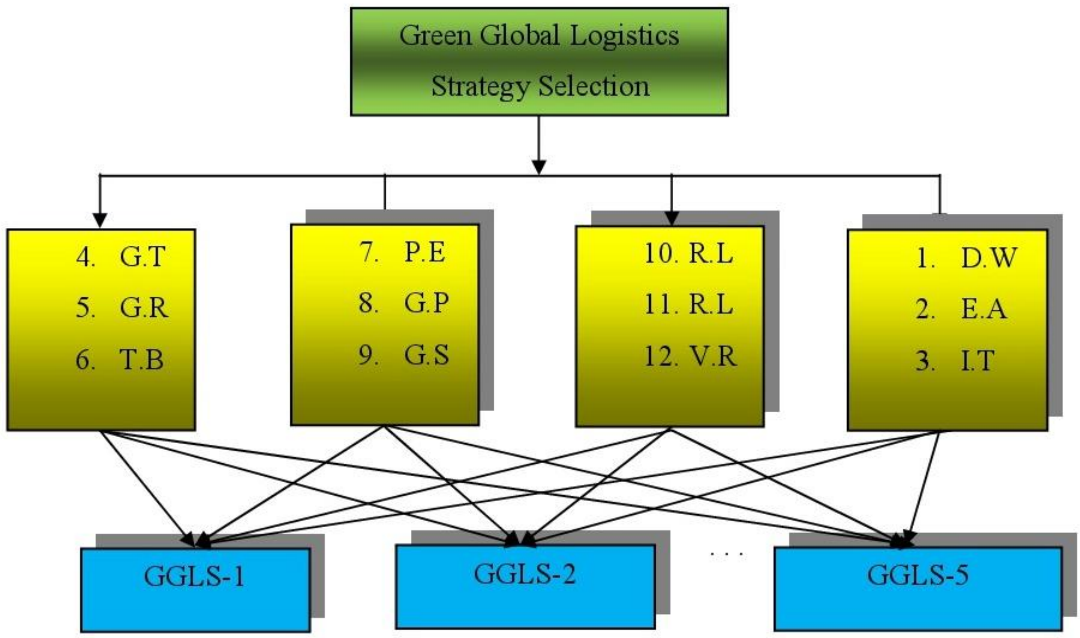

Figure 2 hierarchical model of green global logistics strategy selection

Step 4 Normalized matrix is formed by dividing each element of the pair-wise comparison matrix with its corresponding column sum, using eq. (2)

$$N_{ij} = \frac{C_{ij}}{\sum_{i=1}^{m} C_{ij}}, \quad \ldots \ldots \ldots (2)$$

Where N_{ij} is the element of normalized matrix, as shown in Table 2.for example

N_{11}= 1/42.007 = 0.024

Step 5 Weights are calculated taking the average of rows, using the eq. (3),

$$W_{ij} = \frac{\sum_{j=1}^{m} N_{ij}}{m}, \ldots \ldots \ldots (3)$$

Here for first row it is

First Row Sum = 0.024+0.008+0.028+0.021+0.020+0.024+0.025+0.025+0.018+0.019+0.011+0.030=0.253

And average will be 0.253/12= 0.021.

Corresponding values are as given in Table 2

Step 6 Consistency Analysis should be done after calculating weights. For this purpose pair-wise comparison matrix is multiplied by the weight matrix to get weighted vector, using the eq. (4),

$$\begin{bmatrix} C_{11} & \cdots & C_{1m} \\ \vdots & \ddots & \vdots \\ C_{mj} & \cdots & C_{mm} \end{bmatrix} * \begin{bmatrix} W_{11} \\ W_{i1} \\ W_{m1} \end{bmatrix} = \begin{bmatrix} v_{11} \\ v_{i1} \\ v_{m1} \end{bmatrix}, \ldots \ldots \ldots (4)$$

As for first row of pair-wise comparison matrix and weighted vector the calculation is

(1.000*0.021) + (0.333*0.026) + (0.333*0.107) + (1.000*0.019) + (0.333*0.074) + (1.000*0.025) + (0.143*0.168) + (0.143*0.168) + (0.200*0.111) + (0.200*0.102) + (0.333*0.046) + (0.333*0.133) = 0.285.

Corresponding values are given in Table 2.

Step 7 After that consistency vector is calculated using the eq. (5),

$$C_{v_{i1}} = \frac{1}{W_{i1}} [v_{i1}], \; for \; i = 1,2,3 \ldots \ldots m. \quad \ldots \ldots \ldots (5)$$

As first consistent vector is 0.285/0.021= 13.495, values are given in Table 2.

Step 8 Value of λ_{max} is calculated using eq. (6).

$$\lambda_{max} = \frac{\sum_{i=1}^{m} C_{v_{i1}}}{m}, \quad \ldots \ldots \ldots (6)$$

And value is obtained as $\lambda_{max} = \frac{13.495+12.526+13.140+13.168+13.455+12.941+13.777+13.777+13.525+13.073+12.906+13.896}{12} = 13.307.$

Step 9 consistency Index is calculated using eq. (7)

$$CI = \frac{\lambda_{max} - m}{m-1}, \quad \ldots \ldots \ldots (7)$$

And here $CI = \frac{13.307-12}{11} = 0.019.$

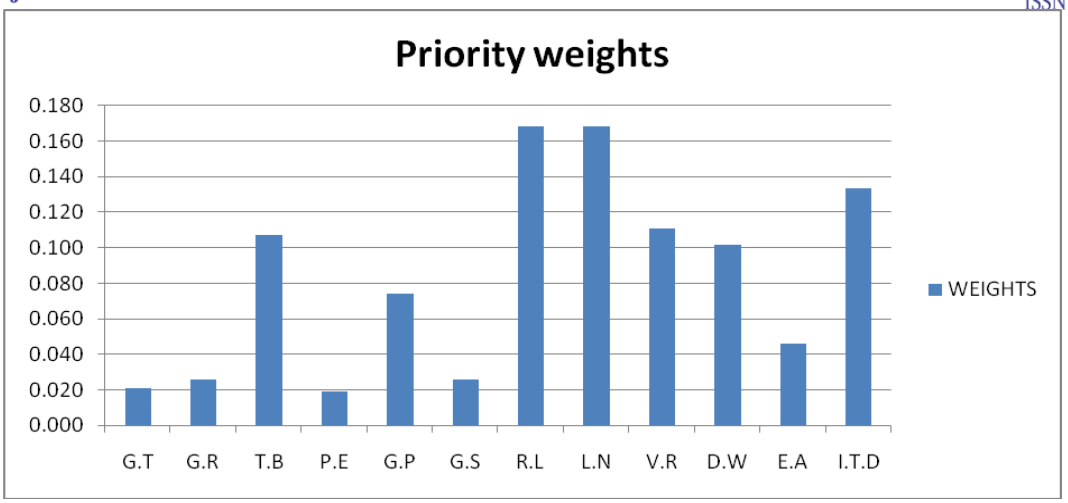

Figure 3 priorities of attributes

Step 10 Consistency ratio is obtained by $C.R = \frac{C.I}{R.I} = \frac{0.119}{1.48} = 0.080$, which is less than 0.1 hence the results are consistent. The value of R.I is taken from Satty's table for random index. Here we are showing the priorities of attributes.

From the above Fig. 3, it is clear that Logistics Network (L.N) and Reverse Logistics (R.L) are given highest priority followed by Improved Technology(I.T), Vehicle Routing(V.R) Trade Barriers (T.B), Decentralized Warehousing (D.W), Green Personnel (G.P), Environmental Audits (E.A), Green Supplier (G.S), Government Regulations (G.R), Green Training (G.T) and Promotion of Efforts (P.E) respectively. Now, these weights will be used for the analysis of green global logistics strategy selection problem.

Table 1 Pair-wise Comparison Matrix

CRITERIA	G.T	G.R	T.B	P.E	G.P	G.S	R.L	L.N	V.R	D.W	E.A	I.T.D
G.T	1.000	0.333	0.333	1.000	0.333	1.000	0.143	0.143	0.200	0.200	0.333	0.333
G.R	3.000	1.000	0.200	1.000	0.200	1.000	0.200	0.200	0.200	0.333	0.200	0.143
T.B	3.000	5.000	1.000	5.000	3.000	3.000	1.000	1.000	1.000	1.000	3.000	0.200
P.E	1.000	1.000	0.200	1.000	0.200	0.333	0.143	0.143	0.333	0.200	0.333	0.143
G.P	3.000	5.000	0.333	5.000	1.000	3.000	0.333	0.333	0.333	1.000	3.000	1.000
G.S	1.000	1.000	0.333	3.000	0.333	1.000	0.143	0.143	0.333	0.200	0.333	0.143
R.L	7.003	5.000	1.000	7.003	3.000	7.003	1.000	1.000	3.000	1.000	5.000	3.000
L.N	7.003	5.000	1.000	7.003	3.000	7.003	1.000	1.000	3.000	1.000	5.000	3.000
V.R	5.000	5.000	1.000	3.000	3.000	3.000	0.333	0.333	1.000	3.000	3.000	1.000
D.W	5.000	3.000	1.000	5.000	1.000	5.000	1.000	1.000	0.333	1.000	3.000	1.000
E.A	3.000	5.000	0.333	3.000	0.333	3.000	0.200	0.200	0.333	0.333	1.000	0.200
I.T.D	3.000	7.003	5.000	7.003	1.000	7.003	0.333	0.333	1.000	1.000	5.000	1.000
Column sum	42.007	43.336	11.733	48.009	16.401	41.342	5.828	5.828	1.067	10.267	29.200	11.162

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4. Application of Grey Relational Analysis

Now application of Grey relation analysis will be made to decide the priority of green global logistics strategies. For this purpose we will forward our analysis step by step. Decision matrix is shown in Table 3. As we can see from the table it is not necessary to normalize the decision matrix because all the entries are from 1 to 9, still for the clarity of the analysis we are normalizing the decision matrix [13&14]. Steps are as follows:

Step 1 Normalize the decision matrix, here all the attributes are benefit attributes. So, we will use eq. (8) only. For

$$For\ larger\ the\ better\ attribute, N_{ij} \frac{D_{ij} - min\,(D_{ij}, i=1,2,3,\dots m)}{max\,(D_{ij}, i=1,2,3,\dots m) - min\,(D_{ij}, i=1,2,3,\dots m)}, \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (8)$$

e.g. N_{11}= (8-6)/(8-2) = 1. Normalized values are given in Table 3.

Step 2 Reference value is taken as 1 shown in Table 4.

Step 3 Grey relational coefficient is calculated using eq. (10),

Table 2 Normalized Matrix, Weights, Weighted sum vector (W.S.V), Consistency Vector (C.V)

CRITERIA	G.T	G.R	T.B	P.E	G.P	G.S	R.L	L.N	V.R	D.W	E.A	I.T.D
G.T	0.024	0.008	0.028	0.021	0.020	0.024	0.025	0.025	0.018	0.019	0.011	0.030
G.R	0.071	0.023	0.017	0.021	0.012	0.024	0.034	0.034	0.018	0.032	0.007	0.013
T.B	0.071	0.115	0.085	0.104	0.183	0.073	0.172	0.172	0.090	0.097	0.103	0.018
P.E	0.024	0.023	0.017	0.021	0.012	0.008	0.025	0.025	0.030	0.019	0.011	0.013
G.P	0.071	0.115	0.028	0.104	0.061	0.073	0.057	0.057	0.030	0.097	0.103	0.090
G.S	0.024	0.023	0.028	0.062	0.020	0.024	0.025	0.025	0.030	0.019	0.011	0.013
R.L	0.167	0.115	0.085	0.146	0.183	0.169	0.172	0.172	0.271	0.097	0.171	0.269
L.N	0.167	0.115	0.085	0.146	0.183	0.169	0.172	0.172	0.271	0.097	0.171	0.269
V.R	0.119	0.115	0.085	0.062	0.183	0.073	0.057	0.057	0.090	0.292	0.103	0.090
D.W	0.119	0.069	0.085	0.104	0.061	0.121	0.172	0.172	0.030	0.097	0.103	0.090
E.A	0.071	0.115	0.028	0.062	0.020	0.073	0.034	0.034	0.030	0.032	0.034	0.018
I.T.D	0.071	0.162	0.426	0.146	0.061	0.169	0.057	0.057	0.090	0.097	0.171	0.090
Sum of Rows	0.253	0.308	1.283	0.228	0.887	0.305	2.017	2.017	1.327	1.223	0.554	1.598
Weight's	0.021	0.026	0.107	0.019	0.074	0.025	0.168	0.168	0.111	0.102	0.046	0.133
W.S.V	0.285	0.321	1.405	0.250	0.995	0.329	2.316	2.316	1.496	1.332	0.596	1.851
C.V	13.495	12.526	13.140	13.168	13.455	12.941	13.777	13.777	13.525	13.073	12.906	13.896

$$C(N_{0j}, N_{ij}) = \frac{\nabla_{min} + \rho\nabla_{max}}{\nabla_{ij} + \rho\nabla_{max}}, \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (9)$$

Where,

$\nabla_{ij} = |N_{0j} - N_{ij}|, \nabla_{min} = MIN(\nabla_{ij}, i = 1,2,3,\dots m, j = 1,2,3,\dots n), \nabla_{max} = MAX(\nabla_{ij}, i = 1,2,3,\dots m, j = 1,2,3,\dots n).$

This is used to show the closeness between the reference sequence and the actual normalized value. Higher value of this coefficient denotes the more closeness to the reference. ρ (Distinguishing coefficient), lies in the range zero to one (0-1).

For e.g. C_{11}= (0+0.5*1)/(0+0.5*1), and the value are shown in Table 6. ∇_{ij}, the difference between reference and the actual value is shown in Table 5. As $\nabla_{11} = 1 - 1 = 0.$ and ρ is taken as 0.5.

Step 4 Grey relational Grade is calculated using eq. (11), weight values are given in Table 2 & Table 6.

$$G(x_0, x_i) = \sum_{j=1}^{n} w_j \, C(x_{0j}, x_{ij})$$ For

$i = 1,2,3,\dots m,$ ……. (10)

w_j is the weight for attributes, $j = 1,2,3,\dots n.$ and moreover $\sum_{j=1}^{n} w_j = 1.$

It is actually the multiplication of Grey relation coefficient matrix and weight vector. Grade calculation for first alternative is as

(1.000*0.021) + (1.000*0.026) + (0.429*0.107) + (1.000*0.019) + (0.500*0.074) + (0.429*0.025) + (0.400*0.168) + (0.333*0.168) + (1.000*0.111) + (0.333*0.102) + (0.333*0.046) + (1.000*0.133) = 0.576,

Higher the Grade higher will be the priority to the alternative. As shown in Table 7. Here, after the application of GRA, we got the priorities order GGLS3>GGLS5>GGLS1>GGLS2>GGLS4. Now, to look at the robustness of pair-wise comparison, we will apply sensitivity analysis.

4.1 Sensitivity Analysis

We can change the weight of each criterion; we are here representing sensitivity analysis giving equal weight to all the criteria's. That means 1/12 = 0.083 to each criterion. Result shows that GGLS1 remains at first priority, but for other rank reversal occur. Results are shown in Fig. 3.

Table 3 Decision matrix for Green Global Logistics Strategy Selection

	Attributes/criterions											
Alternatives	**G.T**	**G.R**	**T.B**	**P.E**	**G.P**	**G.S**	**R.L**	**L.N**	**V.R**	**D.W**	**E.A**	**I.T.D**
GGLS1	8.000	8.000	7.000	9.000	8.000	6.000	6.000	6.000	9.000	5.000	8.000	9.000
GGLS2	8.000	7.000	6.000	9.000	7.000	8.000	5.000	8.000	5.000	6.000	9.000	9.000
GGLS3	6.000	5.000	8.000	7.000	8.000	6.000	9.000	9.000	7.000	9.000	9.000	9.000
GGLS4	7.000	5.000	7.000	8.000	9.000	5.000	5.000	9.000	5.000	7.000	8.000	7.000
GGLS5	6.000	7.000	9.000	5.000	8.000	6.000	8.000	7.000	8.000	8.000	8.000	9.000
MAX-MIN	2.000	3.000	3.000	4.000	2.000	3.000	4.000	3.000	4.000	4.000	1.000	2.000
MIN	6.000	5.000	6.000	5.000	7.000	5.000	5.000	6.000	5.000	5.000	8.000	7.000

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Table 4 Grey Relational Generating

	Attributes/criterions											
Alternatives	**G.T**	**G.R**	**T.B**	**P.E**	**G.P**	**G.S**	**R.L**	**L.N**	**V.R**	**D.W**	**E.A**	**I.T.D**
GGLS1	1.000	1.000	0.333	1.000	0.500	0.333	0.250	0.000	1.000	0.000	0.000	1.000
GGLS2	1.000	0.667	0.000	1.000	0.000	1.000	0.000	0.667	0.000	0.250	1.000	1.000
GGLS3	0.000	0.000	0.667	0.500	0.500	0.333	1.000	1.000	0.500	1.000	1.000	1.000
GGLS4	0.500	0.000	0.333	0.750	1.000	0.000	0.000	1.000	0.000	0.500	0.000	0.000
GGLS5	0.000	0.667	1.000	0.000	0.500	0.333	0.750	0.333	0.750	0.750	0.000	1.000
reference	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
∇_{min}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
∇_{max}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ρ	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500

Table 5 Table for ∇ij

	Attributes/criterions											
Alternatives	**G.T**	**G.R**	**T.B**	**P.E**	**G.P**	**G.S**	**R.L**	**L.N**	**V.R**	**D.W**	**E.A**	**I.T.D**
GGLS1	0.000	0.000	0.667	0.000	0.500	0.667	0.750	1.000	0.000	1.000	1.000	0.000
GGLS2	0.000	0.333	1.000	0.000	1.000	0.000	1.000	0.333	1.000	0.750	0.000	0.000
GGLS3	1.000	1.000	0.333	0.500	0.500	0.667	0.000	0.000	0.500	0.000	0.000	0.000
GGLS4	0.500	1.000	0.667	0.250	0.000	1.000	1.000	0.000	1.000	0.500	1.000	1.000
GGLS5	1.000	0.333	0.000	1.000	0.500	0.667	0.250	0.667	0.250	0.250	1.000	0.000

Table 6 Grey Relational Coefficients

	Attributes/criterions											
Alternatives	**G.T**	**G.R**	**T.B**	**P.E**	**G.P**	**G.S**	**R.L**	**L.N**	**V.R**	**D.W**	**E.A**	**I.T.D**
GGLS1	1.000	1.000	0.429	1.000	0.500	0.429	0.400	0.333	1.000	0.333	0.333	1.000
GGLS2	1.000	0.600	0.333	1.000	0.333	1.000	0.333	0.600	0.333	0.400	1.000	1.000
GGLS3	0.333	0.333	0.600	0.500	0.500	0.429	1.000	1.000	0.500	1.000	1.000	1.000
GGLS4	0.500	0.333	0.429	0.667	1.000	0.333	0.333	1.000	0.333	0.500	0.333	0.333
GGLS5	0.333	0.600	1.000	0.333	0.500	0.429	0.667	0.429	0.667	0.667	0.333	1.000
WEIGHTS	0.021	0.026	0.107	0.019	0.074	0.025	0.168	0.168	0.111	0.102	0.046	0.133

Table 7 Grey Relational Grade and Priorities

Alternatives	**Grey Relational Grade**	**Priorities**
GGLS1	0.576	3
GGLS2	0.555	4
GGLS3	0.810	1
GGLS4	0.532	5
GGLS5	0.658	2

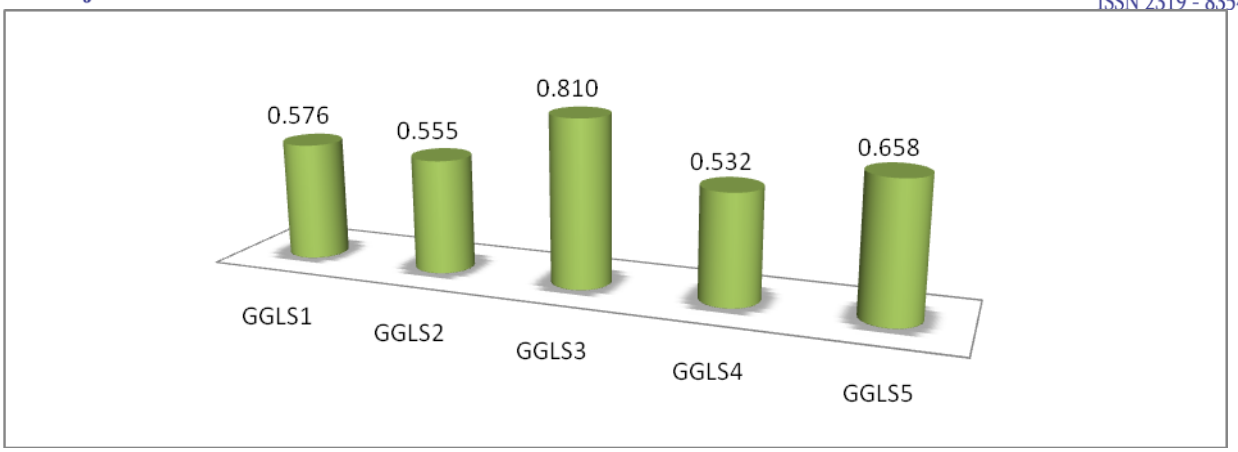
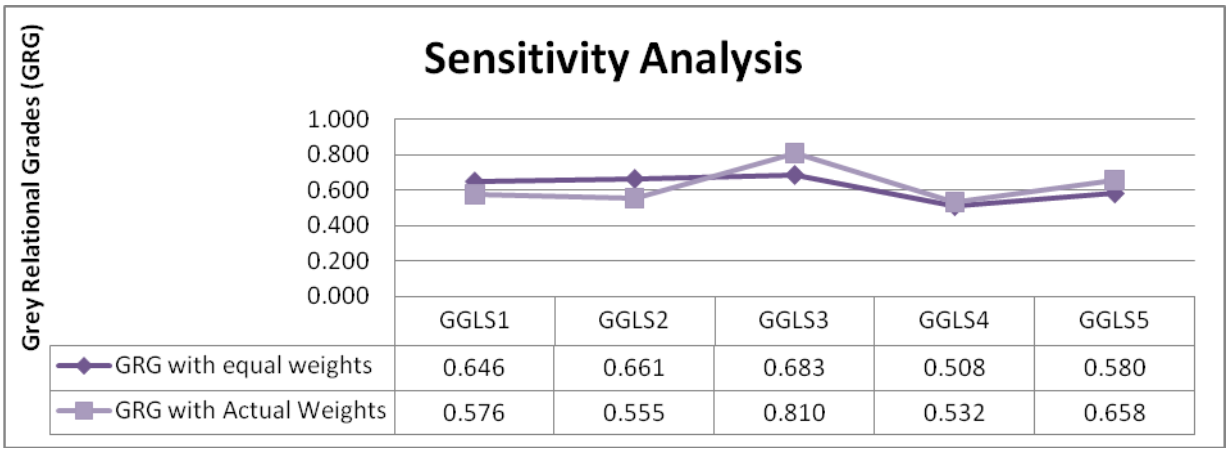


Figure 4 grey relational grades



	GGLS1	GGLS2	GGLS3	GGLS4	GGLS5
GRG with equal weights	0.646	0.661	0.683	0.508	0.580
GRG with Actual Weights	0.576	0.555	0.810	0.532	0.658

Figure 5 sensitivity analysis

5. Discussion

So far, we have calculated priorities of the criterions/attributes, in which we found Reverse Logistics (R.L) and Logistics Network (R.L.N) were came out to be at the same priority level, as results are shown in Fig. 3. Furthermore, Improved Technology (I.T) came out to be next to them followed by Vehicle Routing (V.R.), Trade Barriers (T.B), Decentralized Warehousing (D.W), Green Personnel (G.P), Environmental Audits (E.A), Government Regulations (G.R), Green Supplier (G.S), Green Training (G.T), and Promotional Efforts (P.E) respectively. That means three attributes R.L., R.L.N. and I.T could play a very important role for the selection of a Green Global Logistics Strategy Selection. Furthermore, we have taken five Strategies given random importance to them. There is no empirical data for the strategy selection but there is a framework, which gives an understanding of how to frame this kind of situation. This framework can be used by any researcher, industrialist, or auditor in future.

We have seen that our consistency ratio is 0.080 which is less than 1 but is very close to one which indicates that the priorities are quite sensitive. Also, sensitive analysis favors the perception, on changing the weights rank reversal occurs except for the first priority. A further improvement could be made to make the framework more robust.

There is a paradox in MCDM analysis that we can hardly say which method is giving the best result [15], but recent concept of "Roll-on Roll-off" by Indian Railways, which is a live example of redesign of logistic network. It gives us a feeling that our research is going into a right direction. Furthermore, Vehicle Scrapping Policy by Government of India has said that it can generate steel scrap worth Rs. 11,500 crore every year, which is a live example of Reverse logistics and it support our results. Also improved technology and design of trucks is always being in top support, but due to high initial investment it is ignored sometimes. However, the implement of these concepts may increase the cost of the goods and services, but it should be promoted for the betterment of the environment and the society.

6. Concluding Remarks

In this paper, we hybridized two MCDM methodologies, AHP for weight calculation and GRA to select best alternative out of five alternatives. The model we have formulated is simple and easy to understand. We used AHP which could fail to show interdependencies among different criterions; in that case we can use Analytical Network Process, a modified and improved form of AHP. Also, if the number of criterions increases it becomes typical for AHP to obtain accepted preference. This model can be used for auditing the performance of any logistic network. According to time, more criterions can be analyzed and to compensate the uncertainty of the data use of grey numbers or triangular fuzzy numbers is suggested. In case of same data values of any attribute for all alternatives this model will not work due to the algorithm of GRA. In that case use of Technique for order preference by similarity to ideal solution (TOPSIS) or Graph theory and Matrix Approach (GTMA) is suggested.

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