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Model to optimize the quantities of delivery products prioritizing the sustainability performance

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***Abstract* - Many manufacturers and retailers often outsource their logistics functions to Logistics Service Providers (LSPs) to focus more on their core business process. Due to the competitiveness and the popularity of the sustainability concept, those organizations evaluate their prospective LSPs not only based on economic aspects like cost, service quality but also on social and environmental aspects as well when selecting LSPs. This paper proposes a methodology that can be used by organizations when evaluating and selecting LSPs based on their sustainability performance. Analytic Network Process (ANP) is used in evaluating the LSPs' sustainable performance since multiple dimensions and indicators need to be incorporated when measuring the sustainability performance. A Linear Programming Problem (LPP) model was proposed which allows the organizations to decide both desired number of LSPs and the volume to be allocated for those selected LSPs. The proposed methodology is flexible as it depends on the sustainability requirements of the organization when selecting LSPs. Both the indicators and their relative importance are up to the organization to decide.**

Keywords - analytic network process, linear programming problem, logistics service providers, sustainability, sustainability indicators

I. INTRODUCTION

Logistics Service Providers (LSPs) which are also called 'Contract Logistics', 'Third-Part Logistics', 'Logistics Alliances', and 'Logistics Outsourcing' are firms that provide logistics services that are often integrated or bundled together for use by customers [1]. The role of LSPs has changed over time from providing transportation services to a wide range of services including warehousing, inventory management, freight forwarding, cross-docking, technology management, etc. At present many manufacturers and retailers often outsource their logistics functions to LSPs as they want to focus more on their core business processes.

Today business organizations are more towards sustainability and sustainable development and focus on making themselves and their supply chain partners economically, socially, and environmentally sustainable. Due to the competitiveness and the popularity of the sustainability concept, those organizations evaluate their prospective LSPs not only based on economic performance like cost, service quality but also on social and environmental performance as well. Although there are studies on one or two dimensions of sustainability performance (Economic and Environmental to be precise), the studies which incorporate social dimension are still lagging [2]. Relatively few studies done on the environmental sustainability of the LSPs [3] and often sustainability dimensions are addressed in isolation [4].

The objective of this paper is to propose a methodology that can be used by organizations when evaluating their LSPs based on their sustainability performance and select the most suitable LSPs as the logistics partners. The proposed methodology is flexible as it depends on the sustainability requirements of a particular organization when selecting LSPs. Both the indicators and their relative importance are up to the organization or the decision-maker to decide.

A. Justification of the research

Many manufacturers and retailers often outsource their logistics functions to LSPs. The Sri Lankan logistics services sector has developed throughout the past few decades providing their customers a satisfactory service. The competitiveness has increased which resulted in LSPs becoming more integrated with their customers. And the research has found that the usage of logistics services will increase to a large extent in the near future. The competitiveness between the Sri Lankan LSPs has increased which has resulted in them being more integrated with customers [5].

LSPs are mainly dependent on both transport vehicles and employees, managing them from the viewpoint of social sustainability as well as from environmental sustainability has become a crucial issue [6],[7]. Selecting the best LSP for an organization is a crucial step. According to Pareto Analysis, [8] commonly used criteria when selecting a LSP are cost, relationship, services, quality, information systems, flexibility, and delivery. But with the popularity of the topic of sustainable development, organizations are now focusing on environmental and social criteria as well.

In general, the research focused on the evaluation of all three dimensions of sustainability are rare to find. Although many studies have been done on the areas of logistics outsourcing and logistics strategies, but relatively few studies on environmental sustainability. The majority of the studies measure the sustainability performance of the upstream supply chain and studies on the sustainability performance of LSPs are minimal [2].

Both quantitative and quantitative approaches have been used in evaluating and measuring sustainability performance. Mathematical models are used under the quantitative approach [9]. Widely used qualitative approaches are AHP, ANP, Fuzzy Set Approach, Balance Score Card, and DEA [2].

There is a need to develop research aimed at identifying standard metrics to measure LSP's environmental performance [3], [7].

B. Objectives of the research

RO1: To identify the sustainability performance measures/indicators/criteria in LSPs

RO2: To develop a methodology to evaluate the sustainability performance of LSPs

RO3: To develop an LPP model to select the most suitable LSPs based on sustainability performance and other constraints.

II. Literature Review

A. Sustainability and LSPs

The economic dimension of sustainability is the aspect that is often evaluated in an organization. Studies that focus on measuring the performance of supply chains or LSPs traditionally have focused on economic aspects of it with cost minimization (Profit maximization) and service level maximization [10]. The study of [11], in their framework, covers the economic performance evaluation in five fields: Reliability, Responsiveness, Flexibility, Finance, and Quality. These five fields are further categorized into subfields with an extensive review of the literature. Further, this study highlights that the 'Finance' field was the field that was analyzed often.

From the business and management perspective, the environmental dimension of the sustainability concept involves all activities and decisions needed to minimize environmental pollution caused by an organization. In the logistics sector, the environmental concern has become a buzz topic due to many factors. Logistics and transport activities are the 2nd biggest contributor to GHSs (Greenhouse Gases) after electricity production. Demand for moving and delivering goods has grown exponentially in recent years and is expected to grow in the coming years which in turn will increase the demand for logistics services. Recent economic crisis and global warming have urged for more environmentally sustainable logistics services [12].

There are relatively few studies done on environmental sustainability in the logistics service industry. [12] in its descriptive analysis of literature has identified that there is a need to develop research aimed at identifying standard metrics to be used to measure green 3PL's environmental performance. And it suggests that future research should be aimed at developing frameworks and applications that may quantify 3PL's environmental commitment and its impact on finance and operational performance. Further the analysis suggests that future research should better evaluate the efficiency of green measures by using alternative performance indicators as well.

Using an extensive review of the literature [13] identified that Triple Bottom Line (TBL) and Global Reporting Initiatives (GRI) applications are the two main frameworks in measuring logistics environmental sustainability. [13] propose a set of environmental indicators for city logistics using the GRI framework as the evaluation basis. The proposed set of indicators falls under five categories: Energy, transport and infrastructure, noise, congestion, and emissions, effluents, and waste.

Social sustainability of LSPs means to operate its services considering their impact on internal and external stakeholders (i.e., society and employees) in terms of welfare, safety, and wellness. [11] includes the social dimension of sustainability to its analytical assessment model with five (5) five social fields/categories: Work conditions, human rights, social commitment, customer issues, best practices. Further, the research categorizes the five fields into subfields/categories as well. The proposed composite index by [14] also includes the social dimension. The taken social performance measures are corruption risk and sourcing from local suppliers.

By using an extensive literature review [6] selected frequently adopted sustainability criteria with the help of industry experts. The study proposes price, service, and social sustainability as main criteria. Social sustainability criteria are sub-categorized into philanthropy and average salary which are quantitative measures and management policy which is a qualitative measure. Management policy is further categorized into organizational learning/training process or programs, human rights and participation, occupational health and safety, and vehicle safety.

Although the definition of sustainability consists of three dimensions and the need for such research papers is high, sustainability dimensions are addressed in isolation and quantified indicators for a social dimension are underdeveloped. [4] mentions the challenges when conducting sustainability logistics services including a wide range of sustainability indicators, measuring and quantifying the indicators – Especially social dimension indicators, integrating sustainability dimensions, trade-offs between the dimensions, influence from the stakeholders, time perspective, and contextual considerations.

B. Sustainability performance management and evaluation

To be more competitive, organizations need to measure and manage their supply chain sustainability effectively and efficiently. Through measuring and evaluating sustainability performance organizations can identify the gaps and areas to be improved for further development. Many research studies have proposed metrics and frameworks to measure sustainable supply chain performance.

Sustainability performance management approaches include environmental management standards like ISO 14001, international Reporting Standards (Global Reporting Incentive - GRI), SCOR framework, Life Cycle Assessment, Multi-Criteria Decision Making (MCDM) tools (AHP, ANP, DEA, etc.), Rough Set Theory, Fuzzy Set approach, Composite indicators, and conceptual frameworks. Industry-specific studies are sparsely present in the literature. The majority of the studies are focused on developing general frameworks to access supply chain sustainability. Even Though there are studies with all three dimensions of sustainability, still the social dimension is lagging. Math-focused methods and tools used to measure sustainability are exponentially increasing. The majority of the studies focused on measuring the sustainability performance between suppliers and manufacturers [2].

Through an extensive analysis of literature [15] has found out that traditional research has focused on measuring supply chain performance in terms of cost, quality, speed, flexibility, and reliability refers to the economic dimensions of sustainability. Further, the analysis has found out that in the last decade a considerable amount of research was based on green supply chains or green logistics referring to environmental sustainability. But little research has shown the social dimension performance of supply chains. It also highlights the importance of developing research models and frameworks that are country and industry-specific as the sustainability dimension impacts are context-dependent and technology-related.

[16] proposes a framework for environmental sustainability assessment by analyzing the literature which consists of seven macro-areas and these seven macro areas are divided into two as inter-organizational and intra-organizational environmental practices. Distribution strategies and transport execution, warehousing and green building, reverse logistics, packaging management, and internal management belong to the intra-organizational practices in the context of the logistics industry while collaborating with customers and external collaborations belong to inter-organizational environmental practices. A study found that LSPs have adapted many sustainability initiatives related to distribution and transportation activities while initiatives related to internal management are less. Internal management initiatives include environmental compliance and auditing programs, environmental performance measuring and monitoring, use of green IT, promotion of environmental awareness among managers, incentives, and benefits for green behaviors, and development of formal environmental sustainability standards of the company. It also highlights the lack of standard methodology for measuring the environmental impact and the need of developing effective performance measurement systems. With the case study conducted, [16] found that the main driver for the environmental sustainability initiatives for LSPs is customers. The case study also revealed that government rules and regulations are also an important driver, but it is often considered as a barrier by the LSPs.

There are many tools to assess Supply Chain Management practices like Odette ENALOG, Efficient Consumer Response (ECR), Oliver Wight Class A Checklist for Business Excellence, and SCOR model. Among them, the most sustainability-oriented model is the SCOR model. The SCOR model has become more mature with GREENSCOR, but still, it lacks the integration of all three dimensions of sustainability.

[17] proposes the ASSC framework (Assessment of Sustainability in Supply Chains Framework) that allows qualitative and quantitative indicators to be employed in assessing environmental and social dimensions. It also allows the aggregation of relevant indicators into KPIs (Key Performance Indicators) with respect to specific aspects of sustainability. The proposed ASSC framework and the aggregation method are stable, but the content or the sustainability indicators used are adaptable which will be able to reflect the dynamics of sustainable development.

[6] has been using Analytical Hierarchy Process (AHP) for its sustainability performance evaluation framework due to its ease of use and applicability in real-world scenarios. For further preciseness fuzzy theory has been incorporated into the AHP to overcome the high degree of fuzziness and uncertainty of the answer.

TABLE I: SUMMARY OF THE SUSTAINABIITY DIMENSIONS AND THE RESPECTIVE MODELS USED IN THE LITERATURE REVIEW

Authors	Sustainability Dimension			Output
	Economic	**Environment**	**Social**	
[16]	—	√	—	Conceptual Model
[11]	√	√	√	Analytical Assessment Model
[10]	√	√	√	Multidimensional Model
[18]	√	√	√	Mathematical Model
[19]	√	√	√	Conceptual Model
[14]	√	√	√	Composite Index
[17]	√	√	√	Conceptual Model (ASSC Model)
[9]	√	√	√	Composite Index
[6]	√	—	√	Multi-Criteria Evaluation Model using Fuzzy AHP
[20]	√	√	—	Network Data Envelopment Analysis (NDEA) Model
[2]	√	√	√	Conceptual Model
[21]	√	√	√	3rd Party Logistics Green Logistics Model (3PL GIF) Index

The proposed framework was used to evaluate three 3PL providers of an e-commerce company. Also, the study has proved that by changing the relative position of the criteria/sub-criteria in the proposed framework, decision-makers can determine the effect of such a change. Although the results show that the proposed framework is a good and a viable alternative to evaluate the social sustainability of 3PL providers, the exclusion of the environmental dimension in the framework is a major drawback.

[21] proposes the Green Innovative framework, 3PL GIF (Third Party Logistics Green Innovative Framework) based on social, economic, and environmental indicators. 3PL GIF checks the implementation of the business policies in all three dimensions of sustainability and helps the LSPs by altering them to use quality standards, measure them and continuously improve them. 3PL GIF provides an easy comparison between organizations and helps to identify lacking fields. 3PL GIF compares the progress in sustainable development between organizations and can be applied to a logistics company of any size.

According to Table I past authors have used different combinations of sustainability dimensions in their studies and their outputs were of different models and methodologies.

III. METHODOLOGY

Sustainability performance indicators for LSPs under each dimension are identified with the literature review, Global Reporting Initiatives (GRI), and expert opinions. Analytic Network Process (ANP) has been used to create a model and give weights or priorities for each dimension/indicator and then the sub-dimensions or subindicators under each dimension and to rank the pool of LSPs available.

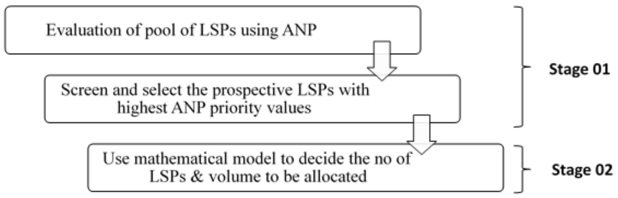

Fig. 1. Flow diagram of the methodology process

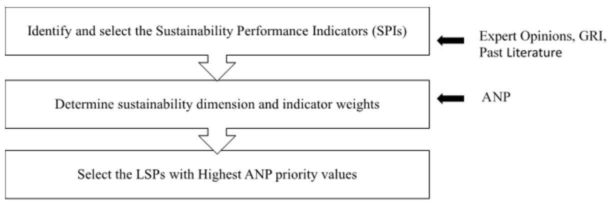

Fig. 2. Flow diagram of stage 1 of the methodology process

After getting the ranks of LPSs using ANP, the desired number of LSPs will be selected using a mathematical optimization model which was formulated as a Linear Programming Problem (LPP) with an objective of maximization of the volume allocated to LSPs with the highest rank while satisfying the constraints. Using the proposed LPP model, both the desired number of LSPs and the capacity to be allocated for those selected LSPs can be determined.

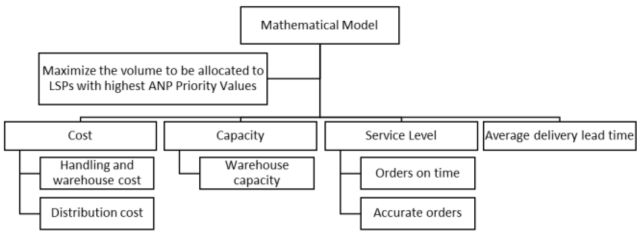

Fig. 3. Optimization Model Structure

C. *Evaluation of LSPs using ANP.*

As the initial step the sustainability performance indicators (sub-criteria) for LSP were identified with the help of literature review, Global Reporting Incentives (GRI), and expert opinions. Opinions on sustainability performance indicators were extracted from the logistics service industry experts through interviews (Table II). All three dimensions of sustainability were considered when selecting the indicators. Ten (10) industry experts from five leading 3PL service providers and a leading apparel manufacturing firm in Sri Lanka. The number and the types of indicators selected depend on the requirement of the organization which provides the flexibility for the proposed model.

The proposed methodology was applied to an apparel organization that uses multiple LSPs. Questionnaires were given to the logistics experts in the organization to determine the relative importance of four selected dimensions and sustainability performance indicators. By the results of the questionnaire, weights of the dimensions of sustainability and sustainability performance indicators were determined using ANP based pairwise comparison using "Super Decision" software.

Then using the data acquired, the execution of the mathematical model was done.

TABLE II. SELECTED SUSTAINABILITY PERFORMANCE INDICATORS WITH THEIR SOURCES

No.	Economic dimension	Environmental dimension	Social dimension
1.	E1 - Direct economic Values generated and distributed (GRI 201-1)	EN1 - Adhering to Environmental laws and regulations (GRI 307-1)	S1 - Number of incidents of corruption reported and investigated (GRI 205-1)
2.	E2 - Market Share (Oršič et al., 2019)	EN2 - Directing waste for reuse/recycle or other recovery operations (GRI 306-4)	S2 - Incorporation of minorities in the workforce (GRI 405-1)
3.	E3 - R&D Expenditure (Salvado et al., 2015)	EN3 - Controlling GHG emissions (GRI 305-5)	S3 - Incorporation of women in the workforce (GRI 405-1)
4.		EN4 - Directing wastewater for recycling/reuse or other recovery operations (GRI 303-3)	S4 - Investments in local community development programs (GRI 413)
5.		EN5 - Controlling energy consumption through conservation and efficiency initiatives (GRI 302-4)	S5 - No of accidents and work-related ill health reported (GRI 403-1)

Table II shows the indicators selected under each sustainability dimension along with the sources of selection.

D. *Development and Implementation of Mathematical Optimization Model*

Assumptions:

- LSPs have unlimited distribution capacity.
- Supply from the manufacturer and the demand by the DCs are equal for the calculating period.

TABLE III. NOTATIONS AND DEFINITIONS OF THE MATHEMATICAL MODEL

Notations	Definitions
Indices	
n	*number of product types*
m	*number of distribution centers*
l	*number of LSPs*

Input Variables	
C_k	*ANP priority value of LSPs*
R_{ik}	*if LSP k can distribute the product i, then R_{ik} is 1, otherwise 0*
P_i	*volume of the one unit of product i*
DC_{jk}	*total cost of delivery from LSP k to distribution centre j*
HC_k	*total cost of of handling at the LSP k*
FD_{jk}	*fixed cost of delivery from LSP k to distribution centre j*
FH_k	*fixed cost of handling LSP k*
VD_{ijk}	*variable cost of delivery of 1 CBM of product i from LSP k to distribution centre j*
VH_{ik}	*variable cost of handling 1 CBM of product i at LSP k*
L_k	*service level of LSP k*
Q_k	*average lead time of LSP k*
V_k	*LSP'k maximum capacity or volume*
D_{ij}	*demand or order qty for product i by the distribution centre j*
W_i	*supply quantity of product i*
B	*available budget for logistics outsourcing*
N	*desired no. of LSPs to have by the manufacturer*
Decision Variables	
X_{ik}	*delivery qty of product i from manufacturer to the LSP k*
Y_{ijk}	*delivery qty of product i from LSP k to distribution centre j*
Z_k	*if LSP k is considered, then Z_k is 1, otherwise 0*

Objective Function

$$Maximize \sum_{k=1}^{l}\sum_{i=1}^{n} C_k * Z_k * L_k * Q_k * X_{ik}$$

Constraints

$$\sum_{k=1}^{l} X_{ik} \leq W_i \qquad for\ i = 1 \dots .. n \tag{1}$$

$$\sum_{i=1}^{n}\sum_{j=1}^{m}(Y_{ijk} * R_{ik}) = D_{ij} \qquad for\ j = 1 \dots \dots m, i = 1 \dots .. n \tag{2}$$

$$\sum_{i=1}^{n}(P_i * X_{ik}) * Z_k \leq V_k \qquad for\ k = 1 \dots .. l \tag{3}$$

$$DC_{jk} = FD_{jk} + \sum_{i=1}^{n} VD_{ijk} * Y_{ijk} * P_i \quad for\ k = 1 \dots . l, \quad j = 1 \dots .. m \tag{4}$$

$$HC_k = FH_k + \sum_{i=1}^{n} VH_{ik} * X_{ik} * P_i \qquad for\ k = 1 \dots . l \tag{5}$$

$$\sum_{k=1}^{l}\sum_{i=1}^{n} DC_{jk} + \sum_{k=1}^{l} HC_k \leq B \tag{6}$$

$$X_{ik} \geq \sum_{j=1}^{m} Y_{ijk} \qquad for\ k = 1 \dots l, for\ i = 1 \dots n \tag{7}$$

$$\sum_{k=1}^{N} Z_k \leq N \tag{8}$$

$$Z_k \in \{1,0\} \quad for\ k = 1 \dots l \tag{9}$$

Defining the constraints:

1. All the units of product i allocated to LSPs should be less than or equal to the manufacturers production capacity of that product i.
2. All the products distributed/ delivered to the distribution centers by the LSPs should be more than or equal to the demand from each distribution center and if LSP k can distribute the product I, then R_{ik} is 1, otherwise 0.
3. The volume that is allocated to the LSP k should be less than or equal to its capacity.
4. Total cost of delivery from LSP k to distribution center j
5. Total handling cost at LSP k.
6. Total cost (Delivery and handling) should be less than or equal the available budget for logistics outsourcing.
7. Quantity of products i allocated to each LSP should be equal or more than the amount of that product distributed by that LSP.
8. Sum of the allocated number of LSPs does not exceed the desired number of LSPs to have by the organization.
9. Binary variable If LSP k is considered, then Z_k is 1, otherwise 0.

IV. Data Analysis

A. *Calculation of weights and priorities using ANP.*

The final weight of each indicator was calculated by multiplying the indicator (sub-criteria) weight by the relevant dimension (criteria) weight as shown in Table IV.

TABLE IV. FINAL WEIGHTS OF SUSTAINABILITY PERFORMANCE INDICATORS

Dimension	**Indicator**	**Indicator Weight**	**Dimension Weight**	**Final Weight**	**Rank**
Economic	E1	0.5810	0.5630	0.3271	1
	E2	0.1954	0.5630	0.1100	4
	E3	0.2236	0.5630	0.1259	3
Environment	EN1	0.3061	0.1763	0.0539	5
	EN2	0.0741	0.1763	0.0131	13
	EN3	0.1734	0.1763	0.0306	10
	EN4	0.1834	0.1763	0.0323	9
	EN5	0.2631	0.1763	0.0464	6
Social	S1	0.5410	0.2608	0.1411	2
	S2	0.0791	0.2608	0.0206	12
	S3	0.1071	0.2608	0.0279	11
	S4	0.1411	0.2608	0.0368	7
	S5	0.1318	0.2608	0.0344	8
				1.0000	

Here three (3) prospective LSPs of the apparel manufacturing firm were considered and using ANP ranks were given to them based on their sustainability performance.

TABLE V. PRIORITY AND RANK CALCULATIONS OF 3LSPS

LSP	Priority	Rank
LSP1	0.32789	3
LSP2	0.33188	2
LSP3	0.34023	1

According to the results, the highest weighted and least weighted sustainability dimensions and the sustainability performance indicators of the organization can be identified. The prospective LSP with the highest priority/rank can be selected as the best alternative.

The following are the results of the calculations done for the data collected from the apparel manufacturing organization. According to the results, the highest importance is given to the economic dimension (0.5630) by the decision-makers, then to social (0.2608), then environmental (0.1763). Priorities of the LSP based on the weights are 0.32789, 0.33188, 0.34023 for LSP 1, LSP 2, LSP 3, respectively. Among them, the highest values were obtained by LSP 3 which is 0.34023 and it is the best selection among the three alternatives. The reason LSP 3 got the highest rank is, it has performed best in the highly weighted sustainability performance indicators by the organization.

B. Results of the mathematical optimization model

Execution of the mathematical model using the data acquired was done using IBM ILOG CPLEX Optimization Studio version 12.9.

Optimization was done with the implementation of the model in the Optimization Programming Language (OPL). The optimization results summary is shown in Table VI(A) and (B). The data used, and the detailed results tables are shown in the Appendix.

Only two prospective LSPs were considered for the execution of the model in CPLEX. According to the results, both LSPs were selected.

TABLE VI(A). OPTIMIZATION RESULT SUMMARY

LSPs	**Product (Units)**					**Total**
	1	**2**	**3**	**4**	**5**	
1	1000	1500	2200	0	800	5500
2	0	0	0	0	0	0
3	0	0	300	500	0	800
Total	1000	1500	2500	500	800	6300

TABLE VI(B). OPTIMIZATION RESULT SUMMARY

LSP	**DC**	**Product**	**Qty (Units) delivered**
1	1	3	1000
1	3	3	750
3	2	5	500
1	4	2	500
1	3	2	500
1	2	3	500
1	2	1	500
1	1	2	300
1	4	3	250
3	4	5	200
1	4	4	200
1	4	1	200
1	2	2	200
1	1	1	200
3	1	5	100
1	3	1	100
1	3	4	50
1	2	4	50
1	1	4	200

V. CONCLUSION

This paper uses Analytic Network Process (ANP) to evaluate the LSPs based on their sustainability performance. Analytic Network Process (ANP) provides the opportunity to the organization to evaluate its prospective logistics partners based on their requirements and priorities and the different sustainability dimensions and indicators. The criteria (Sustainability dimensions) and sub-criteria (Sustainability Indicators) used to select the LSP can be different from company to company and this methodology enables such options and provides the flexibility to select criteria and sub-criteria accordingly. The relative importance of the dimensions and sustainability indicators was determined through pairwise comparison. The LSP with the highest priority value is selected as the best sustainability performer.

As the next step, the desired number of LSPs will be selected using a mathematical optimization model which was formulated as a LPP with an objective of maximization of the volume allocated to LSPs according to the rank obtained during the Analytic Hierarchy Process values while satisfying the constraints. Using the proposed LPP model, both the desired number of LSPs and the capacity to be allocated for those selected LSPs can be determined.

Due to the difficulty in the collection of actual figures or quantitative values for the performance levels of sustainability, performance indicators were measured using a 9-point Likert Scale for getting data to do pairwise comparison which made the results subjective to the person who is giving the scores for the relevant performance. This requires future studies to collect the real quantitative indicator values of the prospective LSPs when using the model to get a more accurate outcome.

The proposed model enables not only to identify the best LSPs who meet the sustainability performance criteria at their best levels but also enables them to distribute the goods to different warehouses or distribution centers after considering all relevant constraints. Though the validity of the model was tested to an apparel industry this could be applied to many other industries.

In the LPP model, two assumptions were incorporated for ease of calculations and to reduce the optimization model complexity. One was considering LSPs have an unlimited distribution capacity which was not true in real life. And researcher has assumed that the supply from the manufacturer and the demand by the Distribution Centers (DCs) are equal for the calculating period. If future research can overlook these limitations and incorporate more constraints into the LPP model to get more accurate results.

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