

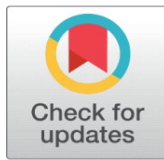
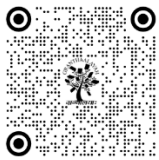
IMPLEMENTATION OF CIRCULAR ECONOMY IN HEALTHCARE SECTOR FOR APPROPRIATE SUPPLIER SELECTION FRAMEWORK

Aayushi Kalra ¹✉, Dr. Anil Khurana ², Dr. Shivani Bali ³

¹ Research Scholar, Deenbandhu Chhotu Ram University of Science and Technology, Murthal, Haryana, India

² Professor, Department of Management Studies, Deenbandhu Chhotu Ram University of Science and Technology, Murthal, Haryana, India

³ Professor, Jaipuria Institute of Management Noida, Uttar Pradesh, India



Corresponding Author

Aayushi Kalra,
aayushi.phd2024@gmail.com

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ABSTRACT

The supplier selection framework is the most interesting and required objective for the healthcare management area for buying the proper products and finding the best supplier. Hence, for finding the finest supplier, the novel technique known as a Hyena Sequence Selection Network (HSSN) was built with the sufficient forecasting features needed. Initially, the suppliers with the circular economic data were collected from the web source and imported into the Python environment. Henceforth, the novel HSSN is built and the prime processes like pre-processing, feature extraction, weighing and supplier ranking scenario were performed. Based on the criterion score, the total weight score was measured, and ranks were provided. At the last, the performance score was evaluated in three categories that are accuracy, error rate and computational complexity. In that, the novel HSSN scored the highest accuracy at 96% with the lowest error rate at 4%. It is quite better than the compared traditional models.

Keywords: Healthcare, Circular Economy, Supplier Selection, Supplier Ranking, Social Criteria, Environmental Criteria and Economic Criteria

1. INTRODUCTION

The global business environment is becoming increasingly competitive while also facing heightened environmental challenges [1]. As a result, companies are constantly looking for innovative ways to improve the efficiency of their operations and adopt more sustainable practices, especially in purchasing materials [2]. Although the specifics may vary from industry to industry, material acquisition can account for up to 70% of total costs for many businesses [3]. Positioned at the forefront of the supply chain, suppliers are instrumental in improving a company's competitiveness and reducing its environmental footprint [4]. The concept of a circular economy (CE) has received significant attention to promote sustainable resource use and reduce waste [5]. The primary objective of a CE is to minimize and ultimately eliminate waste while optimizing the use of limited resources [6]. This is accomplished through a closed-loop framework

that includes practices such as reuse, sharing, repairing, renewing, reproducing, and recycling [7]. These strategies help reduce initial resource input into the system and lead to lower levels of waste, pollution and carbon emissions [8]. Implementing circular practices can extend the life of products, equipment and infrastructure, thereby reducing the need for raw materials, energy and various other resources, leading to significant cost reductions [9]. A key aspect of creating a CE is the long-term use of products, equipment and infrastructure, improving their overall value. As a result, incorporating circular practices into supply chain management (SCM) has emerged as an essential consideration for companies trying to maintain their competitiveness in the marketplace [10].

Additionally, the process of selecting suppliers within circular supply chains is critical to addressing climate change and meeting sustainability objectives [11]. This selection process promotes efficient use of resources and reduction of waste. By choosing suppliers that prioritize sustainable practices, including recycling, remanufacturing and the use of renewable materials, companies can significantly reduce their carbon emissions and reduce their dependence on finite resources [12]. Careful selection of suppliers plays an important role in ensuring that products and materials are efficiently distributed throughout the supply chain [13]. This practice reduces the need to extract new resources and helps reduce emissions. Suppliers that emphasize energy-efficient and low-carbon production techniques help significantly in reducing the overall environmental impact [14]. Therefore, accurate supplier selection within circular supply chains is essential to promote long-term sustainability and advance climate action initiatives [15]. The importance of the circular economy (CE) has evolved beyond its conventional function as an environmental strategy, as it has recently been associated with economic benefits [16].

Sustainability emphasizes establishing environmentally friendly methods and practices that do not harm the ecosystem over time [17]. In contrast, CE focuses on efficient reuse and recycling of discarded materials, materials and components [18]. The objective of CE is to reduce waste generation and consumption of materials and resources. In addition, CE promotes the repair and reuse of products, along with the innovation of new solutions for materials at the end of their life cycle [19]. It aims to improve the efficiency of production and consumption processes, promote the use of renewable resources and mitigate the environmental impact of various activities [20]. The key contribution of this study is described as follows,

- Initially, healthcare product suppliers and economy data are considered for this study and trained to the system as input
- Consequently, a novel Hyena Sequence Selection Network (HSSN) is built for this supplier selection study
- The noisy features were eliminated, and the required features were selected by the hyena fitness.
- Here, based on the economical moving rate, the supplier selection has been performed, the economical moving growth was tracked through the hyena fitness solution
- Hence, the finest economic tracing outcome provided the proper supplier selection outcome.

The present research article is organized based on section 2 describes the literature review, section 3 defines the proposed model, section 4 elaborates the outcome of the proposed model in the form of tables and graphs and section 5 concludes the research chapter.

2. LITERATURE REVIEW

The CE is increasingly recognized within European Union policies, commercial practices, and academic research as a vital component for promoting sustainable development and environmental conservation. However, the management of medical waste presents a considerable challenge, exacerbated by the rising global population and the escalating demand for medical services. To tackle this problem, S. Jafarzadeh Ghouschi et al [21] have introduced an innovative approach known as a novel strategy based on multi-objective optimal solutions within fuzzy sets based on spherical features to address the limitations of supplier selection. However, it encounters difficulties in accurately predicting the weights assigned to various criteria.

L Liu et al [22] introduced an innovative approach known as the conceptual framework for the sustainable supply chain sector, which integrates five cutting-edge digital technologies: cloud services, artificial intelligence, big data analytics, blockchain technology, and the Internet of Things (IoT). The cloud framework is designed to minimize material consumption and enhance remanufacturing, reuse, and recycling throughout the design, production, delivery, utilization,

and disposal phases of products and services. However, it encounters challenges related to financial uncertainties and heightened complexity.

Increasing pollution and waste generation are forcing industries around the world to integrate circular economy (CE) principles into their supply chains. The pharmaceutical industry also contributes significantly to environmental degradation. To solve this problem, F. Kahn et al [23] developed a new hybrid method called Consistency Fuzzy Full Method to analyze barriers and facilitators. This methodology also provides a framework to support the adoption of CE and Chain Management in the pharmaceutical industry. However, a limitation of fuzzy logic is the reliance on both precise and imprecise data, which can compromise accuracy. As a result, it may not be suitable for scenarios that demand a high degree of precision.

M. Sheykhzadeh et al [24] have developed an innovative technique called decision-making based on hybrid fuzzy features approach that is used to evaluate indicators within the data extraction framework and compare outcomes before and after the pandemic. The findings indicate that before the epidemic, the most important factors were superiority, association, safety role and ecological considerations. Conversely, after the pandemic, the primary factors shifted to on-time distribution, lead period, safety routine, and ecological criteria. This research proposes that establishing a supplier selection strategy that can meet demand quickly and maintain excess inventory can improve the ability of healthcare systems to adapt to market demands. However, this approach can lead to inconsistencies between criteria and their classifications.

Bamukar et al [25] introduced an innovative decision-making framework that combines a category-based optimal evaluation technique with a newly developed integrated distance-based evaluation method that measures attractiveness. This framework addresses issues of supplier assortment throughout the Covid-19 pandemic. It uses fuzzy approximation numbers to quantify uncertainty and was implemented in a practical case study in Istanbul, Turkey. Findings indicate that job creation and occupational health and safety systems are the primary criteria, with the supplier (A1) emerging as the most favourable option based on its distance score. However, it faces challenges such as segments with no clinical relevance, insufficient observations, or leading to empty cells when multiple segments are established.

3. METHODOLOGY

For the supplier selection, the economic parameter has played an important role. Hence, the economic parameter is considered for this study. For every stakeholder, the best suppliers were ranked based on the sold economical rate. Hence, to make a deep analytical framework for the economic and healthcare product industry, a novel Hyena Sequence Selection Network (HSSN) was introduced. In the initial phase, the noisy variable was neglected and the needed parameter features were analysed and predicted. Then the economic analysis was done and the suppliers were ranked more appropriately. The layers of the proposed model are exposed in Fig. 1.

Figure 1

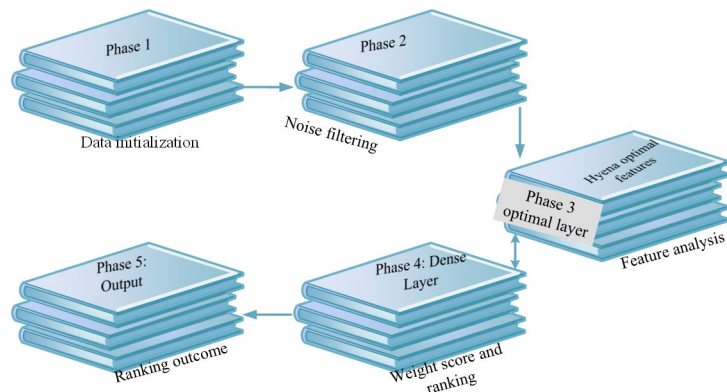


Figure 1 Proposed layer diagram

The introduced supplier ranking algorithm was built based on the sequence neural network [29] features and the hyena optimal solution [28]. To meet this objective the databases was collected based on the following features like healthcare product suppliers, economic criteria and environmental impact [27] and supplier ranking [26]. These, three

data features have afforded the outcome of supplier selection in circular economy. The data initialization process is exposed in eqn. (1).

$$F(m) = m\{r, t, u, e\} \quad (1)$$

Here, defines the data of circular economy, represents the data that is related to the economy, is the environmental impact data, defines the social features and determines the criterion features. Then to make the data analysis process easier for the HSSN, the filtering function was executed for pruning the noisy features. Here, the empty column, empty column and row with unnecessary symbols were considered as the noisy features that were analysed and neglected in the pre-processing stage. Here, are the pre-processing parameters that define neglecting the noisy features.

$$s(m) = \frac{i - (r, t, u, e)}{m} \quad (2)$$

Here, is the unwanted noisy features that are eliminated from the trained database, which is described in eqn. (2). Then for the feature selection process, the needed data features were analysed and extracted for performing the further weighting and the ranking process.

$$G(m) = \frac{r + t + u}{m} \quad (3)$$

Needed features were selected by processing eqn. (3) the weighting scenario was performed for each criterion. The weight score of each criterion was determined by evaluating the healthcare product acceptance rate and sold rate with the total available healthcare products. The weight score evaluation process is exposed in eqn. (4).

$$W(m) = \frac{P^* + S^*}{T(p)} \quad (4)$$

Here, is the weight score parameter, is the healthcare product sold rate, is the total healthcare product and the is the healthcare product acceptance score. Based on these two parameters the weight scores were determined for each criterion.

Figure 2

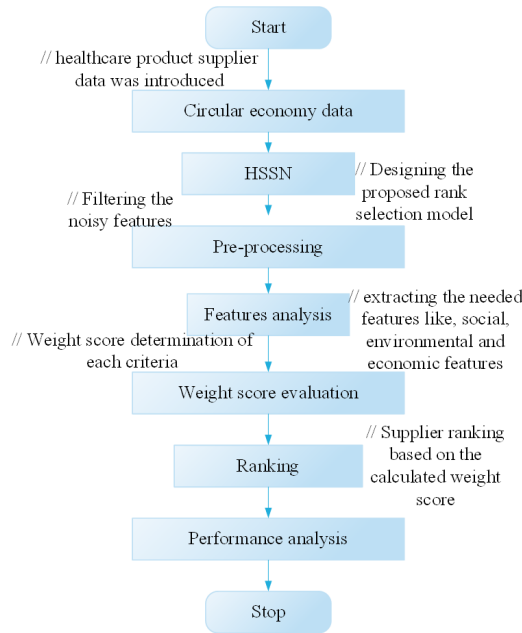


Figure 2 Flow of HSSN

Then the ranking was determined based on the highest weight score of each criterion for the different suppliers.

$$R(s) = T(p)[W(P) + d] \quad (5)$$

Here, T is the greatest weight score, W is the weight score of the specific circular criteria, R is the ranking parameter and d determined the supplier. Hence, based on the highest weight score, the ranking features were determined by eqn. (5).

Table 1 Needed Suppliers characters

Suppliers required characteristics	
Suppliers	Characteristics
1	The vendor was established in the year 2001 and specializes in shipping and marketing foreign enterprises that sell healthcare and veterinary products. They focus on apparatus for diagnosing illnesses and medical gadgets.
2	The seller was established in 2001 & engages in the sales, repair, and maintenance of medical equipment. They focus on ultrasound imaging, surgical, inhalation, and various other medical apparatus.
3	The supplier was established in 2004 & specializes in shipping medical goods and equipment. They specialize in heart disease, radiology, anaesthesia, and various other health areas.
4	The supplier, established in 2009, specialises in the importation, set up, and servicing of diverse medical and manufacturing equipment. Manufacturers focus on measuring tools and instruments used for surgery.
5	The supplier has grown in and engages in the shipping, repair, and upkeep of medical electrical devices. They focus on the servicing and marketing of healthcare supplies.

The needed supplier's characters are exposed in Table 1, and the entire stepwise process is described in Fig. 2.

4. STATISTICAL ANALYSIS

To conduct the statistics evaluation, the Python programming sector was adopted with the version of 3.9, which is effectively executed in the Windows 10 platform. In the initial phase, the required supplier selection data was gathered from the different literature. After that, the mathematical model is designed for selecting and ranking the suppliers based on the sold products and the circular economy rate.

4.1. CASE STUDY

The primary obstacle identified is the "high-cost demand for circular innovations and implementations," which received an overall weight score of 0.131. Significant barriers identified include: "Adverse government rules and procedures regarding circular healthcare," "Insufficient financial resources for ecological investments," "Inadequate safe custody of waste materials in healthcare," "Absence of circular procedures, enticements, and rules in medical services," "The absence of encouragement and devotion from the highest levels regarding circularity," "The intricacy of circularity within healthcare structures," and "Difficulties in recognizing the economic advantages of environmental stakes." The description with the circular criteria is exposed in Table 2.

Table 2 Circular Criteria with Description

Circular criteria	Description
Quality (e1)	The quality of healthcare products and expectations of customer
Price economic (e2)	The value, which suits the specific product and services
Delivery on time (e3)	Relation between customer and supplier, deadline and time of the received product
Reliability (e4)	Assurance to completed assigned target works
Social policy (e5)	Public opinion about the suppliers and the sold products
Security and Disciplinary Practice (e6)	Promising the security for the executed products and the stock products
Training (e7)	Training should be arranged often for the employees based on the introduced new products.
Labour health and safety of work (e8)	The work offered should be in a high safety manner and also ensure good labour health.
Environmental criteria (e9)	Testing that conducted for manufactured healthcare products that are green eco-friendly and pollution-free products.
Pollution control (e10)	The introduced products should be pollution-free and have less harmful ingredients
Green research (e11)	The organization has sufficient ability to reach the green standard of the products during the healthcare products manufacturing products.
Green products (e12)	The manufactured products should be eco-friendly

In the circular economy, the supplier selection is held based on the weightage of each circular criteria impact that is economic, social and environmental. The circular criteria's weight score and rank is exposed in Table 3.

Table 3 Weight score and rank of Circular criteria

Economic weight				
Decision	e1	e2	e3	e4
1	0.218	0.266	0.212	0.125
2	0.211	0.245	0.210	0.167
Mean	0.215	0.255	0.211	0.146
Rank	5	2	6	8
Social weight				
Decision	e5	e6	e7	e8
1	0.268	0.232	0.092	0.087
2	0.265	0.222	0.103	0.070
mean	0.266	0.227	0.097	0.078
Rank	1	4	10	12
Environmental weight				
Decision	e9	e10	e11	e12
1	0.120	0.176	0.095	0.234
2	0.131	0.176	0.097	0.220
mean	0.125	0.176	0.096	0.228
Rank	9	7	11	3

The three-dimensional visualization graphs for the circular economy criteria are exposed in fig.3. Here, the axis values represent the weight score count of each criterion.

Figure 3

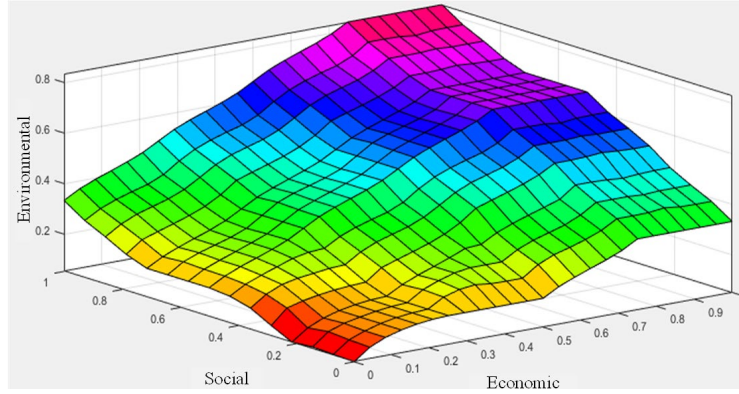


Figure 3 3-D visualization of circular criteria

4.2. IMPLICATION OF MANAGERIAL SECTOR IN ECONOMIC

The findings of the research indicate that inadequate or absent infrastructure expenditures in hospitals stem from the significant costs associated with embracing and carrying out these cyclical technologies. Moreover, this outcome indicates that hospitals must adopt an aggressive strategy to enhance their medical facilities, facilitating swift adaptability to evolving conditions, and hence improving turnaround times during epidemics. To address the challenges faced by healthcare organizations with limited resources for investing in circular innovations and development of cloud computing solutions are suitable because of their equipment and diverse platforms, enabling consumers to set up and use services on simulated servers tailored to their particular demands.

4.3. IMPLICATION OF SOCIAL POLICY

Policy hurdles are among the dual most significant impediments, as indicated by global assessments across all dimensions. Consequently, policy implications are causally linked with additional barriers, and addressing these barriers may yield effective solutions for others. In addition, the primary cause of most hurdles is the deficiency in knowledge and adequate rewards. It is essential to implement federal laws for learning about circular patterns. The ability to utilize technological innovations proficiently must be a primary emphasis in the medical sector. The electronic competencies, critical thinking, and decision-making capacities of pupils have become increasingly vital and closely linked to the swift transition and adaptation to constantly evolving circumstances. This method entails the integration of algorithms and data extraction into digital skills learning. Moreover, the optimization tool of large amounts of data enhanced analytical reasoning. Ultimately, optimization and statistical tools can be tailored for processes of decision-making. Moreover, emphasizing education can significantly contribute to alleviating gaps in knowledge, training, and knowledge. Tax breaks are a vital component owing to the substantial expenses associated with in-job retraining necessary for worker growth. The governing bodies must promote and endorse these cost-related expenditures. ML and data extraction instruments can mitigate the cost impact of these obligations.

4.4. SUPPLIER RANKING

To Rank the suppliers in the healthcare sector or any other domains, the weight score of each circular economy criteria have to be described and calculated. The weight score of every circular feature for every supplier is exposed in Table 4.

Table 4 Suppliers and Weight Score

Supplier	economic	social	Environment
1	0.345	0.329	0.193
2	0.241	0.211	0.221
3	0.098	0.078	0.148
4	0.321	0.2438	0.196
5	0.298	0.275	0.316
6	0.184	0.194	0.189

7	0.222	0.201	0.266
8	0.244	0.212	0.268
9	0.197	0.315	0.311
10	0.219	0.316	0.263
11	0.264	0.171	0.188
12	0.189	0.212	0.368

By determining the total weight score of the complete circular economy features, the supplier's rank was determined, as defined in Table 5.

Table 5 Supplier Ranking

Supplier ranking		
Suppliers count	Total score	Rank
1	0.867	2
2	0.673	9
3	0.324	12
4	0.765	6
5	0.889	1
6	0.567	11
7	0.689	8
8	0.724	7
9	0.823	3
10	0.798	4
11	0.623	10
12	0.769	5

4.5. IMPLICATION OF THE ENVIRONMENTAL SECTOR

The implication sector for the environmental policy is more common like reducing the pollutant and making the green environment. Also, they ensure the assurance for fabricating or manufacturing green healthcare goods, which satisfies the customer needs and their expectations.

4.6. PERFORMANCE ANALYSIS

Altering specific features within decision-making matrices, such as adding another option or removing an existing one, might result in shifts in preferences. Subsequently, various scenarios are constructed to simulate alterations in the components found in the decision-making grid. The supplier with weight score is graphically exposed in Fig. 4.

Figure 4

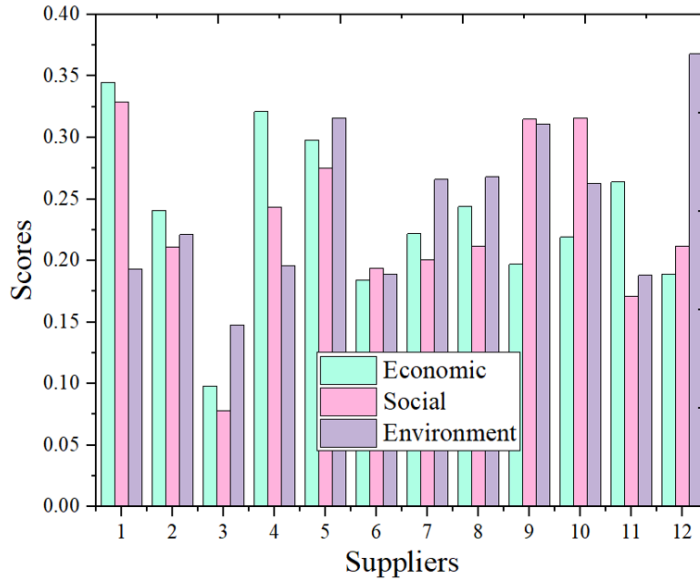


Figure 4 Suppliers with Weight Score

The situations are structured to eliminate the least favourable choice from further analysis in each instance. Simultaneously, for every situation, the other choices are prioritized based on the revised original decision-making grid. For evaluating the performance, the hybrid models were tested individually based on Fuzzy Model (FM), Sequence Neural Approach (SNA), and Hyena Optimizer (HO). Moreover, the hybrid proposed model was also tested and compared with each other. The metrics that are adopted for this performance evaluation is accuracy, time and error rate.

Figure 5

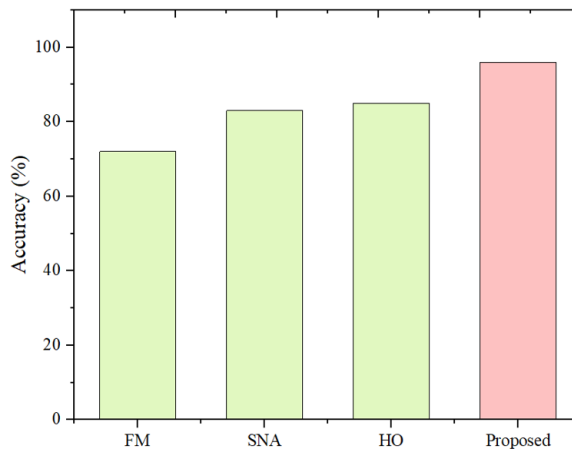


Figure 5 Accuracy Performance

The performance metric accuracy is measured by validating the exactness score of the weight score and ranking scenario determination. Here, the FM scored 72% accuracy, SNA scored 83% accuracy, HO scored 85% accuracy. Considering all this, the novel model HSSN scored the highest accuracy as 96%. It is described in Fig. 5.

Figure 6

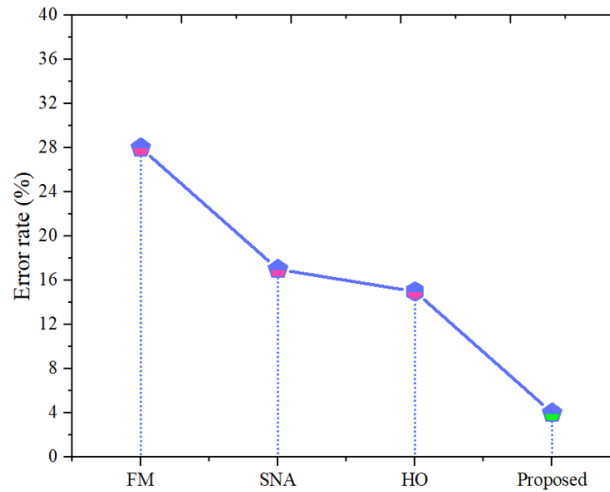


Figure 6 Error rate

To understand the misclassification score of the designed model, this error rate parameters were measured. The reported error rate for the model FM is 28%, SNA 17%, and HO 15%. Compared to all these traditional models, the proposed hybrid approach has earned a less error score of 4%, which is less compared to other models.

Table 6 Overall performance score

	Accuracy (%)	Error rate (%)	Time (s)
FM	72	28	21
SNA	83	17	16
HO	85	15	22
Proposed	96	4	5

The overall performance score in the supplier ranking and the weight score evaluation is exposed in Table 6. The performance parameters like accuracy, error rate and time were considered. In every aspect, the proposed model has received the finest outcome that verified the need of the proposed work.

5. CONCLUSION

The research investigation was processed with a novel HSSN for supplier selection in the healthcare sector circular economy. Here, the suppliers were ranked based on the different circular economy criteria and their weight score, the greatest weight score received the first rank. Like this, all the twelve suppliers were ranked and represented in both tabular and graphical ways. Then to determine the effectiveness of the implemented hybrid model, the performance was measured in terms of accuracy, computational complexity and time. In that, the introduced novel solution has scored the finest accuracy as 96% for the ranking healthcare product suppliers. Compared to other models, the novel HSSN has improved the accuracy by up to 10%. Also, it has reported less computational complexity as 5s to process this supplier selection process for the circular economy domain. However, the supplier's scenario is not collected as practically. In the following future work, collecting the supplier's review by the customer in practice will reward the most accurate outcome.

CONFLICT OF INTERESTS

None.

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