Int J Syst Assur Eng Manag (April 2020) 11(2):261–273
https://doi.org/10.1007/s13198-019-00854-1

ORIGINAL ARTICLE

Enhancement of mail operational performance of India post facility layout using AHP

Vadivel Sengazhani Murugesan[1] · **A. H. Sequeira**[1] · **Deeksha Sanjay Shetty**[1] · **Sunil Kumar Jauhar**[2]

Received: 25 April 2019 / Revised: 6 August 2019 / Published online: 26 August 2019

Abstract The paper intends to evaluate the facility layout design (FLD) models using the analytical hierarchy process (AHP) method. FLD focuses on streamlining the workflow and increasing productivity. This study examines how the model can help to find out the optimum layout to improve the production metrics through improving operations and the working environment attributes. In this study, seven layout designs have been discussed under critical parameters of optimal layouts such as cost (operation and flexibility) and working environment (safety, facilities, and control). This case study FLD conducted in national sorting hub, Mangalore, and Karnataka State in the southern part of India. Empirical results show that the AHP method is one of the promising ways to solve the FLD problem.

Keywords Analytical hierarchy process (AHP) · Facility layout design · Operational performance · Mail operations

Abbreviations

ALDEP	Automated layout design program
AHP	Analytic hierarchy process
BWM	Best–worst method
CAD	Computer aided design/drafting
CI	Consistency index
CORELAP	Computerized relative layout planning
CR	Consistency ratio
CRAFT	Computerized relative allocation of facilities technique
DM	Decision maker
DoE	Design of experiment
DEA	Data envelopment analysis
ELECTRE	Elimination et choice translating reality
FLD	Facility layout design
GA	Genetic algorithm
GRA	Grey relational analysis
MADM	Multi-attribute decision making
MCDM	Multi-criteria decision making
MNOP	Mail network optimization project
MOORA	Multi-objective optimization on the basis
NLP	Non-linear programming
NSH	National sorting hub
PROMETHEE	Preference ranking organization method
REL	Relationship chart
RI	Randomized index
SAW	Simple additive weighting
TD	Town delivery (local mails)
TOPSIS	Technique for order preference by similarity
VIKOR	VlseKriterijumska optimizacija i kompromisno resenje in serbian

List of symbols

ℷmax	Maximum Eigen value

✉ Vadivel Sengazhani Murugesan
sm16f09.vadivel@nitk.edu.in

A. H. Sequeira
ahs@nitk.edu.in

Deeksha Sanjay Shetty
deeksha.shetty1@gmail.com

Sunil Kumar Jauhar
skjauhar@iimj.ac.in

[1] School of Management, National Institute of Technology Karnataka, Surathkal 575025, India

[2] Operations and Supply Chain Management, Indian Institute of Management Jammu, Canal Road, Jammu 180016, India

aij The normalized value of ith criterion for the jth alternative
ajk The normalized value of jth criterion for the ith alternative
W Weight set
Ai The number of alternatives for a certain MCDM problem
n The number of criteria for a certain MCDM problem

1 Introduction

The primary role of the post office is collecting, scanning, sorting, transmission; and delivery of mail with consistent, speed, and security. The Indian postal service has taken a significant role in sorting and transporting the mails throughout the countries. Though the degree of the sorting process varies from country to country, the ultimate aim is to make letter-sorting a fully customized one. For example, developed countries such as the USA, Japan are using the automatic sorting machine to increase their delivery speed, whereas, in India, sorting is being done manually because of abundant labour availability. The processing, transmission, and delivery of mail are the core activities of the postal department. In India, daily mails are collected from almost 579,595 letterboxes and processed through a network of 389 mail offices by roads, rails, and airlines transportation.

The NSH sorting process is based on two types of mails/articles such as Town Delivery (TD—local mails) and Non-TD articles (except local mails). Recently, NSH has worked on the Mail Network Optimization Project (MNOP) to improve the standardization and operational processes in terms of mail processing, transmission, and delivery (McKensy India Post mail Network Optimization Project 2010). In this context, a vital part of the work was involved in modifying the existing layout design to enhance operational excellence by increasing the production of delivery articles to reach the customer on time.

Creating a FLD is a multi-objective problem task and it involves many inputs, either quantitative or qualitative in nature. FLD problem contains algorithms, or it will generate the alternate layouts within the layout space. According to Yang and Kuo (2003), neither an algorithmic nor a procedural layout design methodology is usually useful in solving a practical design problem. Therefore, an AHP method can be implemented to find the optimum layout to improve operational performance through lean service evaluation.

In industries AHP has been well-accepted for multi-criteria decision-making. The application of AHP is to make a decision based on criteria, sub-criteria and alternatives forms the complete hierarchy process. The benefit of AHP is its capability to accommodate subjectivity and inconsistency in human judgments. It can deal with ill-structured and multi-criteria problems without severe complexities (Saaty 1990).

1.1 Rationale of the study

This study is helpful for the researchers who are trying to evaluate the optimal layout selection among the alternatives to enhance operational performance. This study also expected the interest of HR managers and a large number of employees who play an essential role in judging the layout alternatives for production efficiency. Postal administration is planning towards growth in operational performance and working environment to enhance the production as well as protect the employees from cramping working conditions. Hence, we have considered 2 main criteria and its relevant sub-criteria to judge the feasible layout. Most of the layout evaluation so far was done in manufacturing industries but not much in service industries, particularly postal service sector. Further, it is evident that the researchers have not conducted any study on postal service layout evaluation in recent years.

The present study will focus on understanding the ideal system for evaluation of the layout design to enhance operational performance.

The key research questions which will be addressed in the study are:

1. How is the performance evaluation of India Post facility layout been judged for the enhancement of operational performance?
2. What is the role of managers and employees in ensuring the operational performance layout among the different alternatives?

1.2 Objectives of the study

The main objectives are:

1. To study the role of performance evaluation of India Post facility layout for the improvement of operational performance;
2. To understand the role of the managers and employees in ensuring the operational performance layout among the different alternative.

This paper organized in the following sequence: Literature reviews about FLD and addressing the research gap followed by research methodology. Then a discussion of the case study of NSH, Mangalore, Karnataka, and South India is taken up. The paper summarizes the result analysis and managerial implications concluding with directions for further research.

2 Literature review

2.1 Quantitative techniques applied in FLD problems

There are many algorithms/computer programs and heuristic methods involved to address this type of FLD problems. Among them, the famous algorithms/computer programs such as CRAFT (Computerized Relative Allocation of Facilities Technique; Buffa 1964), CORELAP (Computerized Relationship Layout Planning; Lee 1967) and ALDEP (Automated Layout Design Program; Seehof and Evans 1967). These algorithms worked on the decision makers' preference to answer the question of which machine or department/section has to allocate with the next location in the systematic layout procedure. Unfortunately, these algorithms are not assured for the complete qualitative data for the optimal layout design, whereas it leads to suboptimal solutions.

The layout design problem is the leading research field in manufacturing and service industries to perform the efficiency and profitability (Meller and Gau 1996). Hu and Wang (2004) and Zouein et al. (2002) established a rule-based design approach using a genetic algorithm (GA) to resolve the unequal area layout problem. In this paper, the multiple objective functions such as MFFC (Material Flow Factor Cost), SRF (Shape Ratio Factor) and AUF (Area Utilization Factor) to reach minimum TLC (Total Layout Cost). Paul et al. (2006), explained the facility layout problem solved by PSO (Particle Swarm Optimization) algorithm, and proposed the method of finding the distance between the facilities. In addition, GA and improved GA comparison of the algorithm was analyzed to find out the efficiency of the algorithms. The Paes et al. (2017) addressed the unequal-area FLP for minimizing the distances among facilities assigned by material-handling flows. They introduced a basic GA, and an improved GA through partial solution deconstructions and reconstructions. Guan and Lin (2016) used a hybrid algorithm based on variable neighbourhood search, and ant colony optimization to solve the single row facility layout problem. Whereas, Tayal and Singh (2017) integrated heuristic (Simulated Annealing) and MCDM method (TOPSIS) to find the optimal layout selection. Vadivel et al. (2018) applied GA to find minimum layout cost and DEA for finding efficiency layout among the alternatives in India Post facility layout design. Benmouss et al. (2019) used AHP for ergonomic evaluation in information systems. It consists of 16 criteria grouped in 4 categories such as accessibility, usability, persuasivity, and emotionality. Meena et al. (2019) applied AHP and Fuzzy AHP methods in Indian agri-food supply chain (AGSC). Besides, these methods were used to priorities their strengths, weaknesses, opportunities, and threats factors of AGSC. Singh and Prasher (2019) integrates Fuzzy AHP and SERVQUAL methods to measure the service quality in 4 Punjab hospitals, India. Fuzzy AHP used to find the best hospital among four hospitals from the patients' point of view.The above authors used algorithms and heuristics to generate optimal layout using quantitative data.

2.2 MCDM tools applied in FLD problems

Initially, Cambron and Evans (1991) applied the AHP technique on printing plant in a standard and hierarchical form to find the optimum layout design. Following that, Yang and Lee (1997) recommended the AHP decision model for the selection of facility layout in IC packaging industries. Foulds and Partovi (1998) developed combined AHP with a graph-theory based DSS for generating a scaled block plan for the construction of the municipal building. Hence, it is evident that AHP is one of MCDM technique to solve FLD Problems. In this context, refer Table 1 for the detailed literature support for FLD with MCDM techniques.

Based on the above literature, there has been a limited number of papers applied AHP in FLD problem for the service industries in the specific, postal service industry. Also, this method allows incorporating tangible and intangible factors that would fulfill the objectives of optimal layout selection. We have considered two criteria's such as cost division and work environment division with 14 sub criteria's for the selection of postal layout operational performance. Literature support has been included for choosing criteria and sub-criteria, as presented in Table 2.

3 Research methodology

Many journal papers reviewed for choosing critical criteria and sub-criteria. The methodological framework of AHP techniques, as shown in Fig. 1.

3.1 Decomposition of structural hierarchy

Decomposition breakdowns a problem into controllable elements individually. It begins with inherent descriptions of the problem (Selection of optimal layout) and proceeds logically to the criteria such as cost and work environment.

After the goal decomposed into manageable element, it should be structured into a hierarchy. Certain things must be prioritized while building the hierarchy as below:

- Goal (selection of best layout) kept on top of the hierarchy.

Table 1 Brief literature review on MCDM tool applied to FLD problem

S.no.	References	Industry applied	Methodology	Description
1.	Cambron and Evans (1991)	Commercial printing and binding facility	AHP	The AHP model proud an operative tool in selecting best one from a set of alternative layouts
2.	Yang and Lee (1997)	Organizations looking for a new site	AHP	The AHP model helped to assist managers in examining evaluating the various location alternatives and choosing the final location sites
3.	Yang and Kuo (2003)	IC packaging company	AHP and DEA (Data Envelopment Analysis)	Qualitative performance measured by AHP. DEA model developed to identify the final layout design alternatives
4.	Kaboli et al. (2007)	Company looking new site for the facility locations	Fuzzy AHP	In the proposed model, decision maker's choice,α ratio, and costs could affect the deterministic factors for prioritizing the locations
5.	Hadi-Vencheh and Mohamadghasemi (2013)	IC packaging company	AHP and NLP (nonlinear programming)	The AHP is applied to find out the qualitative criteria weights and NLP model applied to solve the facility layout design considers both the quantitative and qualitative data simultaneously
6.	Chauhan and Singh (2016)	Finding the location of healthcare waste disposal	ISM with Fuzzy AHP,TOPSIS	ISM method applied for selecting the criteria and then fuzzy AHP facilitated in computing the priority weights in terms of triangular fuzzy numbers. Fuzzy TOPSIS helps to determine the final location selection
7.	Wang et al. (2016)	IC packaging company	Hybrid MCDM with SAW, TOPSIS and GRA based on experimental design	The ranking results were compared MCDM methods such as TOPSIS, AHP, GRA, DEA, PSI, ANP, SAW, ELECTRE, MOORA, PROMTHEE and the graph approach. Proposed method can be used to solve real-life MCDM problems
8.	Wang et al. (2017)	IC (integrated circuit) packaging plant	Improved TOPSIS, DoE, and Chebyshev regression	They had considered 6 performance attributes such as flow distance, adjacency score, shape ratio, flexibility, accessibility, and maintenance for the suitable layout in order to increase the production activities
9.	Durmusoglu (2018)	Recycling facility located in Turkey	Alternatives are ranked using TOPSIS method	Activity relationship chart (ARC) evaluated by environmental, safety and manufacturing efficiency factors
10.	Parhizgarsharif et al. (2019)	The Mehr Construction Project in Tehran, Iran.	Best Worst Method (BWM), Grey Relational Analysis(GRA) and VIKOR methods	This study presents a new hybrid framework based on the multi-criteria decision making in order to rank the potential site layout locations by consideration of the cost and safety criteria.
11.	Lin and Wang (2019)	Facility layout planning based on human reliability for operating theatre	SHELL and fuzzy AHP method	Proposed new methodology with fuzzy AHP and human reliability assessment, to design the optimal layout. They used SHELL model to analyse the human reliability
12.	Vadivel and Sequeira (2019)	Operational performance based facility layout evaluation	Grey relational analysis (GRA) and design of experiment (DoE) called DoE-GRA method	A case study of India speed Post sorting facility layouts. The comparison result showed that DoE-GRA method is simple and robust, fast calculation and practical

- Decompose the goal into sub-goals (cost and work environmental branch).
- Further, decompose sub goals into necessary sub-criteria (attributes) to measure the goals.
- Alternatives added to the bottom of the hierarchy (layouts 1–7).

3.2 Preference measurement and priority synthesis

A comparative scale used for the pair-wise comparisons of the attributes in each level of hierarchy formation. Pair-wise comparisons made using verbal statements about the strength of dominance (importance or likelihood) of one

Table 2 Brief information of each criterion and sub-criterion with reference

S.no.	Criteria	Sub-criteria	References
1.	Cost division (flexibility and operation)		
		C_{11}: Materials (mails) flow	Cambron and Evans (1991), Rexhepi and Shrestha (2011)
		C_{12}: Personnel flow	Cambron and Evans (1991), Vadivel (2015)
		C_{13}: Minimum throughput time	Black (2007)
		C_{14}: Future expansion	Field survey, Vadivel (2015)
		C_{15}: Space Consumption	Cambron and Evans (1991)
		C_{16}: Process suitability and equipment changes	Chadha et al. (2012), Shah and Ward (2007), Arslankaya and Atay (2015)
		C_{17}: Aesthetics	Cambron and Evans (1991)
2.	Work environment division (safety and control)		
		C_{21}: Emergency exit	Field survey, Vadivel (2015)
		C_{22}: Security	Cambron and Evans (1991)
		C_{23}: Supervision	Cambron and Evans (1991)
		C_{24}: Comfort	Rossi et al. (2013)
		C_{25}: Light facilities	Field survey
		C_{26}: Noise control	Cambron and Evans (1991)
		C_{27}: Pollution control	Field survey

attribute to other attribute symbolized using Saaty rating scale [1–9]. Then, the matrix structure has been formed to develop a local priority vector. After that, we have to combine the local priorities to obtain a global weight for the final decision. The priority vectors can be computed using—Eigenvalue/Eigenvector method, simple average method, weighted average method (refer "Appendix"). Then global weight can be calculated by adding from the top level to the bottom level of the hierarchy. (Saaty 1990).

3.3 Consistency ratio

The comparisons obtained on subjective assessment; a consistency ratio is needed to check the accuracy. A comparison matrix "A" is said to be consistent if aij * ajk = aik for all i, j, and k. However, consistency shall is required. Too much flexibility is disagreeable because of this method contracts with human judgment. Saaty (1990) demonstrated that for consistent reciprocal matrix, the largest Eigenvalue is equal to the size of the comparison matrix, or $\mathbf{\exists max} = \mathbf{n}$. Then Saaty described the measure of consistency, called Consistency Index (CI) as deviation or degree of consistency using Eq. 1.

$$\mathbf{CI} = \frac{(\mathbf{\exists max} - \mathbf{n})}{(\mathbf{n} - 1)} \tag{1}$$

Further, CI recommended for comparing it with the appropriate one. The appropriate Consistency index is called Random Consistency Index (RI). Saaty randomly generated reciprocal matrix using scale 1/9, 1/8,…, 1,…, 8, 9 and get the random consistency index to see if it is about 10% or less.

The random consistency index can be calculated using Eq. 2.

$$\mathbf{RI} = 1.98 * \frac{(\mathbf{n} - \mathbf{2})}{\mathbf{n}} \tag{2}$$

Then, he suggested Consistency Ratio, which is a comparison between the Consistency Index and Random Consistency Index using Eq. 3.

$$\mathbf{CR} = \frac{\mathbf{CI}}{\mathbf{RI}} \tag{3}$$

If the value of Consistency Ratio is lesser or equal to 10%, the inconsistency is adequate. If the Consistency Ratio is greater than 10%, the subjective judgment is needed to be revised or eliminate the questionnaire form of the decision makers.

4 The model applied in NSH Mangalore—a case study

The facility layout consists of 5 active areas, as shown in Table 3. Important mail flow exists among 1 of the 5 active areas shown in the table, known as relationship

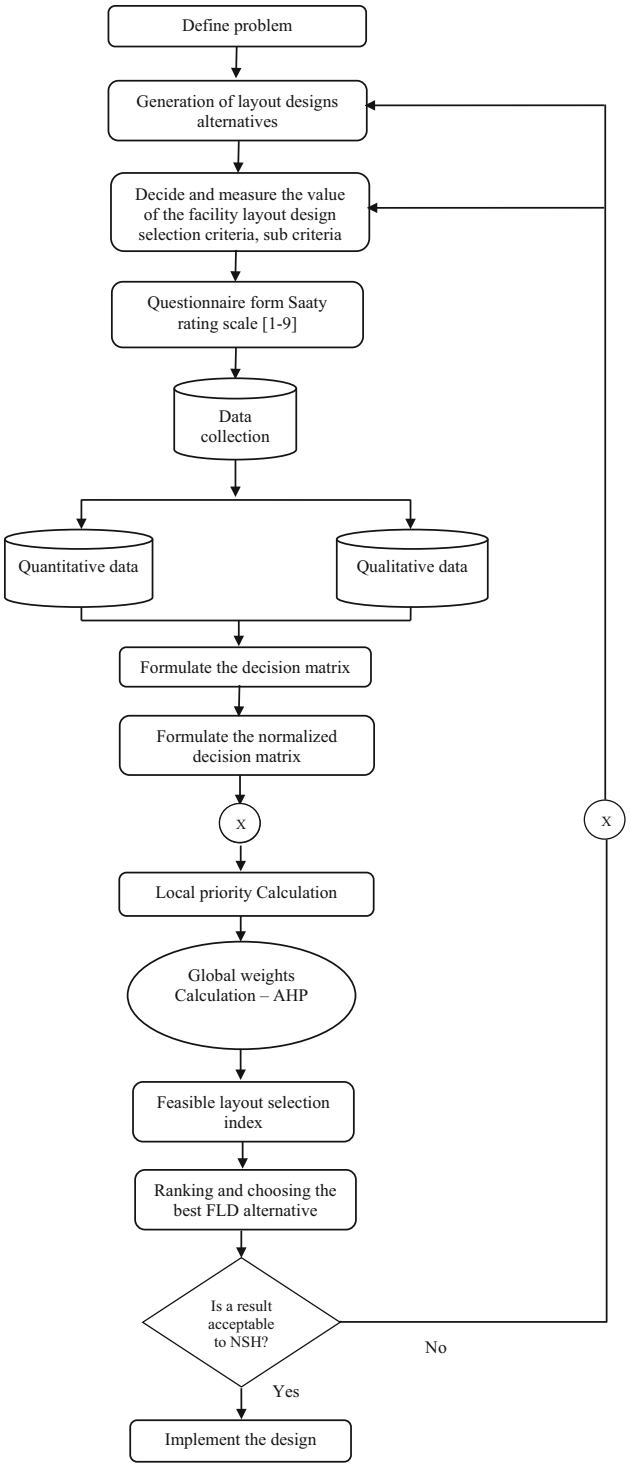

Fig. 1 Flowcharts for the proposed AHP methodology facilities layout

chart (REL). These ratings (a for absolutely necessary, e for especially important, i for important, o for ordinary closeness OK, and x for unimportant) are used to denote the significance related with two departments located next to each other. This facility layout was generated with the help of REL chart and space necessities of the departments, as shown in Table 4.

Table 3 Active areas of department

No.	Departments	Area in Sq. ft
1	Scanning section (SS–TD)	102
2	Scanning section (SS–Non TD)	48
3	Sorting-TD	107
4	Sorting-Non-TD	62
5	Dispatch	43

The existing layout has many problems as follows: (refer Figs. 2 and 3)

- Cycle time is long (171 s/article)—verified in value stream map.
- The employee feels not comfortable for long time work—confirmed in a questionnaire survey.
- There is no emergency exit for the whole layout.
- There is a chance of mixing of received and dispatch bags (backtracking mails).
- Present production delivery articles (12,000 articles/day) are not satisfactory as compared to the target.

4.1 Facility layout design

Seven alternative layouts have considered because each layout has its own merits and demerits. For example, layout 1 suitable for space utilization. Layout 2 is good for an arrangement of light facilities. Layout 3 is appropriate for minimum throughput time. Layout 4 is fit for ease of supervision and security concerns. Layout 5 is apt for process suitability and handling the equipment accessories. Layout 6 is flexible for mail flow and personal flow. Finally, layout 7 is suitable for aesthetics and comfort to the postal employees. These seven layouts meet all the expectations from postal managers to employees by careful observation through interview and questionnaire study—initially, 18 layouts drawn in different combinations of layout design. The brainstorming sessions conducted among the postal employees. Then, it reduced to 7 layouts

Table 4 Mail flow REL charts

From/to	1	2	3	4	5
1	–	e	o	x	x
2	i	–	o	a	i
3	x	i	–	i	a
4	i	a	i	–	i
5	x	i	a	i	–

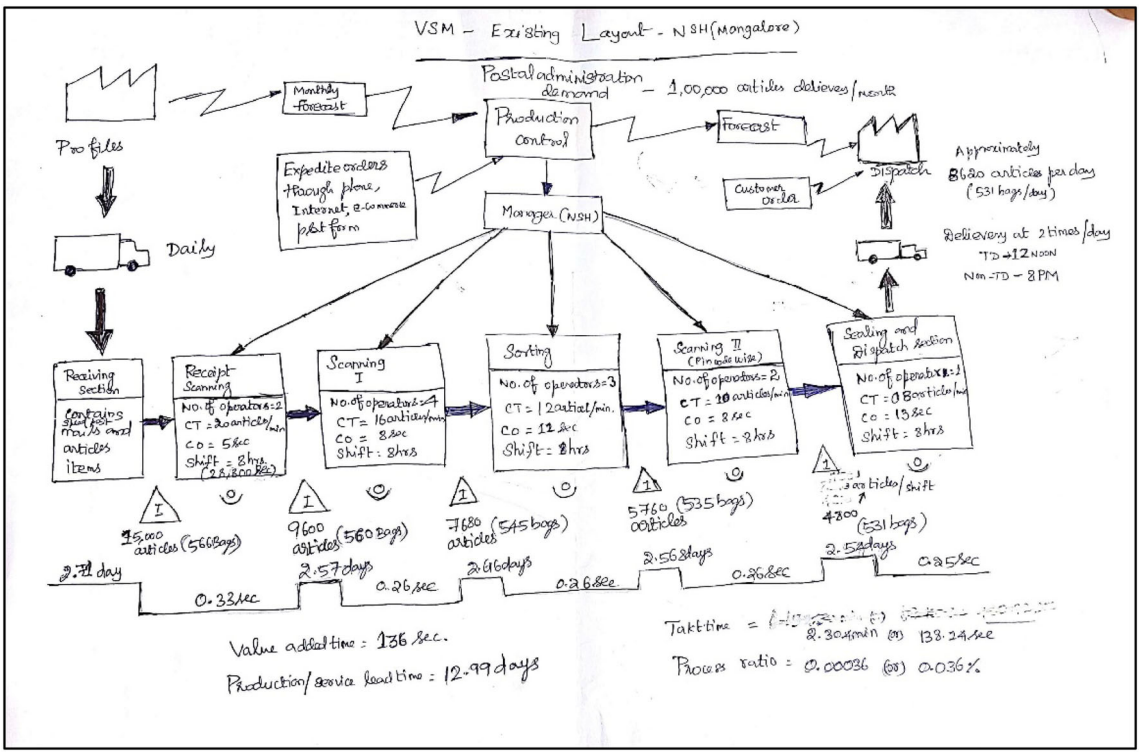

Fig. 2 Value stream map—existing layout

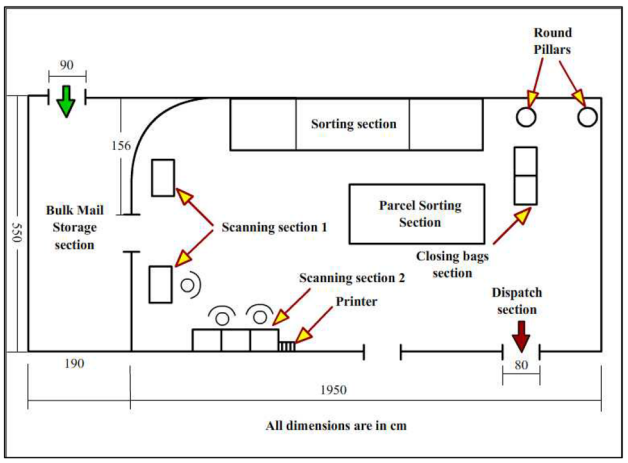

Fig. 3 National speed post hub (NSH) Mangalore—current layout

which had been accepted by both managers as well as workers for the evaluation of feasible layout. After that, these 7 layouts drawn by Computer Aided Software (CAD) tools (refer Fig. 4).

Initially, we started with the following important observations such as light facilities, pollution control, throughput time, housekeeping, safety, backtracking, and bypassing process.

4.2 Formation of hierarchy

Criteria by which the layouts can judge are numerous. So, the two main criteria cost and work environment division are applied to decide the optimal layout from the seven alternatives, and it is relevant to sub-criteria. For example, the movement of mail flow is the most common and valuable criteria used to judge layouts under cost divisions sub-criteria. Previously, developed REL charts clearly shows the most critical route (i.e.) scanning—Sorting and Dispatch. This paper recommends seven layout design alternatives to evaluate the feasible layout selection such as Layout 1, Layout 2, Layout 3, Layout 4, Layout 5, Layout 6 and Layout 7 as shown in Fig. 4 (Fig. 5).

5 Result analysis

5.1 Numerical calculation

Pairwise comparisons were made and then converted into the framework of a matrix used to develop a local priority vector as an estimate of relative magnitudes related to the elements compared.

The overall priority of the alternative computed as follows (refer Table 5):

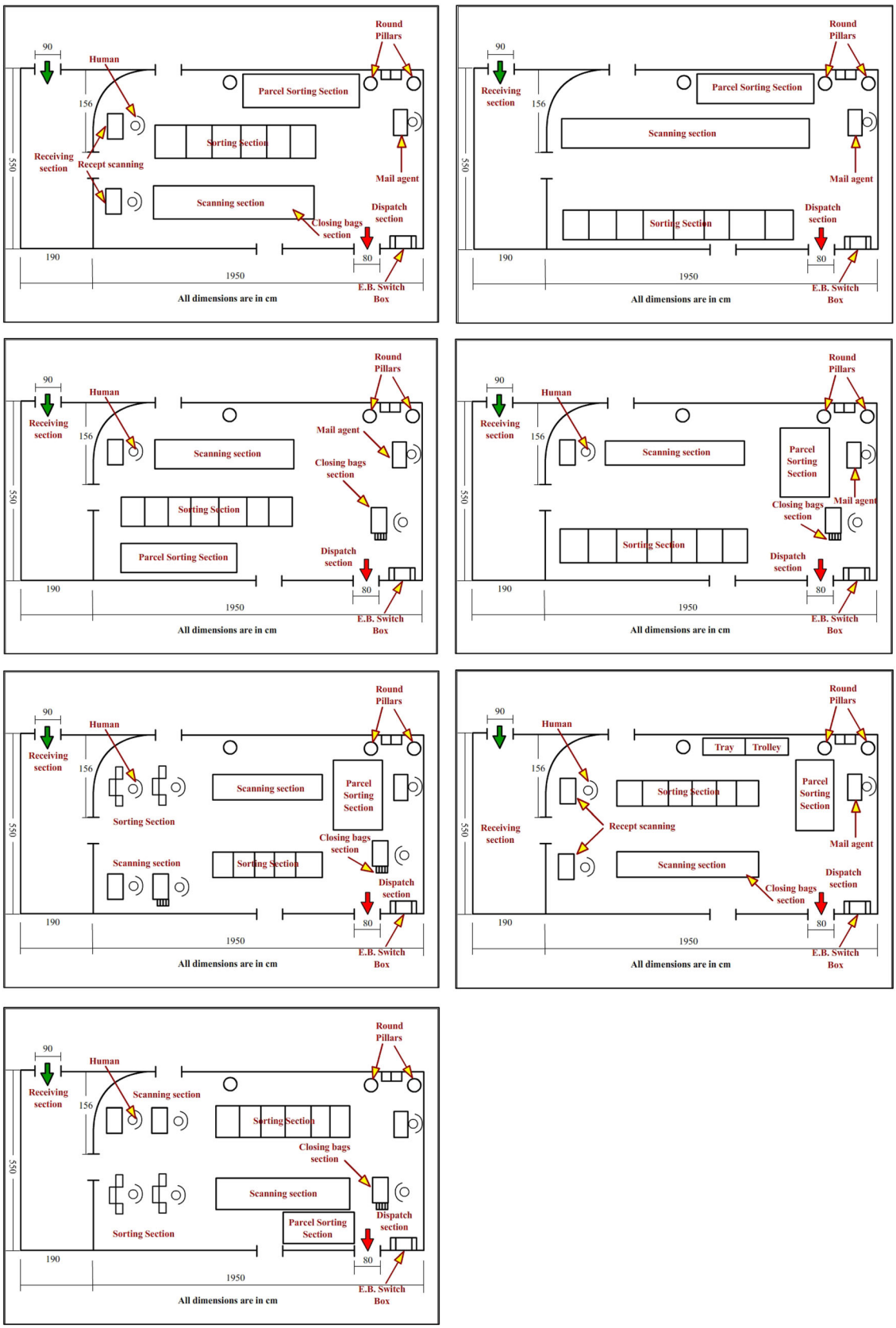

Fig. 4 Alternatives layout design from CAD

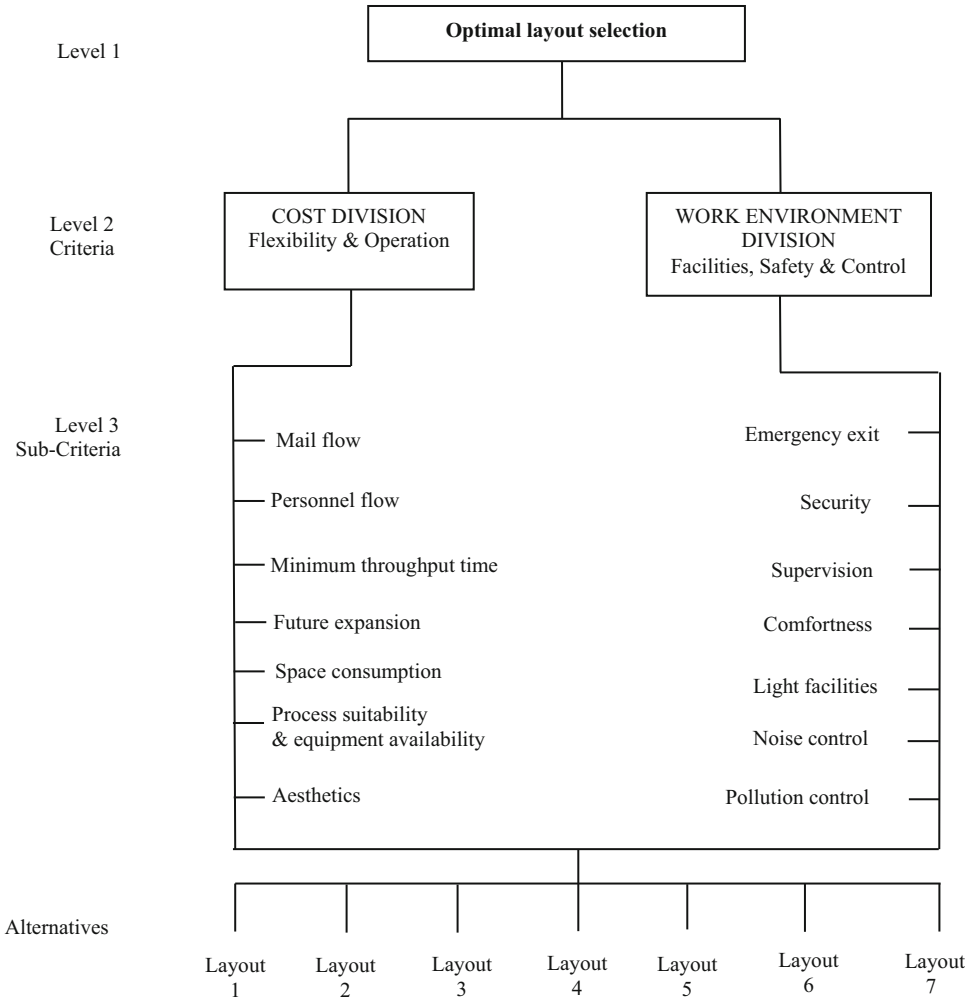

Fig. 5 Hierarchy formations for the selection of facility layout

$$\text{Global rating} = \sum(\text{Priority of alternative concerning subcriteria}) \times (\text{Relative priority of sub criteria}) \quad (4)$$

Inference on AHP:

$A_6 > A_4 > A_5 > A_1 > A_2 > A_7 > A_3$.

From the above Table 6 and seven based on the comparison, optimal layout 6 has been selected, since it has the highest weight (0.22587) among seven alternative layouts. Based on the preference, in AHP, layout 4 is at the second choice. In Table 5 exemplified the global layout ratings using the AHP method. Practically, sensitivity analysis could be made to determine the robustness in the pairwise rankings. Finally, the postal department agreed and adopted layout 6 as its operational performance-oriented layout.

5.2 Practical managerial implications

FLD problem can be solved either by the company looking for a new site or trying for a new business in the existing departments or interchanging departments. This paper presents the AHP model for India Post seeking operational excellence through modifying the inter-changing departments and simplifying the process through a single piece flow. The hierarchical structure illustrated in Fig. 4 is a simplified and well-structured one. Hence, the AHP model can help the decision makers to examine the numerous layout designs, assessing layout alternatives, and choose the optimal one.

The hierarchy structure starts with the goals of the organisation followed by criteria, sub-criteria, and ending with alternatives (complete hierarchy chain). The AHP model provides the decision makers' the various priorities focusing towards layout characteristics, employees' managerial experience, and their judgment. This research work

Table 5 Overall values of facility layouts projected by postal layout using AHP

Criteria	Sub criteria	Weight	Local weights						
			Layout 1	Layout 2	Layout 3	Layout 4	Layout 5	Layout 6	Layout 7
Operation and flexibility	Mail flow	0.37329	0.12750	0.04250	0.06317	0.10981	0.10646	0.46531	0.05325
0.67500	Personnel flow	0.07323	0.12598	0.09581	0.05248	0.14411	0.14773	0.17054	0.12336
	Minimum throughput time	0.05670	0.16800	0.18592	0.04134	0.10602	0.15074	0.18348	0.12449
	Future expansion	0.15602	0.13138	0.17762	0.14258	0.17121	0.09372	0.20585	0.08763
	Space consumption	0.16391	0.15275	0.13765	0.14087	0.16436	0.12745	0.15262	0.15430
	Process suitability and equipment changes	0.06302	0.08258	0.09220	0.07633	0.21044	0.12134	0.27928	0.13782
	Aesthetics	0.23620	0.21095	0.10503	0.12555	0.20660	0.19490	0.15698	0.15698
Work environment	Emergency exit	0.34310	0.12526	0.16015	0.057641	0.12217	0.21488	0.12333	0.14026
0.32500	Security	0.15307	0.10755	0.17650	0.11620	0.06028	0.16289	0.21040	0.16619
	Supervision	0.07727	0.26659	0.18080	0.12893	0.11234	0.10234	0.14888	0.06013
	Comfortness	0.05028	0.13911	0.18896	0.14260	0.15388	0.17229	0.10875	0.09441
	Light facilities	0.03892	0.05537	0.02921	0.09027	0.24625	0.37709	0.082693	0.11912
	Noise control	0.05427	0.27476	0.22937	0.17663	0.11779	0.08757	0.07157	0.04232
	Pollution control	0.06688	0.40675	0.16385	0.09405	0.09364	0.05077	0.06068	0.13026

Criteria	Sub criteria		Global weights						
			Layout 1	Layout 2	Layout 3	Layout 4	Layout 5	Layout 6	Layout 7
Operation and flexibility	Mail flow		0.02810	0.01255	0.01750	0.02865	0.02570	0.11366	0.01297
0.67500	Personnel flow		0.01191	0.00700	0.00510	0.01257	0.01531	0.01554	0.01414
	Minimum throughput time		0.00834	0.00972	0.00155	0.00576	0.00798	0.00960	0.00667
	Future expansion		0.01763	0.02580	0.02071	0.02487	0.01361	0.02990	0.01273
	Space consumption		0.02761	0.02505	0.02220	0.02619	0.01993	0.02420	0.02448
	Process suitability and equipment changes		0.00455	0.00508	0.00421	0.01160	0.00669	0.01540	0.00760
	Aesthetics		0.00623	0.00277	0.00371	0.00610	0.00575	0.00463	0.00463
		Sum	0.10437	0.08797	0.07498	0.11574	0.09497	0.21293	0.08322
Work environment	Emergency exit		0.00466	0.00245	0.00273	0.00453	0.00827	0.00539	0.00526
0.32500	Security		0.00206	0.00338	0.00222	0.00115	0.00312	0.00403	0.00318
	Supervision		0.00257	0.00175	0.00125	0.00109	0.00099	0.00144	0.00058
	Comfortness		0.00087	0.00119	0.00090	0.00097	0.00108	0.00068	0.00059
	Light facilities		0.00027	0.00014	0.00044	0.00120	0.00183	0.00040	0.00058
	Noise control		0.00186	0.00156	0.00120	0.00080	0.00059	0.00049	0.00029
	Pollution control		0.00340	0.00137	0.00079	0.00078	0.00042	0.00051	0.00109
		Sum	0.01569	0.01184	0.00953	0.01052	0.0163	0.01294	0.01157
		Overall priority	0.12006	0.09981	0.08451	0.12626	0.11127	0.22587	0.09479

Table 6 Overall rating of the facility layouts alternatives

Layouts	L1	L2	L3	L4	L5	L6	L7
AHP global weights	0.12006	0.09981	0.08451	0.12626	0.11127	0.22587	0.09479
AHP-ranking	4	5	7	2	3	1	6

was oriented towards India Post service to improve the operational excellence through production and betterment of the working environment. The main goal of the AHP decision model is to satisfy the decision makers to choose from alternative designs of facility layout problems. In reality, FLD is a complex problem in order to select optimal one from a set of layout design alternatives.

The data provided in these FLD problems are explored with suitable data sets from India Post service by identifying the issues and modifying the entire existing layout. The modifying layout has some advantages, as follows:

- Improved production rate 9.62% from 8620 delivery articles.
- Improved housekeeping.
- Improved working environment.
- Improved mail flow with an organization (inbound flow).

Initially, postal employees did their sorting in a line sequence. The movement of the personnel during the sorting process takes longer cycle time (171 s/article) between town delivery articles and non-town delivery articles. After modifying the facility layout TD and Non-TD was separated and cellular approach was implemented (grouping the sorting case into TD and Non TD sorting case). After that, the cycle time (157.32 s/article) and walking distance of employees' movement reduced. Initially, separate sections of trolley, basket, and empty bags were not provided. After modifying the facility layout, we have provided these sections and improve the housekeeping through 5S and visual management. All these modifications', were supported by the postal department, they also spent approximately INR 2.0 Lakhs for the implementation.

The AHP layout model helps the managers to analyse the hierarchical structure entirely well in advance. Managers can gather the required information, time allocation, cost expansion, and also get the support from the employees by choosing the most optimal layout design. The managers can also understand the area of improvement by visualizing the complete hierarchy structure during a brainstorming session among the postal employees. The layout changes or finding the new location is subject to the location site or layout characteristics and the management requirements.

A general complaint from practitioners is that righteous judgment or comparison between layouts on qualitative factors are purely based on subjective consistency. Providing the right result is beyond the nature of human beings. In a practical sense, the proposed AHP layout model was attractive to the managers in the way of pair-wise comparison mechanism. Hence, managers are giving the relative grading rather than absolute preference, at a time, on qualitative items. It is observed that the projected AHP layout model is exciting and practically provides insight into industrial engineers and managers. The AHP layout model, which has been implemented successfully in NSH can be a benchmark for the other postal service, focusing on the enhancement of operational performance.

6 Conclusion

This paper presents the AHP methodology to select the best and optimum layout (Layout 6) among the seven alternatives discussed. The advantage of this research is to choose the best layout under cost and working environment criteria using both qualitative and quantitative data. Alternatives were compared and assigned with ranks using the AHP model. The postal department has adopted 'Layout 6', as it is ranked number one as per global weight. Thus, it implemented in April 2018 in NSH Speed Post Centre, Southern India. In this way, the practical implications of the model, as mentioned above could be justified. Also, this model exhibited overall operational performance in terms of production, better working environmental conditions, also housekeeping. This paper used a systematic approach based on AHP, which could be useful in the layout selection process and also the practical usage of time. However, results shown in the postal service sector cannot be generalized in other firms due to requirements of the respective organisations. In the future, researchers can work on this problem in other MCDM methods such as Fuzzy AHP, ANP, TOPSIS, SAW, and DEA for the better result.

Acknowledgements The authors gratefully acknowledge the valuable support and co-operation extended by India Post authorities, especially the Post Master General, South Karnataka Region, India and the Authorities of NSH Mangalore Speed post services. This research work as the approval of the jurisdictions mentioned above. The authors are immensely grateful to the reviewers for their insights and suggestions in improving the quality and value of this paper.

Appendix

See Tables 7 and 8.

Table 7 Saaty rating scale [1–9]

1–9 Scale	
Intensity of importance	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	For compromises between the above
Reciprocals of above	In comparing elements X and Y—if X is 3 compared to Y—then Y is 1/3 compared to X

Table 8 Pairwise comparison matrix for efficient mail flow sub-criteria

Efficient mail flow	Layout 1	Layout 2	Layout 3	Layout 4	Layout 5	Layout 6	Layout 7	Local priorities
Layout 1	1	4	2	2	2	2	6	0.2944
Layout 2	1/4	1	1	3	1	1	2	0.1435
Layout 3	1/2	1	1	3	2	2	2	0.1782
Layout 4	1/2	1/3	1/3	1	2	3	2	0.1286
Layout 5	1/2	1	1/2	1/2	1	1	2	0.1001
Layout 6	1/2	1	1/2	1/3	1	1	1	0.0890
Layout 7	1/6	1/2	1/2	1/2	1/2	1	1	0.0628
$\lambda max = 7.5984$			CI = 0.0997			CR = 0.075 < 0.1		

References

Arslankaya S, Atay H (2015) Maintenance management and lean manufacturing practices in a firm which produces dairy products. Proc Soc Behav Sci 207:214–224

Benmouss K, Laaziri M, Khoulji S, Kerkeb ML, El Yamami A (2019) AHP-based approach for evaluating ergonomic criteria. Proc Manuf 32:856–863

Black J (2007) Design rules for implementing the Toyota Production System. Int J Prod Res 45(16):3639–3664

Buffa ES (1964) Allocating facilities with CRAFT. Harvard Bus Rev 42(2):136–158

Cambron KE, Evans GW (1991) Layout design using the analytic hierarchy process. Comput Ind Eng 20(2):211–229

Chadha R, Singh A, Kalra J (2012) Lean and queuing integration for the transformation of health care processes: a lean health care model. Clin Gov Int J 17(3):191–199

Chauhan A, Singh A (2016) A hybrid multi-criteria decision making method approach for selecting a sustainable location of health-care waste disposal facility. J Clean Prod 139:1001–1010

Durmusoglu ZD (2018) A TOPSIS-based approach for sustainable layout design: activity relation chart evaluation. Kybernetes 47(10):2012–2024

Foulds LR, Partovi FY (1998) Integrating the analytic hierarchy process andgraph theory to model facilities layout. Ann Oper Res 82:219–232

Guan J, Lin G (2016) Hybridizing variable neighborhood search with ant colony optimization for solving the single row facility layout problem. Eur J Oper Res 248(3):899–909

Hadi-Vencheh A, Mohamadghasemi A (2013) An integrated AHP–NLP methodology for facility layout design. J Manuf Syst 32(1):40–45

Hu MH, Wang MJ (2004) Using genetic algorithms on facilities layout problems. The International Journal of Advanced Manufacturing Technology 23(3–4):301–310

India post mailing service, Indian postal mail operations. https://www.indiapost.gov.in/VAS/Pages/RTI/RTI-Manual-1.aspx. Accessed 5 Dec 2018

Kaboli A, Aryanezhad MB, Shahanaghi K. and Niroomand I (2007) A new method for plant location selection problem: a fuzzy-AHP approach. In: IEEE International Conference systems, man and cybernetics, pp 582–586

Lee RC (1967) CORELAP-computerized relationship layout planning. J Ind Eng 8(3):195–200

Lin Q, Wang D (2019) Facility layout planning with SHELL and fuzzy AHP method based on human reliability for operating theatre. J Healthc Eng. https://doi.org/10.1155/2019/8563528

McKensy India Post mail Network Optimization Project (2010) Mail network optimization project: speed post KPIs and first class mail network. https://www.scribd.com/presentation/120445248/McKinsey-India-Post-Mail-Network-Optimization-Project. Accessed 5 Dec 2018

Meena SR, Meena SD, Pratap S, Patidar R, Daultani Y (2019) Strategic analysis of the Indian agri-food supply chain. OPSEARCH, pp 1–18

Meller RD, Gau KY (1996) The facility layout problem: recent and emerging trends and perspectives. J Manuf Syst 15(5):351–366

Paes FG, Pessoa AA, Vidal T (2017) A hybrid genetic algorithm with decomposition phases for the unequal area facility layout problem. Eur J Oper Res 256(3):742–756

Parhizgarsharif A, Lork A, Telvari A (2019) A hybrid approach based on the BWM-VIKOR and GRA for ranking facility location in construction site layout for Mehr project in Tehran. Decis Sci Lett 8(3):233–248

Paul RC, Asokan P, Prabhakar VI (2006) A solution to the facility layout problem having passages and inner structure walls using particle swarm optimization. Int J Adv Manuf Technol 29(7–8):766–771

Rexhepi L, Shrestha P (2011) Lean service implementation in hospital: a case study conducted in University Clinical Centre of Kosovo, Rheumatology department [dissertation]: Urmeå University

Rossi D, Bertoloni E, Fenaroli M, Marciano F, Alberti M (2013) A multi-criteria ergonomic and performance methodology for evaluating alternatives in "manual" material handling. Int J Ind Ergon 43(4):314–327

Saaty TL (1990) How to make a decision: the analytic hierarchy process. Eur J Oper Res 48(1):9–26

Seehof JM, Evans WO (1967) Automated layout design program. J Ind Eng 18(12):690–695

Shah R, Ward PT (2007) Defining and developing measures of lean production. J Oper Manag 25(4):785–805

Singh A, Prasher A (2019) Measuring healthcare service quality from patients' perspective: using Fuzzy AHP application. Total Qual Manag Bus Excell 30(3–4):284–300

Tayal A, Singh SP (2017) Integrated SA-DEA-TOPSIS-based solution approach for multi objective stochastic dynamic facility layout problem. Int J Bus Syst Res 11(1–2):82–100

Vadivel SM (2015) Implementing lean ergonomics in indian postal service industries—a case study, Unpublished MS thesis, Indian Institute of Technology Madras, pp 01–83

Vadivel SM, Sequeira AH (2019) A hybrid method for the selection of facility layout using experimental design and grey relational analysis: a case study. Int J Hybrid Intell Syst 15:101–110

Vadivel SM, Sequeira AH, Jauhar SK (2018) Metaheuristic for optimize the india speed post facility layout design and operational performance based sorting layout selection using DEA method. In: 18th international conference on intelligent systems design and applications (ISDA 2018) held in Vellore, India, vol 941, pp 1035–1044

Wang P, Zhu Z, Wang Y (2016) A novel hybrid MCDM model combining the SAW, TOPSIS and GRA methods based on experimental design. Inf Sci 345:27–45

Wang P, Zhu Z, Huang S (2017) The use of improved TOPSIS method based on experimental design and Chebyshev regression in solving MCDM problems. J Intell Manuf 28(1):229–243

Yang J, Lee H (1997) An AHP decision model for facility location selection. Facilities 15(9/10):241–254

Yang T, Kuo C (2003) A hierarchical AHP/DEA methodology for the facilities layout design problem. Eur J Oper Res 147(1):128–136

Zouein PP, Harmanani H, Hajar A (2002) Genetic algorithm for solving site layout problem with unequal-size and constrained facilities. J Comput Civ Eng 16(2):143–151