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THE PERFORMANCE ANALYSIS OF HEALTH, SAFETY, ENVIRONMENT, AND ENERGY INTEGRATED MANAGEMENT SYSTEM (HSEE-IMS) USING FUZZY COGNITIVE MAPPING METHOD

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Keywords:

Performance assessment; Integrated management system; Leadership; HSEE-IMS; Policy making; FCM.

A B S T R A C T

The performance assessment of strategic levels of an integrated management system (IMS) is critical to policy making phase of executive organizations. Because, the integrity of objectives and strategies in the overall system performance insures the integrity of activities and performance in the subsidiary departments and units. Unfortunately, this approach of assessment has been rarely focused. Here, the Fuzzy Cognitive Mapping-Relative Degree Analysis (FCM-RDA) technique was chosen to assess the performance trend of the health, safety, environment, and energy (HSEE)-IMS in a ministry during 2014-2019. There were 12 HSEE-IMS strategic sub-elements and 6 system sub-performances. The Gephi0.9.2 software was applied to simulate the FCM model. Accordingly, the sub-performance of policy and leadership was placed at the first priority. The development of HSEE management, and review (of policies and programs) were two HSEE-IMS sub-elements, categorized in the second priority. The results showed an ascending trend of the system performance during 2014-2018 and a descending trend during 2018-2019. It was found that the poor performance of HSEE-IMS sub-elements in the strategic and tactical levels resulted in the poor performance of system at the operational levels. There was found a strong relationship between the HSEE-IMS sub-elements and system sub-performances.

1. INTRODUCTION

The development of Health, Safety, Environment, and Energy (HSEE) processes requires performance assessment based on proper indicators. However, using a suitable procedure in performance determination of a management system is an important concern to managers and, the HSEE-IMS is not excluded from this principle (Amir-Heidari et al., 2017; Sadoughi et al., 2012; Shamaii et al., 2016). The managers need to have the right data at the right time to manage efficiently based on the valid and relevant data (Sellak et al., 2017; Torabi, 2016). Time is the hidden layer of a system performance and is expanded in a line with the overall activities of organization (action plan), decision making, and performance assessment. It seems that, the performance

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network of HSEE should be developed within all managers in both static and dynamic forms. The communication of network in the static form requires that each manager has the right indicators at the right time. In the dynamic form of the network, it is necessary to have the right key performance indicators (KPIs) to collect operational indicators and use them to induce strategic motives (Torabi, 2016).

Cognitive map (CM) models have been introduced in the late1970s by Axelrod and have been widely applied to subjects including political analysis and decisions in the international relations (Alipour et al., 2019; Groumpos, 2019; Tsadiras et al., 2001). The structural and decision-making potentials of these models have been assessed with the aim of expansion of its capabilities and assurance of its prediction power. The introduction of fuzzy logic gave CMs new capabilities and resulted in the development of fuzzy cognitive mapping by Kosko in the late 1980s (Tsadiras et al., 2001; Yue et al., 2018). FCM technique is a causal knowledge-based technique and known as a semi-quantitative technique with selective approach for dynamic and complex systems (Kyriakarakos et al., 2014; Shamaii et al., 2016; Sperry & Jetter, 2019; Tomé, 1999; Yue et al., 2018). It is a combination of the neural networks and fuzzy logic which provides the possibility of predicting concept changes in the causal mapping (Kang et al., 2016; Skład, 2019; Tomé, 1999; Vergini & Groumpos, 2016). FCM is applied in development of some areas such as political and military sciences, history, international relations, and organizational theory (Skład, 2019), and recently it has taken into consideration by fields of business planning, medicine, environmental management, and energy applications (Kang et al., 2016; Kyriakarakos et al., 2014; Mpelogianni & Groumpos, 2019; Sperry & Jetter, 2019). FCMs models are being created as a set of concepts and various causal relations between concepts. The concepts are determined by nodes and the causal relations by directional arcs between the nodes. One of the significant characteristics of this model is the property of determining the impact of type and portion of concepts on each other (Alipour et al., 2019; Groumpos, 2019; Kyriakarakos et al., 2014; Papageorgiou et al., 2009). It empowers the capability of various resources to overcome the limitations of the expert opinions, and considers the multivariate interactions which results in nonlinearity and describes implicit defaults in cognitive models (Jetter & Kok, 2014). Anna Skład (2019) applied FCM technique to study the influence of processes on the effectiveness of the occupational health and safety management system and concluded that the safety performance is significantly influenced by improvement in leadership process(Skład, 2019). Assadzadeh et.al (2013) assessed the integration factors of macro-ergonomic and HSE using the FCM technique in a gas refinery industry. They focused on the direct and indirect effects of HSE factors on the performance indicators of the system. They applied the FCM technique to develop some useful leading indicators in proactive management of productivity, damage rate, and job satisfaction (Asadzadeh et al., 2013). Kyriakarakos et.al (2014) applied FCM technique to study efficient planning of a sustainable renewables energy systems. Based on the reported results, decision support systems such as FCM can be useful in local policy making and well supporting of a renewable energy system environment in local communities (Kyriakarakos et al., 2014). Kang et.al (2016), studied the 10 years implementation of HSE management system in an organization from the aspects of job satisfaction, employee productivity, and social reputation using FCM-RDA, and then reported the continuous improvement of the system during 10 years (Kang et al., 2016).

The present study, aims to assess the HSEE-IMS of a ministry of a country (Iran) in different levels of performance with a focus on integration aspects of the system (including policy, leadership and commitment, planning, implementation (DO), check and review, continuous improvement, and risk management of HSEE) from 2014 to 2019. The policies, priorities, elements and performance indicators (sub-elements) of the system were ranked by weighting the direct and indirect relations and interactions of those in accordance with neural networks and fuzzy logic (FCM-RDA technique). The direct and indirect effects of the sub-elements on the sub-performances were studied.

2. MATERIALS AND METHODS

The performance assessment of HSEE-IMS using FCM-RDA technique was implemented in five phases including several steps (Kang et al., 2016) (Figure 1).

Phase 1. FCM technique was implemented during the following three steps (Alipour et al., 2019; Kang et al., 2016):

Step1. Forming an expert panel: 15 people of the professionals and experts in HSEE with useful experience in HSEE-IMS and policy-making ability were chosen as the expert panel.

Step 2. Study of criteria, laws, regulations, and requirements related to the HSEE: According to the expert panel's opinions, some of the main sub-elements and sub-performance were suggested, weighted, prioritized, and chosen as SMART[1] sub-elements and sub-performances, respectively (Moridi H & R, 2019). There were considered some elements (human, organization, culture, environment, and facility) and the main performance indicators (sub-elements) of *strategic levels* (review of policies, strategies, programs and

[1] Specific, Measureable, Achievable, Realistic, Time-sensitive

authorities), *tactical* (organization framework, legislation and development of HSEE management, education and cultural promotion of HSEE, and health promotion of employees), *technical* (preparation and distribution of the national and international requirements and procedures of the HSEE, and communication and participation (internal and external), *operational* (environmental management, optimization of energy consumption, recognition of hazard centers and accident management, and continuous monitoring of subsidiary organizations and units), and *defensive factors* (crisis management and emergency response planning) as SMART key performance indicators. The performance of the system was assessed from 6 sub-performances (Figure 2).

Step3. Weighting and ranking the selected SMART sub-elements and sub-performances

A connection matrix consisting of sub-elements and sub-performances (as concept nodes) was designed. The interaction of concept nodes was considered as arcs in FCM model and the members of expert panel gave an influence weight to each interaction (in terms of verbal character) (Mpelogianni & Groumpos, 2019). The weight was defined the effect of each concept node on the others and was expressed d by terms of; “zero”, “weak”, “medium”, “strong”, and “very strong”. Then the connection matrix was analyzed using Gephi (version 0.9.2) software and thus the weight of each concept node and arc was determined. Gephi software is developed by Mathieu Bastian et al., 2008 and is open-source software for network visualization and analysis.

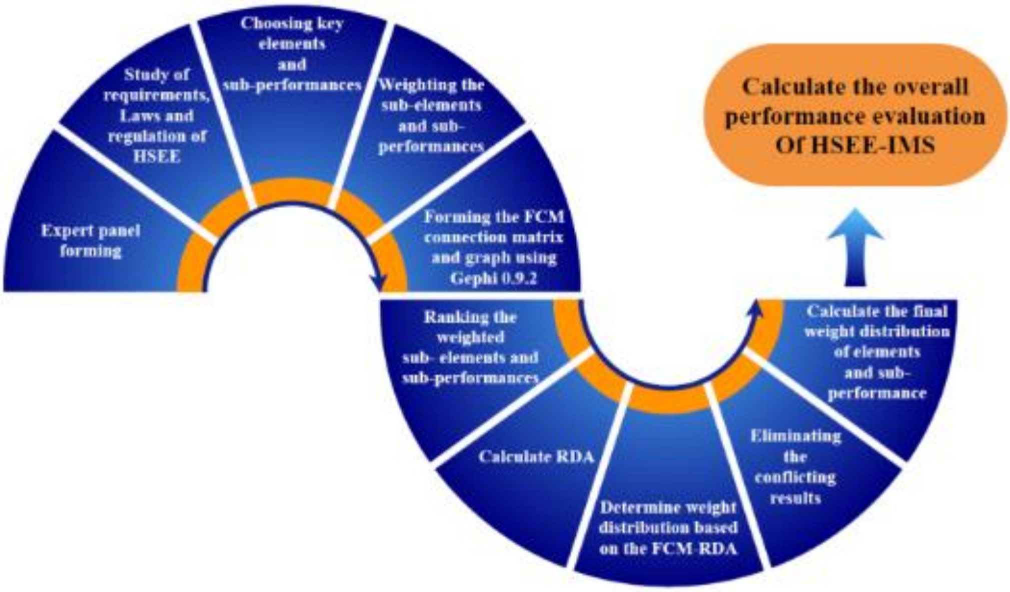


Figure 1. Steps of study design

Phase2. the correlation degree of sub-elements and sub-performances was calculated using RDA technique. The aim of applying RDA was to understand the correlation properties existed in the large data and thereby, to find the regulation and principles determining how changes in some occurrences influences the other ones (Kang et al., 2016). This phase was implemented through 7 steps including; the study of auditing and assessment records during 2014-2019 for each sub-element and sub-performance (step1), the comparison of each sub-element to the regulatory requirements by designing a number between 0 – 100 (step2), calculating the mean value of sub-elements (X0) for each year (step3), calculating the difference of each sub-element from the mean value (Δ_{0i}) (step4), calculating the relative coefficients of each sequence to the reference sequence using the following formula (step5)

$$= \frac{(|\Delta_{0i}(k)| + \rho Max_i Max_k |\Delta_{0i}(k)|)}{(Min_i Min_k |\Delta_{0i}(k)| + \rho Max_i Max_k |\Delta_{0i}(k)|)} \quad (1) \quad \zeta_{01}(k)$$

ρ is a value between 0, 1. The bigger ρ, results in the greater resolving power. The value of ρ demonstrates the degree in which the minimum numbers are being emphasized to correlate with the maximum numbers (step 5), calculate and normalize the correlation coefficient of ith sequence to the referenced sequence using the following formulas respectively (step 6);

$$r_{0i} = \frac{1}{\mathrm{N}} \sum_{\mathrm{k}=1}^{\mathrm{N}} \zeta_{0i}(k) \quad (2)$$

$$\mathrm{Z_i} = \frac{x_i - \min(\mathrm{x})}{\max(\mathrm{x}) - \min(\mathrm{x})} \quad (3)$$

The numerical effects were explained as verbal variables, matched and compared with the results of the FCM technique. For this, the M rule was applied and the expressions of “μ_Z”, “μ_W”,” μ_M”,” μ_S “, and “μ_{VS}” were applied for an influence close to the “0”,”0.25”,”0.5”,”0.75”, and “1” respectively (step 7).

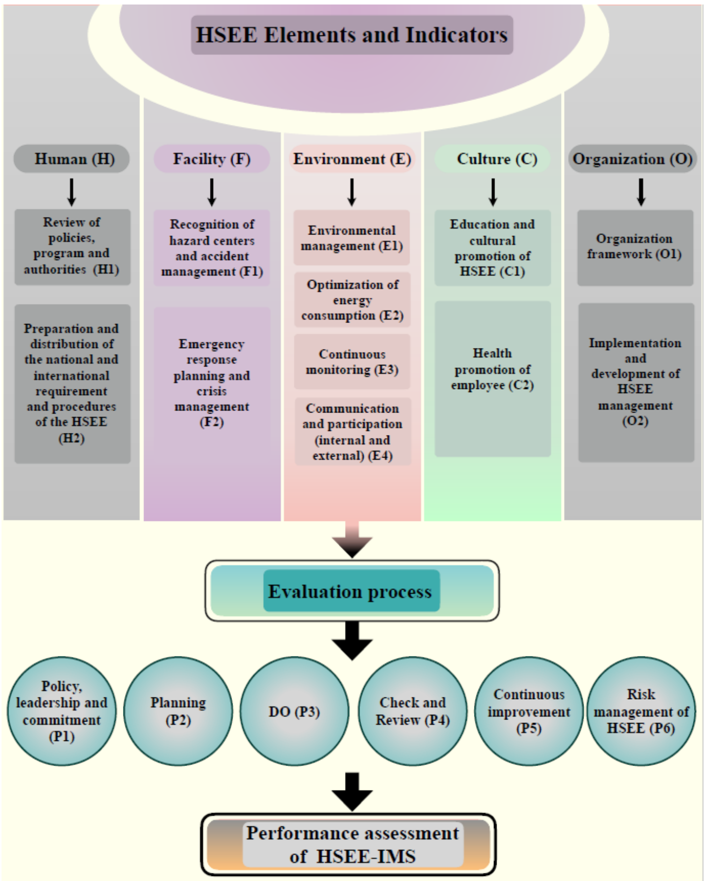


Figure 2. Selected SMART elements (H, F, E, C, and O), sub-elements (H1, H2, F1, F2, E1, E2, E3, E4, C1, C2, O1, and O2), and sub-performances (P1, P2, …, P6) for performance assessment of the HSEE-IMS in macro strategic levels

Phase 3. The weight distribution of sub-elements was determined by the comparison results of the FCM and RDA and the sub-elements with conflicting result were reviewed.

Phase 4. By analyzing FCM-RDA results, the final weight distribution of sub-elements on the sub-performances was achieved.

Phase 5. The overall performance evaluation of HSEE-IMS:
By putting the score of each sub-element in the final weight distribution using the following formula, the overall performance evaluation was determined. The M rule was applied again to quantify the values;

$$y = \frac{\sum x_i w_i}{\sum w_i} \qquad (4)$$

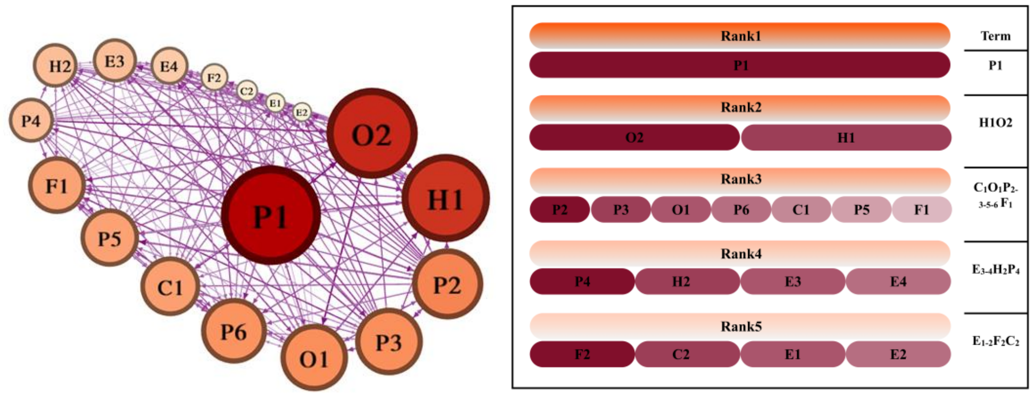
x_i= the score of ith sub-element, w_i= the weight of ith sub-element

3. RESULTS

3.1 The results of weighting and ranking sub-elements and sub-performances based on the FCM technique

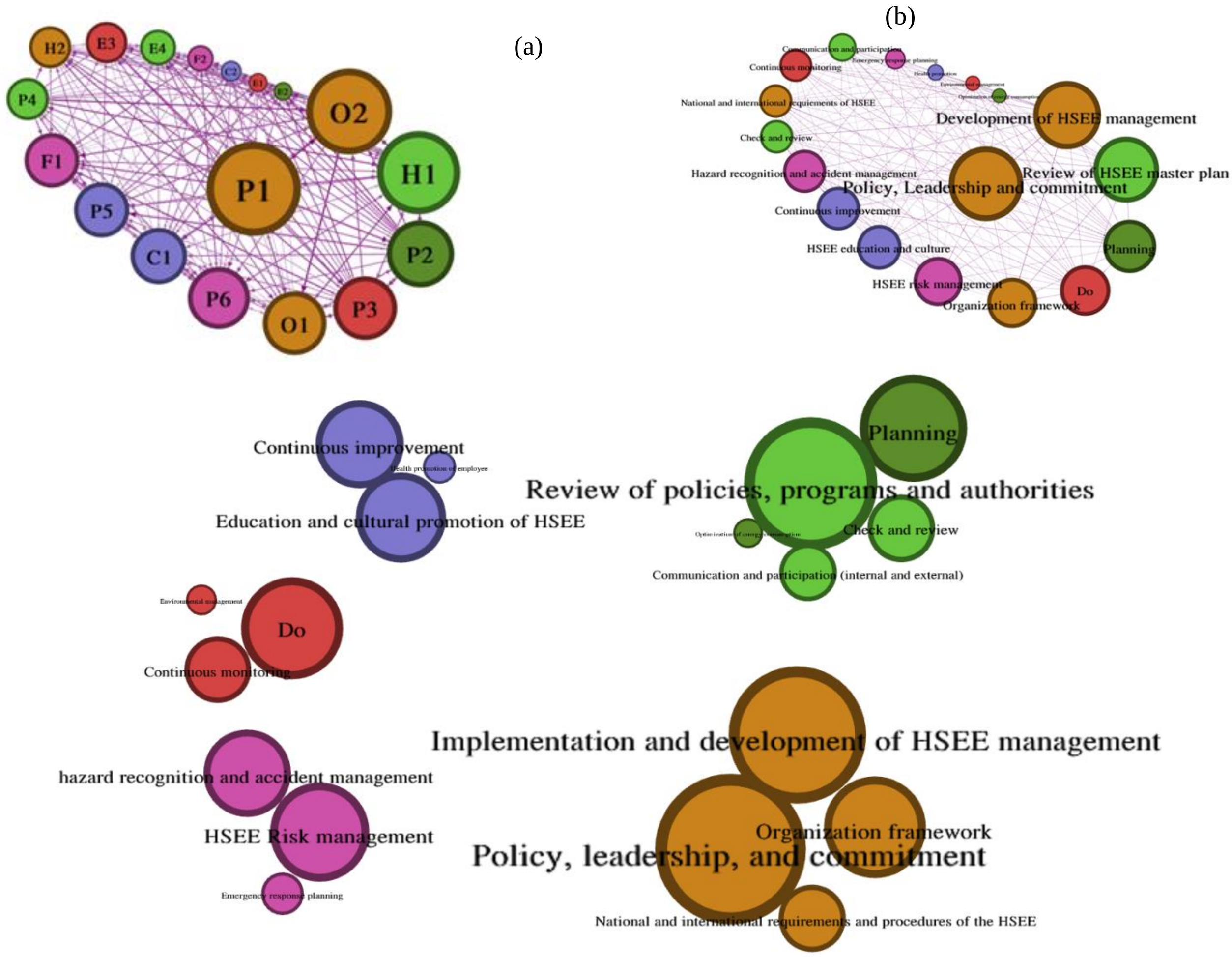
Based on the questionnaires filled by the expert panel, the connection matrix of sub-elements and sub-performances was presented (see Appendix).

Based on the weighting results derived from Gephi output, the sub-elements, and sub-performances were categorized into 5 categories. The analysis and weighting process was performed using Gephi software (version 0.9.2). The FCM connection of the nodes and arc which was distinguished based on the weight of the nodes and arcs, is shown in Figure 3. Accordingly, all of the nodes had a two-way relation with each other. Also, modularity class as ranking criteria in network analysis was calculated in Gephi to find and classify the nodes with high dense edges (Figure 4).



(a) (b)

Figure 3. The FCM connection graph (a) and causal ranking (b) of HSEE-IMS sub-elements and system sub-performances based on the weight degree



(c)

Figure 4. Classification of weighted nodes based on the modularity class in terms of node code (a), full name of nodes (b), and number of nodes in each category (c).

3.2 The correlation degree of sub-elements based on the RDA technique

The auditing and assessment results during 2014-2019 for each HSEE-IMS sub-element were considered as the main data (Tables 1) and the annual mean score of sub-elements was calculated as referenced sequence to the RDA sequencing (Tables 2). By achieving the correlation coefficients (Table 3) and relevant coefficients (Table 4), the comparative effects of HSEE sub-elements on the sub-performances of the HSEE-IMS performance were drawn using the FCM-RDA technique (Figure 5).

Table 1. RDA sequences from assessment and auditing documents during 2014-2019.

Time/sequence	X0	O1	H1	O2	H2	C1	C2	F1	F2	E1	E2	E3	E4
2014-2015	57.3	90	85	45	75	25	52	48	45	55	53	65	50
2015-2016	59.1	60	65	75	50	42	60	58	51	64	53	62	69
2016-2017	87.5	100	65	100	98	100	85	87	80	83.3	72	100	80
2017-2018	97.7	100	100	100	100	100	91.6	92	98	97	94	100	100
2018-2019	68.045	25	55	60	79	75	77	78.57	76.66	68.5	61.81	75	85

Table 2. the differences of evaluating sequence to the referenced sequence.

Time/Δ_{0i}(k)	Δ_{01}	Δ_{02}	Δ_{03}	Δ_{04}	Δ_{05}	Δ_{06}	Δ_{07}	Δ_{08}	Δ_{09}	Δ_{010}	Δ_{011}	Δ_{012}
2014-2015	32.7	27.7	12.3	17.7	32.3	5.3	9.3	12.3	2.3	4.3	7.7	7.3
2015-2016	0.9	5.9	15.9	9.1	17.1	0.9	1.1	8.1	4.9	6.1	2.9	10.1
2016-2017	12.5	22.5	12.5	10.5	12.5	2.5	0.5	7.5	4.2	15.5	12.5	7.5
2017-2018	2.3	2.3	2.3	2.3	2.3	6.1	5.7	0.3	0.7	3.7	2.3	2.3
2018-2019	43.045	13.045	8.05	10.96	6.96	8.96	10.525	8.615	0.455	6.235	6.96	16.96

Table 3. Correlation coefficients of each sequence compared to the referenced sequence.

Time/ζ_{0i}(k)	ζ_{01}	ζ_{02}	ζ_{03}	ζ_{04}	ζ_{05}	ζ_{06}	ζ_{07}	ζ_{08}	ζ_{09}	ζ_{010}	ζ_{011}	ζ_{012}
2014-2015	2.63	2.36	1.53	1.82	2.6	1.16	1.37	1.53	1	1.1	1.29	1.26
2015-2016	1	1.53	2.58	1.86	2.7	1	1.02	1.76	1.42	1.55	1.2	1.97
2016-2017	2.02	2.87	2.02	1.85	2.02	1.17	1	1.6	1.31	2.27	2.02	1.6
2017-2018	1.6	1.6	1.6	1.6	1.6	2.73	2.61	1	1.11	2.01	1.6	1.6
2018-2019	2.94	1.57	1.34	1.47	1.3	1.38	1.46	1.37	1	1.26	1.3	1.75

Table 4. Relevant coefficients of ith sequence with referenced sequence after normalization.

9	O1	H1	O2	H2	C1	C2	F1	F2	E1	E2	E3	E4
r0i	0.9886	0.93	0.7377	0.627	1	0.3637	0.368	0.3227	0	0.536	0.3535	0.5325

3.3 The weight distribution of HSEE–IMS sub-elements on the system sub-performances based on the FCM-RDA technique

The comparison results of both techniques of FCM and RDA is shown in Figure 5.

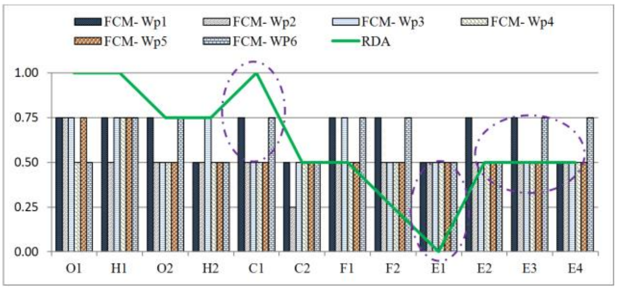


Figure 5. the effect of sub-elements on the sub-performances of HSEE-IMS based on the FCM-RDA technique

As it is shown in Figure 5, the sub-element of E1 had a medium effect on the system sub- performances, but according to the RDA results, its effect was found to be zero. Also, the sub-element of C1, based on the FCM results, had a medium effect on four sub-performances of the system, but a strong effect on two sub-performances. based on the RDA results this effect was found to be very strong. Thus, to review these conflicting results between FCM and RDA, two questionnaires were designed and provided to the expert panel. The items of E1 sub-element were consisted of influencing aspects of the communication, education, participation, compliance with laws and requirements. And the items considered for the C1 was consisted of awareness and culture promotion, compliance with laws, requirements, and productivity. Therefore, using those two questionnaires to review and reassess the interactions between each item of the HSEE-IMS sub-elements and system sub-performances by the expert panel were useful.

3.4 Evaluate the overall performance of HSEE-IMS during 2014-2019.

Final weight distribution of 12 strategic sub-elements of HSEE-IMS on the six system sub-performances was as follows:

Wp1: {S, S, S, M, S, M, S, S, M, S, S, M}
Wp2: {S, M, M, M, M, W, M, M, M, M, M, M}
Wp3: {S, S, M, S, M, M, S, M, M, M, M, M}
Wp4: {M, S, M, M, M, M, M, M, M, M, M, M}
Wp5: {S, S, M, M, M, M, M, M, M, M, M, M}
Wp6: {M, S, S, M, S, M, S, S, M, M, S, S}

By putting the scores of each HSEE-IMS sub-element in the final weight distribution of each system sub-performance, the overall performance of HSEE-IMS in each system sub-performance was achieved (Table 5). The numerical value of sub-performances in annual performance of the management system were not significantly different from each other (Figure 6).

Table 5. The performance evaluation of HSEE-IMS in terms of system sub-performances during 2014-2019.

Time/ Sub-performance	P1 (Policy and commitment)	P2 (Planning)	P3 (DO)	P4 (Check and review)	P5 (C.I)	P6 (HSEE risk management)
2014-2015	57.25	58.916	59.785	58.44	59.65	56.1
2015-2016	58.875	59.08	58.964	59.32	59.346	59.35
2016-2017	87.64	88.15	87.52	86.624	87.14	87.5
2017-2018	97.7875	98.06	97.757	97.808	97.9	97.91
2018-2019	66.88	65.88	66.81	67.52	65.89	68.98

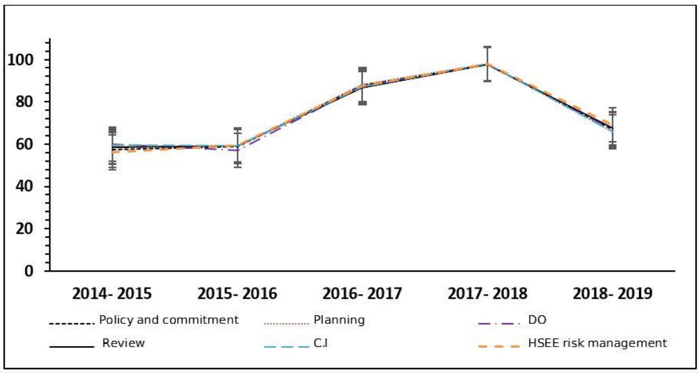


Figure 6. The comparison of sub-performances of the HSEE-IMS performance during 2014-2019.

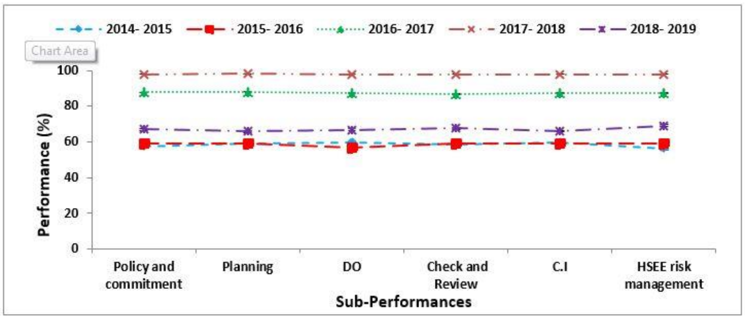


Figure 7. The growth rate and changes of sub-performances of the HSEE-IMS performance during 2014-2019.

4. DISCUSSION

Based on the FCM results, the sub-performance of leadership and management commitement (P1) was considered the first priority, and the two HSEE-IMS sub-elements including; implementation and development of HSEE management (O2), the review of policies, programs and authorities (H1) were categorized into the second priority (Figure 3). These two sub-elements are strongly influenced by the P1 sub-performance (Books, 1997). The sub-elements of environmental management (E1) and optimization of the energy consumption (E2) were categorized into the 5th category due to having low weight distribution compared to the other ones, and may be including in the operational levels of a HSEE-IMS. It was elicited that, there were different levels in integrity formalization of a sustainable management system (Abrahamsson et al., 2010). Commonly, the goals and strategies were closed to each other in the strategic, tactical and technical levels. But in the lower levels of activities, the actions were very specific and their inheritance was distinguished. Thus, the intensity of integration may decrease in the operational level (Sellak et al., 2017). In other words, the higher closeness and integration, the higher weight and rank in the performance assessment process.

By given results of the RDA technique (Tables 1 to 4), the relevant coefficients (r0i) of O_1(organization framework and structure), H_1, and C_1 (education and culture promotion) were 0.98, 0.93, and 1 respectively. The inherent relation between the education, culture, and strategic policies in the management system was described as a supportive and promoted relation of three mentioned sub-elements with each other, resulting in the considerable enhancement of the relevant coefficients and synergy effect of the intended sub-elements. Also, the lowest relevant coefficients were designated to the E_1 (0), F_2 (0.32), E_3 (0.35). The decrease in the r0i value of the mentioned sub-elements was due to the lower priorities of them in the strategic priority ranking and programms during 2014-2019. However, due to the less matching with the real performance during 2014-2019, those sub-elements (E_1, F_2, E_3) were reviewed (Kang et al., 2016) and the related relevant power with the programms and policies were confirmed again (Council, 2011).

The comparitive results of FCM and RDA techniques (Figure 5) showed a positive influence of HSEE-IMS sub-elements on the system sub-performances resulting from the quantity and quality of O1 and H1. The synergistic effect of sub-elements (O1 and H1) and sub-performances was resulted in a high relative coefficients of O1 (0.98) and H1 (0.93). This finding described the potent relation and integrity between the HSEE-IMS sub-elements and system sub-performances, and thereby, emphasized the convergence of the results drived from the FCM and RDA (Kang et al., 2016). Two gaps were recognized between FCM and RDA findings. The first one was about C1 sub-element (Figure 5). According to the FCM results, the C1 sub-element had a positive and potent influence on two sub-performances (P1 and P6), but this was just one-third of the sub-performances weight influenced by C1 (two thirds of sub-performances influenced by C1 with a medium weight distribution), emphasizing on the different roles of each system sub-performances in the overall evaluation of system performance. In other words, the weight distribution of the sub-performances was not the same as the overall system performance and two sub-performances of P1 and P6 possessed higher distributions in HSEE-IMS of the present study. The strong correlation between the culture and organization performance was found to be important (Hult et al., 2003), since the managers of international companies have applied all of the HSE requirements by culture promotion in HSE issues, and thus, used it as a key to increase their benefit (Gholami et al., 2015; Torabi, 2016).

The next gap was found in the case of E1 sub-element. It had the minimum relative coefficient with the HSEE-IMS sub-elements and system sub-performances. Wherase, according to the FCM results, it had medium influence over all the sub-performances. This gap was related to the RDA technique in the normalization step. During that step, one of the sub-elements (with the lowest relative coefficient) has the value of zero. The designed questionnair was analyzed to clarify that gap. The result revealed the main influence of E1 sub-element on performance of HSEE-IMS. Thus, the weight value of this sub-element derived from RDA technique was increased.

The comparative results of FCM and RDA (Figure 5), showed the convergence and equality of medium weight distribution of E2, E3, and E4 over the system sub-performances.

According to the given results from performance assessment of HSEE-IMS, the system performance was found to have an ascending trend with tangible improvement during 2014-2018 and a descending trend during 2018-2019 (Table 5 and Figure 6). The improvement in the HSEE-IMS performance during 2014-2018 was due to the constant coherent management system in the organization and special support of the top management (including the minister, general managers, deputy of the minister) in attending issues and subjects related to the employee's health, environment, production and productivity.

By studing the root causes of reduction in the system performance during 2018-2019, it was found that HSEE-IMS was one of the newly founded IMS in the ministry compared to the other ones. Less supportive attitude towards the HSEE due to several changes in the top management levels of the ministry was an undeniable fact, affecting the managers commitment to consistency of HSEE-IMS, policies, plans (e.g, action plan), regulatory and control actions included in the HSEE-IMS framework and also performance promorion. Thses changes and the lack of management tendency in support of action plan during 2018-2019 broke the growth rate, and also resulted in the inverse performance improvement of 2018-2019 (reduction of performance to equally 33%) compared to the 2017-2018 (Council, 2011; Gholami et al., 2015; Mohammad et al., 2013; Rundmo, 2000). The importance of leadership and management commitement (P1) and policies in the system performance was confirmed by FCM results (Figue 3 and 4) and other reports (Carter & Greer, 2013; Jing et al., 2020; Skład, 2019). Lack of tendency to the HSEE occurs when the managers are not able to present their performance positively or if there is no interest in the system to distinguish its performance during the short times and long times (Torabi, 2016). In other words, in any principal types of changes in the organization, the integration process is not without challenge, unless the top management leads the system to an active and dynamic system, and shows its support and commitment to the system integration. Otherwise IMS faces the risk of faliure (Books, 1997; Pardy & Andrews, 2009). It was found that changes in the running process of action plan is influenced the output indicators of annual performance (Chinn & San Ramon, 2001). The weakness in the implementation of the action plan caused the poor performance in the progress of the given objectives and priorities. Also, the lack of management support may cause the attitude changes of other departments of organization, problems in cooperation between parts, expert's turnover, weakness in the monitoring programs, and lack of the external participatory.

The different performance levels were tangible during the first (2014-2015) and the last years (2018-2019) compared to other years. It may coming from the direct relation of organizational factors (external) over the specific missions of the organization. The growth and fluctuations in the sub-performances of HSEE-IMS performance during the given time duration (Figures 6 and 7) found to have a slow trend and changes in the sub-performances level compared to each other in terms of studied years (2014-2019).

The politic considerations should be applied in the core of many policies (Meijer et al., 2019). The primary cooperation of the stakeholders, and using the right political strategies in design and implementation of the policy was found to be necessary to deal with the oppositions (Abrahamsson et al., 2010; Bomheuer et al., 2020; Elias, 2019; Programme, 2004; Torabi, 2016; Živković et al., 2017) and also known as a sustainability criteria (Živković et al., 2017). Also, in the performance network of HSEE, the poor communication will result in the weak commitment to the HSEE of both senders and recievers (Asadzadeh et al., 2013). However, the influence of the top management over the subsidiary organizations was found to be higher than the influence of subsidiary organizations on the upper level of management. In fact, low category managers will lose their attention to the issues and subjects that are not followed actively by the upper managers (Meijer et al., 2019; Torabi, 2016).

Also, dependability of the HSEE programs same as the other programs on socio-economical considerations in the country were the other causes influencing every newly founded IMS (Abrahamsson et al., 2010; Živković et al., 2017). The changes in the economic policies (supply-demand chain) and limitations in the technology transfer (mainly due to sanctions), showed a performance drop in the monitoring of sub-elements particularly during 2018-2019. It has been reported that there is a direct relation between IMS implementation and economic performance trend in companies (Ionescu et al., 2018).

There was found a strong relationship between HSEE-IMS sub-elements and system sub-performances. The findings showed that poor performance of the sub-elements in the strategic and tactical levels same as the other IMS will result in the poor performance in the technical and operational levels (Tehrani & Izadshenasan, 2019).

5. CONCLUSION

The performance assessment of the strategic indicators included in the HSEE-IMS of a ministry was studied using FCM-RDA technique. Based on the given results from FCM, the system sub-performance of policy, leadership and commitment ranked as the first priority and influenced other system sub-elements and sub-performance significantly. It was found that the sub-performances had a close relationship with each other in the annual overall system performance and thus there was an integrity within them. It was concluded that the integrity of actions were aligned with the integrity of strategies.

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Appendix

Table 1. FCM connection matrix

		Organization framework	Review of policies, programs and authorities	Implementation and development of HSEE management	Preparation and distribution of the national and international requirements and procedures of the HSEE	Education and cultural promotion of HSEE	Health promotion of employee	Recognition of hazard centers and accident management	Emergency response planning	Environmental management	Optimization of energy consumption	Continuous monitoring	Communication and participation (internal and external)	Policy, leadership, and commitment	Planning	Do	Check and review	Continuous improvement	Risk management of HSEE
		O1	H1	O2	H2	C1	C2	F1	F2	E1	E2	E3	E4	P1	P2	P3	P4	P5	P6
Organization framework	O1		S	S	S	S	M	M	M	M	M	S	S	S	S	S	M	S	M
Review of policies, programs and authorities	H1	S		S	S	S	S	S	S	S	S	M	S	S	M	S	S	S	S
Implementation and development of HSEE management	O2	S	S		S	S	S	S	S	S	S	S	S	S	M	M	M	M	S
Preparation and distribution of the national and international requirements and procedures of the HSEE	H2	S	S	M		S	S	S	M	S	S	M	M	M	M	S	M	M	M
Education and cultural promotion of HSEE	C1	M	M	M	M		S	M	S	S	S	M	S	S	M	M	M	M	S
Health promotion of employee	C2	M	M	M	M	M		M	M	M	M	S	M	M	W	M	M	M	M
Recognition of hazard centers and accident management	F1	M	S	S	M	M	M		S	M	M	S	M	S	M	M	M	M	S
Emergency response planning	F2	M	M	M	M	M	M	S		M	M	M	M	S	M	M	M	M	S
Environmental management	E1	M	M	M	M	M	M	M	M		W	M	M	M	M	M	M	M	M
Optimization of energy consumption	E2	M	M	M	M	S	M	W	W	M		S	M	S	M	M	M	M	M
Continuous monitoring	E3	M	S	M	M	M	M	M	M	M	M		S	S	M	M	M	M	S
Communication and participation (internal and external)	E4	M	S	M	M	M	M	M	M	M	M	M		M	M	M	M	M	S
Policy, leadership, and commitment	P1	S	S	S	S	S	S	S	S	S	S	S	S		S	S	S	S	S
Planning	P2	S	S	S	S	S	S	S	S	S	S	S	S	M		S	S	S	S
Do	P3	S	S	S	S	S	S	S	S	S	S	S	S	M	S		S	S	S
Check and review	P4	M	S	S	S	M	M	S	M	S	M	S	M	S	S	M		S	S
Continuous improvement	P5	S	M	S	S	S	S	S	M	S	S	S	S	M	M	M	S		M
Risk management of HSEE	P6	M	S	M	M	S	S	S	S	M	M	M	M	M	M	M	S	M	