Integrated Management Framework for Tackling Better Environmental Performance

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***Abstract*— over the past decades, quality management, environmental management / performance, occupational health and safety and sustainable products have become one of the main concerns of organizations managers. Integration of management systems is the way to overcome the drawbacks of separate implementation. This paper proposes a framework for the integration of different management systems and developing an evaluation method for the degree of implementation of different management practices that cover different stakeholder's requirement, sustainability management and the degree of integration of different management systems. On the other hand an evaluation method for the degree of products sustainability produced from such integrated system, considering the environmental, economical, and social impacts of the products upon life-cycle. To do so, mathematical tools that allow assessing the weight of different items of the framework starting with the degree of integration and implementation of different management practices was proposed. also the degree of sustainability of the products. In this study fuzzy analytic hierarchy process (FAHP) methodology is used to determine the relative importance of each element and sub elements in the framework. The weight of elements and sub elements in the framework is based on pairwise comparison of the elements in the framework with the help of expert in the field studied. This methodology does not require the generation of rules which simplify the process and makes it more precise. This study helps organizations to evaluate the real level of integration of different management systems, stakeholder's requirement and sustainability management. Also recognizing the differences between the desired and current status of implementation of different management practices. Moreover the evaluation of the degree of products sustainability. These evaluation methods identify the improvement areas and develop the strategies for the sustainable development implementation.**

Keywords*— Integrated management systems; Environmental performance, Sustainable development, Fuzzy AHP

I. INTRODUCTION

Over the past decades, quality management, environmental management / performance and occupational health and safety have become one of the main concerns of organizations managers. Sustainability and sustainable development are becoming an important topics among the managers of every organization, not only because of environmental and eco-systems crisis but also because of the high competitiveness in the markets.

Sustainable development is a pathway toward sustainability which introduced a new paradigm for product / service / process development [1]. The advantages of sustainable development are market expansion, environmental sustainability, improving organizational performance; increasing production capacity and flexibility and improve aspects of health and safety.

"Curtis & Walker [2] defined sustainability as Balancing social, ethical and environmental issues alongside economic factors within the product or service development process to ensure that the needs of both the business customer and society are met while protecting the ecosystem.". Also, the concept of sustainability have been defined or described in many other researches [2], [3] & [4]. The different definitions of sustainability from research to another depend on the goals of research or the context of application.

There is an increasing awareness about sustainability and sustainable development, and it is not surprising that a quantifiable sustainability rating would one day be required for all the manufactured products via some obligatory regulations (like energy efficiency labeling for electronic appliances) [1].

Also, quality, environmental and health and safety management systems support organizations to achieve sustainability considering the economical, environmental and social needs of different stakeholder's, internal and external in a balanced and sustainable way.

Quality, environmental and health and safety management systems are used to be implemented separately. In the last years it has been seen that separate implementation is an effort wasted with excessive bureaucratic, costs and redundancies.

In this context, to improve the overall management system efficiency, create sustainable competitive advantages and to overcome of the drawbacks of separate implementation of management systems, many researchers has cautioned to the importance of the integration [5], [6], [7] [8], [9] & [10].

Different management frameworks and models have been proposed. At this point, an important issue arising whether these frameworks and models cover different management practices in different organizations reflects the real level of integration, managing different stakeholder requirements, and can be evaluated mathematically.

In this research to facilitate the integration process, insure the sustainability of different processes in the organization and also satisfying the demands of critical stakeholder's, it is required to develop a framework for integrating different management systems.

Hence, the aims of the research are, producing such framework and developing an evaluation method for the degree of implementation of different management practices that cover different stakeholder's requirement, sustainability management and the degree of integration of different management systems. On the other hand an evaluation method for the degree of products sustainability produced from such integrated system, considering the environmental, economical, and social impacts of the products upon life-cycle.

Framework assessment methodology using mathematical techniques by integrating fuzzy analytical hierarchy process (FAHP) - instead of using fuzzy rules generation which is time consuming and also can lead to redundancy and inaccuracy especially in large number of factors- and Shannon's entropy formula was implemented in this research to measure the disorder in a set of collected data. Also the uncertainty degree of the experts, such method was used before in different researches, but didn't used before in the evaluation of degree of integration, to produce a quantifying evaluation method for the degree of integration instead of the evaluation on the base of qualitative measures.

The framework was presented in a hierarchy form, for the evaluation method using FAHP technique.

The proposed FAHP uses the triangular fuzzy numbers as a pairwise comparison scale for deriving the weight of different elements and sub elements in the hierarchy.

Also, these weights for different elements and sub elements in the integrated management system (IMS) hierarchy and the product sustainability hierarchy can be used by different organizations to evaluate the integration process and the degree of product / process sustainability level based on acquired weights.

Thus, the IMS and the sustainability level of products will be translated into numbers that can help decision makers to decide on intelligible and tangible measures. This method is not only for counting the level of integration and sustainability of a product but also toward sustainable manufacturing.

II. Literature review

Integrated management systems

Over the last decade, management systems standards are more aligned. This alignment is characterized by a common base, the PDCA cycle (Plan, Do, Check, Act) of continual improvement that supports the structure of ISO 9001 QMS, ISO 14001 EMS, and OHSAS 18001 OHSMS "[5], [8] & [10]".

According to [11] "An IMS is a construction to avoid duplication of tasks that aims to take advantage from the elements common to two or more separate systems, putting them to work together in a single and more efficient IMS".

At the last decade, several researchers have studied the field of IMSs, from different perspectives, such as motivations, drivers, benefits and drawbacks. This can be seen in the work of [7], [10] & [12] integration levels by [13], [9] also the field of audits integration in the work of [14], [15] integration strategy in the work of [5], [12] and models for integration process [16], [8].

The findings of benefits of integration showed that it is not separated from the drivers and motives of integration which include the improvement of organizational efficiency from two ways. The first one are the internal benefits such as (task simplification, human resources saving, time, higher transparency…etc.). The second benefits are external ones such as (company image, competitiveness…etc.) also Increase of organizational efficiency (cost reduction, saving time…etc.) [17], [6], [8], [9] & [10].

There are different studies investigated the level of integrating among them, the work of [13] which stated that the integration is achieved by integrating the three main elements of the system: objectives, resources and procedures. Despite of the difference approaches and elements of the integration, most of them classified the IMS into three levels of integration [18], [19], [20], [21], [22] & [9].

Moreover, ISO had publication in 2008 a handbook that provides guidelines for integration of management system standards. Also in Both ISO 9001:2015 (QMS) and 14001:2015 (EMS) were revised based on the guidelines of Annex SL, to promote compatibility between the various standards [23].

Sustainable development through IMSs

Organizations working in a turbulent environments characterized by limited recourses and high competitiveness, this requires from organizations to develop their management systems.

There are more and more organizations that have more than one certification and looking forward to integrate their management systems [24]. In order to meet the requirements of the interested parties and high competitiveness, there is an increase in the number of organizations looking forward for certification of quality management systems [13].

Moreover there is a growing belief that the integration of multiple MSs with its holistic view of a business context encompasses all management activities, both certifiable and non-certifiable, adds value and, thus, enhances the sustainable development (SD) of organizations [25].

According to [21] the integration level of management systems is the procedure for measuring the degree of sustainability of MSs. So the integration of MSs isn't in itself a mark of sustainable MSs. Also the motives and drivers for integration are the keys for the success of the integrated systems [12].

There is an increasing pressure on organizations to integrate SD with quality management systems (QMSs), this pressure from both internal and external interested parties. In response to this pressure many organizations adapted the "triple bottom line" (TBL) [26] of their overall economic, environmental, and social performance, in a balanced and coherent way. Hence, to implement SD the focus must be placed on the integration of internal MSs [25].

A lot of the requirements of the different MSs can be integrated to lower costs, less work, improve operations and better product/ processes/ service. Hence, optimizing resources in line with the Triple Bottom Line perspective and considering the SD regarding economic, social and environmental aspects.

Though, in order to create competitive advantages for the organization and contribute to a sustainable development, the IMS has to be expanded to include the whole product chain and all stakeholders.

It is essential to take into account when investigating the life cycle of a product/ process/ service the interrelations between the operational areas for instance, the negative environmental impact of a product/ process/ service must be considered in relation to the improvement on quality, occupational health and safety.

According to [27] IMS is argued to be a means of reducing redundancies and managing resources efficiently. Further, an integrated management system is seen as a way to identify aspects of a QM system that could be supportive to sustainability in general.

The implementation of an IMS is currently a strategic decision of a significant importance for the competitiveness and sustainability of organizations.

Integrating sustainability management with IMSs

There is an increasing pressure on managers in many organizations to address the issue of sustainability SD.

According to [28] the MSs for quality, environmental, corporate social responsibility, and occupational health and safety can help managers to systematically address organization's key stakeholder requirements. These MSs are not systematically addressing stakeholder requirements but also providing an interesting leverage points for integrating sustainability issues into mainstream business processes.

A conceptual model presented by [29] for stakeholder's management, expanding on the relationship between organizational sustainability and global sustainability. The authors considered stakeholder's to be "actors that provide essential means of support required by an organization; and could withdraw their support if their wants or expectations are not met". According to [29], satisfying the demands of critical stakeholder's is the way to organizational sustainability.

However, even though there are a lot of measuring tools for implementing and maintain the elements of sustainability. The question is how to integrate sustainability into the day-to-day operations of organizations through their integration of different QMSs.

The framework for corporate sustainable development through an IMS approach was developed by [28], [30], to integrate sustainability into organizations through their integration of different QMSs.

Integration performance measurement

Performance assessment of IMS is an emerging research topic. Karapetrovic and Willborn [31] introduced the notion of an "integrated performance management system". In the research of [32] the authors recommended to establish a performance measurement system in parallel with the integration of MS.

Tarí, Juan José and Molina-Azorín, José F. [33] proposed the use of the European Foundation for Quality Management (EFQM) model to integrate both QM and EM systems and also to measure the IMS. In a case study by [34] in an airline company the author developed an integrated performance measurement model and emphasized on the importance of evaluation regarding long-term effectiveness of an IMS on an organization's overall performance.

Nikolaou, Ioannis E. and Tsalis, Thomas A. [35] proposed the “Sustainability Balanced Scorecard” based on this concept to integrate stakeholder management as well as environmental and social performance within the balanced scorecard to successfully support a corporate sustainability strategy.

Tsai, Wen Hsien and Chou, Wen Chin [36] developed a novel model of prioritizing available management systems and selecting optimal management systems under resource constraints, for sustainable development.

III. Framework for Integrated Management System

To facilitate the integration process, insure the sustainability of different processes in the organization and also satisfying the demands of critical stakeholder’s, it’s required to develop a framework for integrating different management systems.

Several researches in the field of IMS implementation proposed different strategies, which led to different integration levels. As a matter of fact, one of the major concerns of organizations is about the real assessment of integration level, the sustainability of the management system and the expected level of the organization sustainable performance. The current framework intends to contribute to fulfill this scientific “gap” and deals, finally, with the question on how companies may assess their IMSs and their sustainable performance and manage their activities and MSs in order to avoid wastage of resources.

For insights into how such a framework may be approached, to provide the needs of different stakeholder’s, expectations and requirements which are the way to organizational sustainability. Organizations implemented individual MSs such as (ISO 9001) for quality management, (ISO 14001) for environmental management and (OHSAS 18001) for occupational health and safety management, those covering the areas of quality, environment and occupational health and safety which are adopted in this research. To improve the overall management system efficiency and to overcome the drawbacks of separate implementation of management systems, there is a need to integrate them into an overall IMS.

From this point, a framework for IMS will not only be the integration of documentation and procedures of different MSs such as in previous researches, but also consists of the special requirements of different practices of different MSs which covers the demands of diverse stakeholder’s. Moreover, the sustainability management practices to insure the organization target, of sustainable performance.

From the previous words and the literature review a framework for an IMS for better sustainable performance is proposed as shown in fig.1.

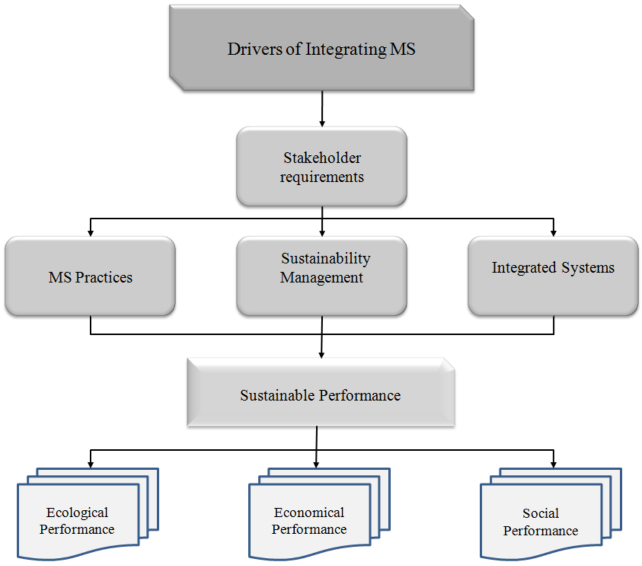

Fig.1: Framework for an IMS for better sustainable performance

The development of the framework and its assessment of the degree of implementation of different management systems and the degree of sustainability depend on a number of methods. The initial process of literature review provided some insights on the identification of the critical success factors of an IMS and its KPIs that influence the degree of implementation. Also the framework builds on previous research conducted by:

- [19], [22], [21, those who highlighted various levels of integration.
- Authors [28], [21], [37], provided the guidance needed to integrate the sustainability concept into business processes.
- Papers [38], [28] stated that organizations must address the needs of several different stakeholder’s.
- 39], [40], [41], [42], [43], [44], [45], [46], [47], [48], [49] are those who studied the relation between quality, environmental and health and safety practices on organization performance.
- References [1], [50], [51] addressed organizations need to clearly consider the environmental, economical and social impacts of their activities.

The conceptual framework in Fig.1 shows that organizations may implement different MSs.

The essential feature of an IMS is that it develops an integrated system to address stakeholder demands in a systematic manner. This is labeled as "integrated management systems" in Figure (1). Because of the increasing pressure on managers in many organizations to address the issue of sustainability and sustainable performance, this is shown in the framework by the label "sustainability management practices".

The last part of the framework represents one of the main goals of the research which is sustainable performance and its "environmental, economical and social" impacts.

In the next section a detailed explanation for the main elements of the framework and the KPIs of each item in the framework.

Management practices:

This part of the framework covers three types of management practices among them quality management, ISO 9001 is a quality management system standard used by many organizations, whether in the manufacturing or service sectors. It is preferred by many organizations whose objective is to implement, manage and improve their processes continuously in accordance with stakeholder's' needs and expectations. The main aim of this standard is to ensure the quality of systems in which goods and services are produced. As it can be seen, the ISO 9001 standard is mainly focused on quality issues. The KPIs adapted in this research for the measurement of individual management practices related to specific quality issues are as follows:

1. Top management commitment
2. Customer orientation
3. Quality system processes
4. Human resources applications
5. Supplier relations
6. Process control and improvement

Environmental management system practices

ISO 14001 is an environmental management system designed to manage the environmental impacts of organizations and reduce the environmental risk associated with organizations activities. Hence, the implementation of ISO14001 has considered one of the most important elements of corporate sustainability. This can be seen in the research of [39], [40], [41], [42], [43], [44], [45], [46], [47]. Also the KPIs and influencing factors adapted in this research for the measurement of individual environmental management practices issues are as follows:

1. Top management commitment
2. Collaboration with customers and suppliers
3. Environmental assessment
4. Plans and procedures to identify and respond to environmental accidents
5. A formal, detailed system is used to consider environmental issues in manufacturing process
6. Communication
7. Training
8. Environmental management technical aspects
9. Internal / external audits
10. Environmental accounting / public environmental report.

Occupation Health and Safety practices

OHSAS 18001 standard is an occupation health and safety assessment series for health and safety management systems. It is anticipated to help an organization to control occupational health and reduce safety risks. In different researches there is a confirmation on the importance of the occupation health and safety management practices and its close relation to environmental practices and on the overall organizations productivity [48], [49]. The KPIs, and influencing factors adapted in this research for the measurement of individual occupation health and safety management practices related to specific OHSAS issues are as follows:

1. Top management commitment.
2. Safety training.
3. Workers' participation.
4. Safety channel for communication and feedback.
5. Safety rules and procedures.
6. Safety promotion policies.

Integrated systems

According to [19] "Obviously, integration means different things to different people, even if we restrict our discussion to function specific management systems only". There are different levels or degrees of integration; the highest level is the one that describes a true IMS. A number of taxonomic proposals for the levels of integration of different management systems have proliferated under this paradigm. The definitions of these levels are based on certain characteristics of the resulting IMS [9].

Regardless of the number of integration levels, most of the published researches propose taxonomies of three levels of integration. Because it means different things to different people our research propose a quantifying method to measure real levels of integration.

Most of the previous taxonomic proposals have been presented from a theoretical perspective. Consequently, there is a shortage of empirical studies dealing with the characteristics of integration levels [9].

Similar to previous studies on IMSs [22] the key variables used to identify and characterize the different integration levels of the IMS are the integration objectives and written documentation and procedures.

Many researches claim that efforts should evaluate IMSs so that a more globally accepted definition based on objective criteria can be obtained [52], [33].

The proposal in this research is to produce a new taxonomic proposal for the most known taxonomic levels of IMS (no integration, partial integration and full integration) using FAHP methods for more objective measures of the real level of integration and for more useful method for the evaluation of the integrated system based on weights obtained.

Documentation and procedures adapted in this research are as follows:

Documentation and goals

Policy, Records, Objectives, Manual, Procedures and Instructions

Procedures

Planning, Internal and external audits, Management review, Control, nonconformities, Preventive and corrective action, Product realization, Resource management, Determination of requirements, Improvement, Document control, Record control and Internal communication.

Sustainability management practices

There is, nevertheless, a need to explore how organizations can capitalize on their experience with standardized MSs to more systematically integrate sustainability issues throughout the organization, and to assess the success or failure of the integration of different MSs and satisfying demands of critical stakeholder's.

The measurement of corporate sustainability has been the focus of numerous studies [28], including [53], [54], [55], [30]. Also [56] provides a recommended framework for organizations interested in reporting on their sustainability performance.

The main KPIs and its sub elements to evaluate the extent of integration of sustainability management practices in this research are:

Management of corporate sustainability

Policy practices

1. Mechanism for identifying, meeting stakeholder requirements.
2. Implications of economic, ecological, and social aspects are understood by individuals.
3. A mechanism to identify sustainability indicators and whether it achieves the company objectives and goals
4. Defining new projects of the organization for sustainability.

Set integration plans

1. Defining the norms and values for corporate sustainability of the organization.
2. Facilitate the resources for integration (human, financial, material, informational, and infrastructural).

Integration methods of key elements

1. The quality manuals and procedures address social, ecological, and economic aspects in an integrated manner.

Developing competencies (competencies and empowerment)

2. Facilitate resources for updating its knowledge about sustainability.

Evaluation and monitoring

3. Employing mechanisms to evaluate the outcomes of integration.
4. The assessment teams have the required competencies.
5. The management reviews carried out regularly to evaluate the stakeholder requirements and the extent of integration.
6. A mechanism for communication, reporting for sustainability outcomes.

Feedback and innovation

1. Employing mechanisms for continuous improvement.
2. The previous experiences incorporated into organizational business process.
3. Ensuring that learning to be sustainable and responsible remains an essential strategic imperative and not an ad hoc process or a one-time activity.

Sustainable performance

Organizations need to clearly consider the environmental, economical and social impacts (positive and negative) of their activities [57], [58], [59]. Those concepts are also symbolized in literature by "3 Ps (People, Planet, and Profit)" which means that an organization can create more values and reduce risks if it takes into consideration the social (people), environmental (planet), and financial issues (profit) as compared to other organizations that focuses merely on the profit.

There is a lot of definitions for sustainability, [73] defined sustainability as “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” Also, sustainability is defined or described in many other researches as “improvement of the quality of human life” [4], [3], [60]. Generally, sustainable product is the product that has little potential impact on the environment [50], [61]. However, a “sustainable product” is a subjective term and includes a large variety of environmental, economical and social considerations [62].

Environmentally friendly manufacturing has become an important issue in different manufacturing organizations all over the world [50]. Consequently, the manufacturing of a sustainable product can help organizations to move toward sustainable manufacturing. The assessment of the degree of sustainability is the first step for sustainable product. In this context, different methodologies for assessing the product sustainability considering -environmental, economical, and social sustainability- one, two or an integration of all three dimensions of sustainability have been developed by various researchers.

To this aim, there are a lot of methodologies, and tools that have been developed to help designers to assess the impact of processes or manufactured products during their life-cycle. These tools are known by life-cycle assessment (LCA): methodological frameworks which are usually generalized and mostly concentrated on environmental aspect only [1].

Eco-design techniques are another way that designers can use to reduce the environmental impact of their new products at the early stage of design. Eco-design techniques include guidelines, checklists, and MET (Material, Energy, and Toxicity) matrix. However, these techniques are not widely adopted by industries since they are not generic and require specific forms of customization prior to use [1].

In the research of [63] the authors proposed a simplified LCA method integrated with eco-design techniques for a rapid sustainability assessment at the early stage of design. This method focused only on environmental aspect. Yet, the crucial objective of sustainable development is the full integration of environmental, economical, and social aspects into the whole life cycle [64].

The authors [65] developed a hierarchical structure evaluation methodology to assess the sustainability content of any given manufactured product. This new method considers all three aspects of sustainability, and each aspect subdivided into its sub elements over its total life cycle (pre-manufacturing, manufacturing, use and post-use). Finally a sustainability index developed using aggregation of different levels of the hierarchical.

In the research of, [1], [50] the authors proposed a sustainability index that covers the three dimensions of sustainability (environmental, economical, and social). In their work, a weighted fuzzy assessment method for product sustainability assessment was developed. Fuzzy analytical hierarchy process was used to weight selected elements and sub elements. Then, fuzzy logic using fuzzy roles was utilized to assess the influencing factor on product sustainability level based on acquired weights in the work of 50]. In the work of [1] a decision making algorithm was used based on analytical hierarchy process (AHP) to determine the relative importance of each element in the hierarchy.

Based on the main goals of the research which is sustainable performance and its “environmental, economical and social” impacts, and the above review of literature, KPIs of sustainable performance and sub elements and influencing factors are:

Ecological performance indicators

1. Reducing solid/ liquid waste
2. Air pollution index
3. Energy consumption index

Economical performance indicators

1. Direct Cost Index
2. Indirect cost index
3. Recyclability index
4. End of life index
5. Legislation index

Social performance indicators

1. Occupational Health Index
2. Workplace environmental index
3. Safety risk index

IV. MEASUREMENT AND ASSESSMENT OF THE FRAMEWORK

Review on the assessment methods:

One of the important advantages of using Fuzzy methods is its capability to handle severe uncertainty and ability to evaluate simultaneously, qualitative and quantitative data regarding the sustainability parameters [66], [50], [1].

The researchers [66] used the application of fuzzy AHP to investigate the criteria and attributes that determine a successful adoption and implementation of cleaner production in reference to Printed Wire Board manufacturing in Taiwan.

In the work of [50] the researchers implemented fuzzy AHP to assess the sustainability level of manufactured products, and focused on the weighing of sustainability elements and their sub elements, but they applied fuzzy rule-base technique with fuzzy AHP. Using fuzzy rule can result in generation of an excessive number of rules which is very exhausting and polemic with large number of variables.

But in the work of [1] the researchers used a fuzzy-inference system to evaluate product/process sustainability. The proposed method does not require generation of rules which simplifies the procedure and makes it more precise. Furthermore, fuzzy AHP was employed to determine the relative importance of each element in the hierarchy.

Zhang, Weiqian, Wang, Weiqiang and Wang, Shoubing [51] proposed an environmental performance evaluation system that enables quantitatively assessing quantitative and qualitative masseurs that affect on EMS in the coating industry. Fuzzy AHP was employed to determine the relative importance of each element in the hierarchy.

From the last Literature review on sustainability assessment, there are different methodologies and different focuses, just one or two dimensions of sustainability was studied in some researches. In addition, some others focused on all three dimensions, weighing of sustainability elements and sub elements using Fuzzy AHP nominated by different researches as an effective method. Also Fuzzy AHP was used to assess different management practices in a hierarchy form.

A lot of researches on different aspects of IMS have been also accomplished in the field of sustainability and sustainable performance. Different models and framework have been produced.

Currently, there aren't researches producing such a framework for integrating different management systems toward achieving more sustainable performance. This framework differentiated between integrated and non integrated practices in such away to facilitate the process of assessment of different practices of different management perspectives and also integrated the sustainability management practices. The framework was presented in a hierarchy form, for the evaluation method using FAHP technique.

Moreover, such hierarchy of the framework presented in this research to assess the overall degree of integration was not produced before. In addition, this research produces two tools for assessment of such a framework. The first one is for the integration part of the framework and the second is for the assessment of sustainable performance.

The next section presents the development of the assessment tool produced from this research.

Framework hierarchy

Sustainability means the interaction of environmental, economical, and social aspects simultaneously [67]. At the same time, each item of sustainability aspects involves several elements.

To better evaluate the framework in terms of degree of integration and also the sustainable performance in terms of sustainability evaluation, the aspects of integration are: management practices, integrated systems, sustainability management practices and the sustainability aspects, which can be interpreted in the form of 4 and 3 levels hierarchical structure for integration and sustainability respectively as shown in fig. (2), (3).

For the degree of integration assessment, level 4 in the hierarchy indicates the overall integration assessment level. Level 3 elements represent the sub elements of the integrated system "management practices, sustainability management and integrated systems". Level two represents the sub elements of management practices, sustainability management and integrated systems. Level one represents the KPIs of quality management, environmental management; OH&S management practices also the integrated system elements (Documentation and goals, Procedures) in addition to sustainability management practices.

Regarding the degree of sustainability assessment, level 3 in the hierarchy indicates the overall sustainability assessment with presenting aspects "environmental, economic, and social". Level one represents the influencing factors that affect sub elements of sustainability of the product. Level 2 correspond to sub elements of sustainability elements. The KPIs of the integration assessment and the sustainability assessment aspects shown in table 1, 2. The selection of KPIs of the integration assessment and the sustainability aspects are based on literature review that studied similar cases and reviewed with experts in the field of study.

Covering all KPIs of different management systems and all issues regarding IMSs all issues regarding sustainability elements and covering all parts of the products life cycle in a one framework with the proposed method of assessing the degree of integration and the degree of sustainability, is very difficult and can be unpractical, because of the variety of issues in different organizations and in different industries.

Establishment of such hierarchical structure for both the integrated framework and the sustainability assessment is an essential key factor in order to have a reliable sustainability assessment for the product and a reliable degree of the integrated management practices and different quality management practices.

The steps used to find the relative weights of the elements of both hierarchies are as follows:

Step 1: Start from level 1 in the hierarchy. For each group of KPIs and its sub elements, collect the relative importance pairwise comparison matrices. These pairwise comparison matrices are collected from the multiple experts. Let $\boldsymbol{E_k}$ (k = 1 , 2 , . . . , m) be the number of experts, and $\boldsymbol{C_i}$ (i= 1 , 2 , . . . , n) be the n KPIs and its sub elements in the level. Consequently, the comparison matrix for each expert ($\boldsymbol{E_k}$) is obtained as Table 3.

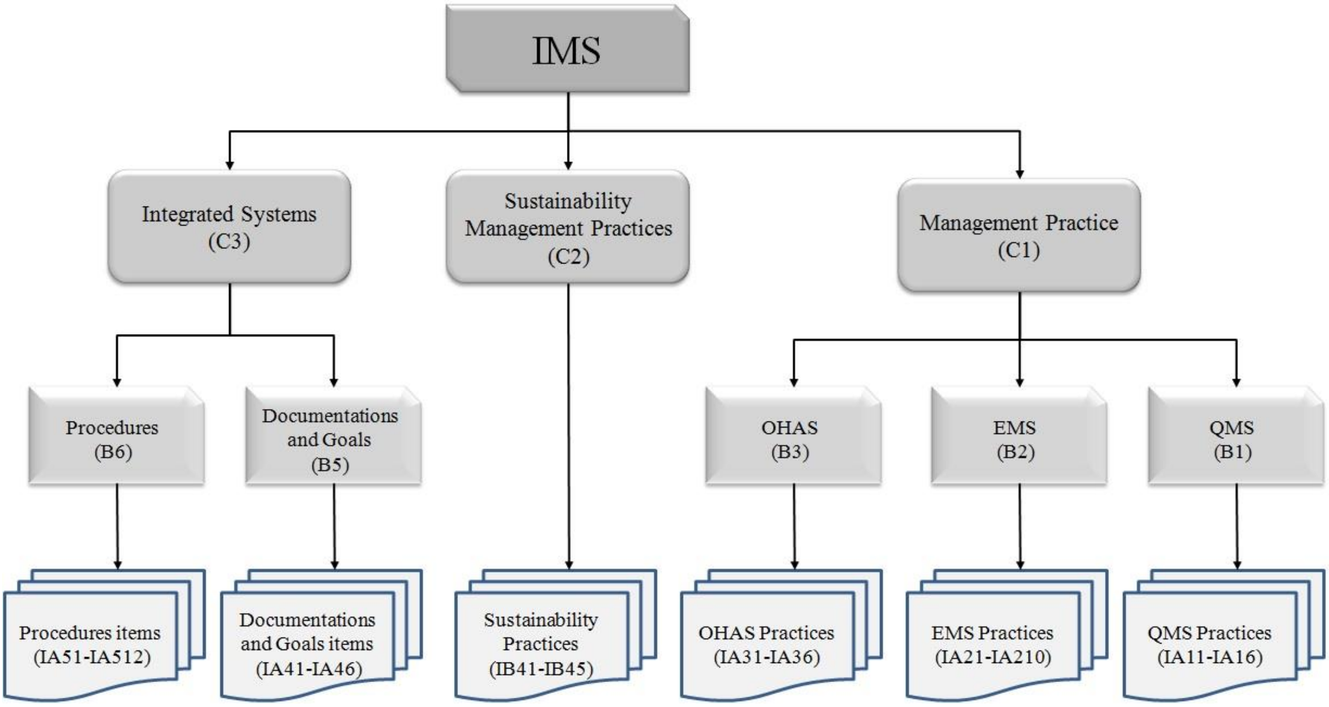

Fig.2: Four levels hierarchical structure for integration

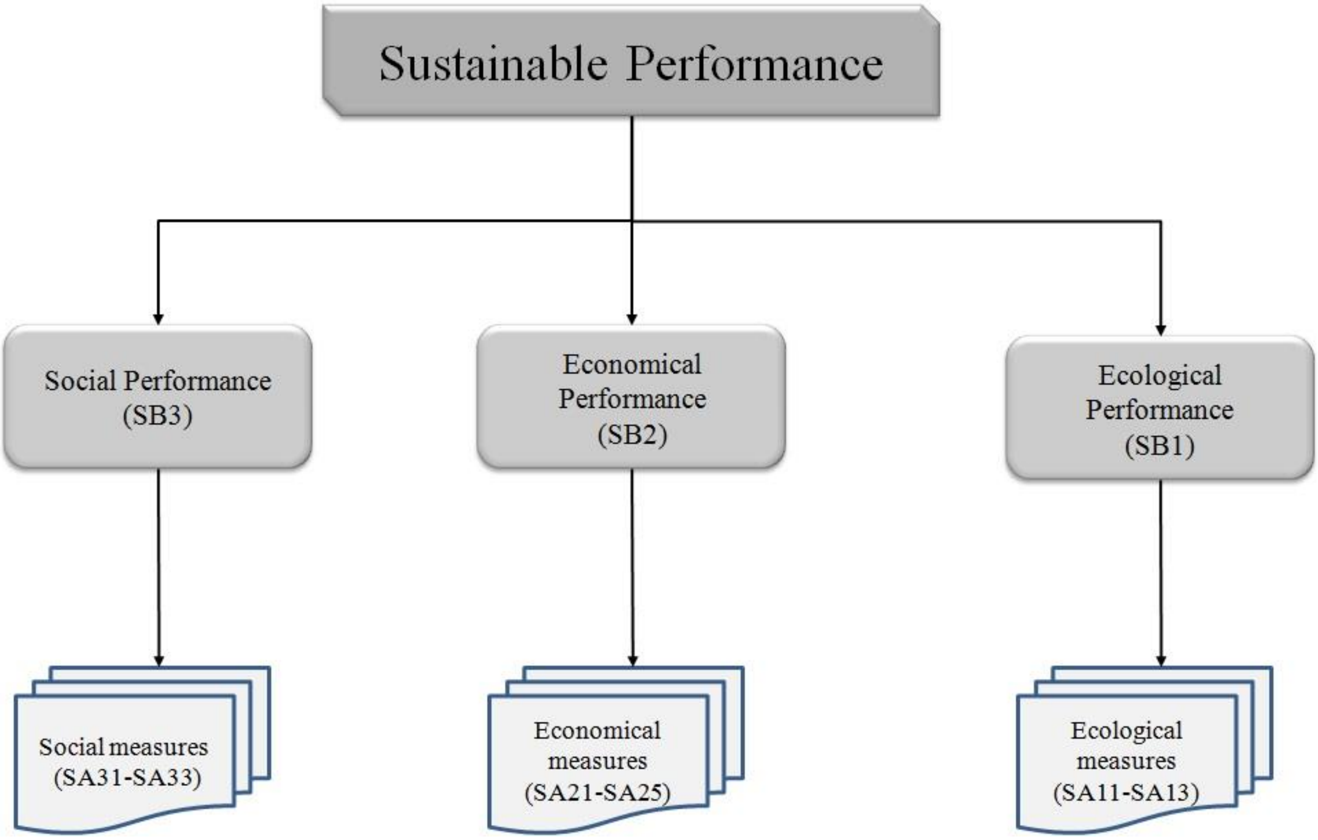

Fig.3: Three levels hierarchical structure for sustainability

TABLE 1. Hierarchy levels and its KPIs for the IMS.

Total degree of integration (level 4)	Integration elements (level 3)	Integration sub elements (level 2)	KPIs of sub elements (level 1)
	Management practices (IC1)	Quality management (IB1)	Top management commitment (IA11)
			Customer orientation(IA12)
			Quality system processes (IA13)
			Human resources applications (IA14)
			Supplier relations(IA15)
			Process control and improvement (IA16)
		Environmental management (IB2)	Top management commitment (IA21)
			Collaboration with customers and suppliers (IA22)
			Environmental assessment (IA23)
			plans and procedures to identify and respond to environmental accidents (IA24)
			A formal, detailed system is used to consider environmental issues in manufacturing process (IA25)
			Communication(IA26)
			Training (IA27)
			Environmental management technical aspects (IA28)
			Internal / external audits (IA29)
			Environmental accounting / public environmental report (IA210)
		OH&S management (IB3)	Top management commitment (IA31)
			Safety training (IA32)
			Workers' participation (IA33)
			Safety channel for communication and feedback (IA34)
			Safety rules and procedures (IA35)
			Safety promotion policies (IA36)
	Sustainability management (IC2)	Management of corporate sustainability (IB41)	
		Integration methods of key elements (IB42)	
		Developing competencies (IB43)	
		Evaluation and monitoring	

		(IB44) Feedback and innovation (IB45)
Integrated systems (IC3)	Documentation and goals (IB5)	Policy (IA41) Records (IA42) Objectives (IA43) Manual (IA44) Procedures(IA45) Instructions (IA46)
	Procedures (IB6)	Planning (IA51) Internal and external audits (IA52) Management review (IA53) Control of nonconformities (IA54) Preventive and corrective action (IA55) Product realization (IA56) Resource management (IA57) Determination of requirements (IA58) Improvement (IA59) Document control (IA510) Record control (IA511) Internal communication (IA512)

Table 2. Hierarchy levels and its KPIs for the sustainability performance.

	Sustainability elements (level 2)	KPIs of sub elements (level 1)
Overall sustainability performance (level 3)	Ecological performance indicators(SB1)	Reducing solid/ liquid waste (SA11) Air pollution (SA12) Energy consumption (SA13)
	Economical performance indicators(SB2)	Legislation (SA21) End of life (SA22) Recyclability(SA23) Indirect cost (SA24) Direct Cost (SA25)
	Social performance indicators(SB3)	Occupational Health (SA31) Workplace environmental (SA32) Safety risk (SA33)

Table 3. Comparison matrix by expert (E_k) for n given KPIs.

Expert E_k	C_1	C_2	….	C_N
C_1	*Je*			
C_2		*je*		
….			*je*	
C_N				*je*

Table 4. The relative importance variables and their corresponding fuzzy numbers.

Relative importance value	TFN	Reciprocal value	Reciprocal TFN
Just equal (je)	(1, 1, 1)	Just equal (je)	(1, 1, 1)
Equally more important (eqm)	(1, 5/2, 4)	Equally less important (eql)	(1/4, 2/5, 1)
Slightly more important (slm)	(5/2, 4, 11/2)	Slightly less important (sll)	(2/11, 1/4, 2/5)
Moderately more important (mom)	(4, 11/2, 7)	Moderately less important (mol)	(1/7,2/11, 1/4)
Strongly more important (stm)	(11/2, 7, 17/2)	Strongly less important (stl)	(2/17,1/7,2/11)
Absolutely more important (abm)	(7, 17/2, 10)	Absolutely less important (abl)	(1/10, 2/17, 1/7)

Step 2: Convert the relative importance relative importance data in the matrices to their corresponding fuzzy numbers according to (Table 4).

Step 3: Apply FAHP to each comparison matrix in step (2). Let (W_{ik}) be the weight value of (C_i) obtained from expert (E_k) ; where $0 \leq W_{ik} \leq 1$ and $\sum_{i+1}^{n} w_{ik} = 1$. Therefore, m number of weight values will be constructed for each element (C_i) as in Table 5.

Table 5. Weights for the n given KPIs.

KPI	E1	E2	Ek	Em	Final weight
C_1	W_{11}	W_{12}	W_{1k}	W_{1m}	$\mathbf{W_1} = \sum_{k=1}^{m} \phi_k w_{1k}$
C_2	W_{21}	W_{22}	W_{2k}	W_{2m}	$\mathbf{W_2} = \sum_{k=1}^{m} \phi_k w_{2k}$
C_3	W_{i1}	W_{i2}	W_{ik}	W_{im}	$\mathbf{W_i} = \sum_{k=1}^{m} \phi_k w_{ik}$
C_n	W_{1n}	W_{n2}	W_{nk}	W_{nm}	$\mathbf{W_n} = \sum_{k=1}^{m} \phi_k w_{nk}$
Sum	1	1	1	1	1
Uncertainty degree	$\boldsymbol{\varphi_1}$	$\boldsymbol{\varphi_2}$	$\boldsymbol{\varphi_k}$	$\boldsymbol{\varphi_m}$	

Absolutely the weights obtained from one expert might be different from another. This is because each expert has his own ideas and viewpoints. By using a simple average to find weights of KPIs, measured by applying FAHP to each comparison matrix will not reflect the real weight of the measured KPIs, because it ignored the diversity of the judgments of each expert. Shannon's Entropy formula has been used in similar research using FAHP, to measure the "disorder" in a set of collected data, also the uncertainty degree of the experts [1], [2]. Thus, the use of Shannon's Entropy formula with FAHP offers a more accurate weight.

Step 4: to calculate the uncertainty degree of the experts. Let φ_k be the uncertainty degree of expert $E_k$for pairwise comparison of the n given elements (Table 4). φ_k is calculated by (1).

$$\varphi_k = \delta_k / \sum_{k=1}^{m} \delta_k \quad (1)$$

Where, $\delta_k = 1 + \varepsilon_k$ *and,*

$$\varepsilon_k = (1/ln(n)) \sum_{i=1}^{n} w_{ik} \, ln(w_{ik})$$

Where δ_k and ε_k are respectively the diversification degree and entropy of expert E_k for pairwise comparison of the n elements.

Step 5: Based on uncertainty degree obtained for each expert, aggregate the weight values to find the final weight (W_i) of

KPIs (C_i) using (2) as shown in Table 5 .

$$W_i = \sum_{k=1}^{m} \varphi_k W_{Ki} \quad (2)$$

Step 6: Repeat steps (1) to (5) for each class of KPIs until the final weights for all the KPIs in the hierarchy are obtained.

By using the fuzzy scale shown in table 4, four experts were asked to make pairwise comparison of the relative importance of each element in the hierarchy of IMS and the hierarchy of the overall sustainability performance of the product.

Firstly, the expert compared the main elements in the hierarchy, level 2 for the IMG hierarchy and level 3 for the sustainability hierarchy. Then, the experts compared the sub elements with respect to the other sub elements. After that, based on Mikhailov's [3] FAHP steps, elements and sub elements have been weighted. The final results of the elements and sub elements for both hierarchy weights are shown in Tables 6 and 7.

I. RESULTS

Fuzzy evaluation for IMS performance:

Table 6. The weights of different levels in the hierarchy of IMS.

	Expert 1	Expert 2	Expert 3	Expert 4	Final WEIGHT
Quality management at level 1					
IA11	16.67%	14.76%	12.19%	3.52%	11%
IA12	16.67%	7.48%	1.63%	7.72%	8%
IA13	16.67%	21.82%	5.17%	20.78%	15%
IA14	16.67%	14.49%	12.57%	26.42%	18%
IA15	16.67%	8.63%	16.40%	20.78%	16%
IA16	16.67%	32.83%	52.03%	20.78%	32%
Environmental management at level 1					
IA21	10.00%	12.06%	2.80%	5.16%	7%
IA22	10.00%	2.14%	0.71%	6.86%	5%
IA23	10.00%	12.51%	0.25%	3.35%	6%
IA24	10.00%	2.46%	0.79%	3.87%	4%
IA25	10.00%	19.81%	1.50%	2.75%	8%
IA26	10.00%	10.16%	4.44%	14.82%	10%
IA27	10.00%	14.19%	8.48%	18.57%	13%
IA28	10.00%	19.51%	16.19%	10.23%	14%
IA29	10.00%	4.70%	47.86%	21.77%	23%
IA210	10.00%	2.46%	16.98%	12.62%	11%
OHAS management at level 1					
IA31	22%	21%	3%	7%	12%
IA32	22%	16%	1%	17%	13%
IA33	13%	18%	8%	25%	15%
IA34	13%	5%	9%	17%	11%
IA35	22%	30%	26%	9%	22%
IA36	7%	9%	53%	25%	28%
Documentation and goals at level 1					
IA41	9.10%	16.50%	2.85%	15.50%	10%
IA42	10.21%	5.57%	7.91%	3.40%	7%
IA43	18.37%	25.73%	5.08%	26.46%	18%
IA44	25.72%	17.70%	21.96%	17.34%	21%
IA45	13.36%	15.00%	43.67%	12.20%	23%
IA46	23.24%	19.50%	18.53%	25.10%	21%

Procedures at level 1					
IA51	1.25%	3.20%	3.43%	18.98%	6%
IA52	6.31%	4.59%	5.28%	14.58%	7%
IA53	6.31%	4.59%	5.28%	16.60%	8%
IA54	3.75%	5.97%	4.98%	12.83%	7%
IA55	3.75%	5.97%	4.98%	10.02%	6%
IA56	1.25%	3.20%	3.43%	6.99%	4%
IA57	1.25%	3.20%	3.43%	5.81%	3%
IA58	1.25%	3.20%	3.43%	4.89%	3%
IA59	6.95%	7.03%	7.07%	3.18%	6%
IA510	27.84%	19.89%	20.09%	2.46%	19%
IA511	27.84%	19.89%	20.09%	1.87%	18%
IA512	12.25%	19.25%	18.52%	1.79%	14%
Management practices at level 2					
IB1	73.33%	72.62%	23.63%	71.03%	60%
IB2	13.33%	16.27%	69.71%	5.71%	26%
IB3	13.33%	11.11%	6.67%	23.26%	14%
Sustainability management at level 2					
IB1	26.04%	35.74%	20.37%	26.04%	26%
IB2	3.90%	26.79%	3.32%	3.90%	9%
IB3	26.04%	19.84%	12.52%	26.04%	20%
IB4	26.04%	10.07%	42.71%	26.04%	28%
IB5	17.99%	7.56%	21.08%	17.98%	17%
Integrated systems at level 2					
IB5	0.5	0.125	0.125	12.5%	13%
IB6	0.5	0.875	0.875	87.5%	87%
Integrated management system at level 3					
IC1	27.68%	30.75%	20.34%	66.67%	36%
IC2	64.92%	17.44%	73.59%	26.67%	53%
IC3	7.41%	51.81%	6.06%	6.67%	11%

Fuzzy evaluation for sustainability performance:

Table 7. Weights of different levels in the hierarchy of sustainability performance.

	Expert 1	Expert 2	Expert 3	Expert 4	Final WEIGHT
Ecological performance at level 1					
SA11	28%	19%	42%	4%	19%
SA12	7%	73%	53%	17%	36%
SA13	65%	8%	6%	79%	45%
Economical performance at level 1					
SA21	5.72%	19.79%	16.19%	54.53%	22%
SA22	9.97%	16.34%	3.37%	13.56%	11%
SA23	9.97%	9.52%	11.51%	12.81%	11%
SA24	9.97%	6.57%	29.80%	12.81%	14%
SA25	64.37%	47.78%	39.13%	6.30%	42%
social performance at level 1					
SA31	58%	65%	6%	6%	29%
SA32	35%	25%	30%	72%	43%
SA33	7%	10%	64%	23%	27%

Main elements of sustainability elements at level 2					
SB1	29%	29%	29%	29%	39%
SB2	43%	43%	43%	43%	29%
SB3	27%	27%	27%	27%	32%

II. CONCLUSION AND FURTHER STUDIES

This study helps organizations to evaluate the real level of integration of different management systems, stakeholder's requirement and sustainability management. Also recognizing the differences between the desired and current status, moreover the evaluation of the degree of products sustainability. These evaluation methods identify the improvement areas and develop the strategies for the SD implementation.

In addition, organizations can also use the evaluation obtained to assess the organization performance in different aspects or assesses the improvement efforts/ programs.

To improve the overall management system efficiency, create sustainable competitive advantages and to overcome of the drawbacks of separate implementation of management systems, KPIs of integrated systems, sustainability management, stakeholder's requirement and products sustainability must be defined and prioritized.

Because the attributes used to evaluate such framework proposed in this study are a combination of qualitative and quantitative indicators in addition to the severe uncertainty combined with it, FAHP is the most appropriate method to assess simultaneously the weight of each element in such a framework.

FAHP approach has been implemented to prioritize/ assess the real weight of integration elements and sub elements and the corresponding sustainable performance attributes.

The main elements in the framework and its KPIs are based on previous research and experience of the experts in the respective fields. The large number of KPIs for elements and sub elements in the hierarchy proposed to assess such framework demonstrate the importance of the selection and evaluation of the KPIs. So the assessment using the hierarchy of such a framework can be capable to evaluate the real level of integration and sustainability of an organization if it's combined with fuzzy evaluation sets.

Consequently, this evaluation method gives the managers and decision makers more precise insights about what is desired and current situation regarding the integration, sustainability management and sustainable performance issues.

In this research, a new methodology was proposed in order to be used as a road map for organizations to move toward an integrated management system and manufacturing more sustainable products. Moreover this methodology takes a step in that direction of implementation priority relevant to both integration of MSs and sustainability attributes in organizations.

For future work, this methodology could be implemented using a fuzzy evaluation sets in order to assess the integration and sustainability level for different organization implemented different MSs and integrated different QMSs and finding the effect of integration on sustainability issues

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