Managing Waste Throughout Lean-Green Perspective

Lamyaa Mohammed Dawood
Production Engineering and Metallurgy Department
Industrial Engineering Division
University of Technology , Baghdad
lamya_alkazaai@yahoo.com

Zuher Hassan Abdullah
Babylon Technical Institute
Mechanical Technologies Department
Al-Furat Al-Awsat Technical university
zuherhassan7477@yahoo.com

Abstract

Managing waste has been known as a crucial need as it may reduce resource consumption, rigid regulations regarded to the environment and occupational health and safety. Lean and green management are two approaches of management that validate waste. Since performance measures are crucial to improve waste management as its goals of to promote the performance of organizations .In this research four primary KPIs have been employed that are significant to lean-green management; operational, environmental, economic and social performance factors, subdivided further into sixteen as (Value stream mapping, life cycle assessment,---etc). Also in this research determination and ranking of these performance measures and their influence on waste minimization is conducted. Interpretive Structural Modeling (ISM) methodology is applied to the classification of Key Performance Indicators (KPIs) according to the priority of their importance and the correlation between them and their impact to waste minimization. Cronbach's Alpha coefficient is employed to assess the reliability of performance measures to minimize waste, and increase customer satisfaction. Results showed that Al-Kufa Cement plant has bad overall performance toward lean green waste management perspective. The highest individual score is for operational performance (6.6) rated as medium. But the lowest individual score is for economic performance [very bad (2.0)].

Keywords:- Waste, lean, Green, KPIs, ISM, Correlation Matrix**.**

الخلاصه

تم تعريف إدارة الضياعات بأنها حاجة ماسة كونها قد تحد من استهلاك الموارد، والقوانين الصارمة التي تخص البيئة ،الصحة والسلامة المهنية. الادارة الرشيقة– الخضراء هما نهجين لإدارة صلاحية الضياعات. بما أن مقاييس الأداء مهمة لتحسين إدارة الضياعات باعتبارها أهداف لتعزيز أداء المنظمات. في هذا البحث تم توظيف أربعة مؤشرات رئيسية ذات أهمية كبيرة في لإدارة الرشيقة– الخضراء؛ التشغيلية، البيئية، الاقتصادية، والاجتماعية، مقسمة إلى ستة عشر عامل مثل (خارطة تيار القيمة، تقييم دورة الحياة، إلخ..). كما تم في هذا البحث تحديد وتصنيف مقاييس الأداء وتأثيرها على الحد من الضياعات. يتم تطبيق منهجية النمذجة الهيكلية التفسيرية لتصنيف مؤشرات الأداء الرئيسية وفقاً لأولوية أهميتها والارتباط بينها وبين تأثيرها للحد من الضياعات. تم توظيف معامل ألفا كرونباك لتقييم موثوقية مقاييس الأداء للحد من الضياعات، وزيادة رضا العملاء. وأظهرت النتائج أن الاداء الكلي لمصنع سمنت الكوفة رديء من منظور الادارة الرشيقة–الخضراء. أعلى نتيجة فردية هي للأداء التشغيلي (6.6) مصنفة على أنها متوسطة. ولكن أدنى نتيجة فردية هي للأداء الاقتصادي [سيئة جدا (2.0)].

الكلمات المفتاحية : الضياعات،الرشيق،الاخضر، مؤشرات الاداء الرئيسية، النمذجة الهيكلية التفسيرية، مصفوفة العلاقة.

1- Introduction

Waste is anything other than the minimum amount of materials, equipment, working time, and parts, that absolutely are needful to manufacturing **(Suresh, 2015;Taj, 2011)**. Waste management is a distinct pursuit of resource recovery, which focuses on delaying the moderate consumption of natural resources **(Tarek, 2013)**. In generic, waste management contains whole waste materials as a single category, whether solid, liquid, gaseous or radioactive substances, and attempt to minify the harmful environmental impacts of each through different approaches **(Sivakumaran, 2015)**. Managing waste has been known as a crucial need as it may reduce resource consumption, rigid regulations regarded to the environment and occupational health and safety, and growing customer

preference for environmental-friendly products**(Jayal, 2010)**. Lean and green management are two approaches of management that validate waste minimization whereas lean management seek in minimizing waste (any activity that does not add value to customer) **(Bergmiller, 2006;Tilina, 2015)**.While green management is management that reduces waste and pollution. Green management aims also to utilize minimal natural resources and save it for future generations. So, green management identifies how goods and services are created with restricted effects on the environment under current technological and economic challenges**(Oliveira, 2008)**. Performance measures are crucial to improve waste management since one of the critical goals of waste management is to promote the performance of organizations in satisfying customers. The qualitative performance measures are immeasurable, such as customer satisfaction, flexibility, information and material flow integration, and effective risk management **[Hutchison, 2009]**. Key Performance Indicator (KPI) or recognized as Key Success Indicator (KSI) is a quantitative measurement tool for the improvement of the performance of an action that is conveniently a key factor in the success of an organization**(Neely, 2000]**. In the next paragraph researchers potential word wild is exposed, followed by data collected from AL-Kufa cement plant as a case study due to high consumption of raw materials, black Oil, energy, and generate different pollutants to air, different types of waste. Four primary KPIs have been employed are; operational, environmental, economic and social performance factors, subdivided further into sixteen as illustrated in table (1). Interpretive Structural Modeling (ISM) is used to manage the individual effect of performance measures and overall effect of four key performance indicators (KPIs) onto waste management through lean-green perspective. It is expected that the evaluation of KPIs can support the Cement industry to improve their lean-green performance that contributes in waste reduction, high effectiveness of equipments, and resources so as to increase the competitiveness. Evaluation of reliability is achieved in terms of degree of correlation and internal consistency among various performance measures associated to the key performance indicators employing Cronbach's Alpha coefficient. Results are analyzed, discussed then summarized conclusions are reported.

2. Literature Review

David (2010) presented different key performance indicator (KPI) that focuses on aspects of organizational performance is the most important subject for the organization success at the time and for the future. He clarified the plan of plot elaboration of KPI in the organization as there should be a relationship that connects between the view, mission, strategies, and key performance indicators

Carvalho *et.al.*, (2011) determined operational, economic and environmental measures which can be utilized to appreciate the impact of lean and green performance measures on supply chain performance at a Portuguese automotive supply chain to experiment qualitatively the truth of their suggested theoretical framework.

Jadhav *et.al.*, (2013) determined and ranked the green-lean performance measures for implementation, to develop and to analyze the interaction between determined green-lean utilizing Interpretive Structural Modeling(ISM) for a ready framework of integrative green-lean system implementation. Their results show green human resource management, that form the basis of ISM hierarchy while low cost practice bundles that are relied on other LG performance measure bundles has been shown on upper of the hierarchy.

Kenneth *et.al.*, (2015) implemented 3R (Reduce, Reuse and Recycle) techniques for municipality in Ghana and they referenced beneficial studies for other municipalities that are displaying similar situations. They concluded that, 3R techniques are a beneficial for efficient and active management of solid waste because they abide by the principles of fulfilling sustainable environment.

Elita *et.al.*, (2015) suggested a set of Key Performance Indicators (KPIs) due to evaluate the sustainable manufacturing and they believed to be suitable to the Cement industry that depends on the triple bottom line of sustainability. They implemented Analytical Hierarchy Process (AHP) to prioritize the performance indicators by abstracting the opinions of experts. They stated that plant-three has fulfilled the major overall performance level of good. On the other side, plant-one has fulfilled the minor overall performance level of fairness.

Haddach *et.al.*, (2016) showed the impact of different combinations of lean, environmental and social performance measures on firm financial, environmental, social, and overall performance. Their results supported leaders to integrate the best performance measures from each category to realize a high level of overall performance in their firms as well as convince different stakeholders.

Jadhav *et.al.*, (2013) reported that Interpretive Structural Modelling (ISM) is a potentially two-way rating method to compare and affirm the findings obtained of the prioritized key performance indicators. ISM methodology suggests the deployment of expert views based on different management techniques such as brainstorming, and nominal group discussion technique in evolving the contextual relation between key performance indicators. The reachability set and antecedent set for each economic and environmental performance are confirmed from the last reachability matrix. Reachability set depends on the performance measure which it influences.

The first reachability matrix from the constructional self-interaction matrix is obtained by converting the input of each cell of CSIM into binary digits (either, 1 or 0). This conversion has been completed by replacing symbols V, A, X, and O by 1 and 0 as per the next rules. Rules for conversion are specified in Table (2) below **(Jadhav, 2013)**.

Table (1) KPIs / Performance Measures (Oliveira, 2008, Helena, 2011, Susana, 2011, Hariram, 2012)

KPIs	Performance measures
Operational performance	Overall equipment effectiveness
	Lead time
	Process cycle efficiency
	Overall resource effectiveness
	Value stream mapping/EVSM
Environmental performance	Solid waste
	Air emission
	Waste reduction
	Efficiency of resource consumption
	Life cycle assessment
	3 R (Reduce, Reuse, Recycling)
Economic	Product flexibility
	Manufacturing cost

performance	Reject rate
Social performance	Gender equity
	Accident rate

While evaluation of reliability is achieved in terms of correlation degree and internal consistency among various performance measures associated to the key performance indicators. The internal consistency of the measurement paradigm is related to the cohesion between structures and their performance measures. This could be reached through the analysis of the key performance indicators using Cronbach's alpha coefficient. This coefficient is increment when the correlations between performance measures increment. Cronbach's Alpha coefficient scales are; (0.7,0.8 and 0.9) referred to the acceptable reliability, good reliability and very good reliability respectively as shown in Table (2) below (**David, 2010**).

Table (2) Rules for Conversion [Jadhav, 2013]

Symbols	Login in the first reachability matrix	
	(n,m)	(m,n)
V	1	0
A	0	1
X	1	1
O	0	0

4.Data Collection , Analysis and Discussion

For three years 2009, 2015,and 2016 data were collected from Cement Al-Kufa manufacturing plant**.** As this plant undergoes different issues as high consumption of raw materials, black Oil , energy, and generate different pollutants to air, different types of waste According to rules in Table (2), sixteen lean-green performance measures were determined throughout literature survey and expert opinions. The structural self-interaction matrix between lean-green practices is shown in Table (3). Where symbols below utilized relation between the lean-green performance measures as the followings;

V: lean or green performance measure n will help to achieve lean or green performance measure m.

A: lean or green performance measure m will help to achieve lean or green performance measure n.

X: lean or green performance measure n and m will help to achieve each other, and

O: lean or green performance measure n and m no effect each other are unrelated.

Table (3) Lean-Green Reachability Matrix

N	Lean-Green performance measures	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1	Value stream mapping/EVSM	V	V	O	O	V	V	V	V	V	V	V	V	V	V	V	X
2	3 R (Reduce, Reuse, Recycling)	V	V	O	O	O	V	V	V	V	V	V	V	V	V	X	
3	Overall equipment effectiveness	V	V	O	A	A	A	V	A	V	V	V	A	A	X		
4	Life cycle assessment	V	V	O	O	V	V	V	V	V	V	V	V	X			
5	Process cycle efficiency	V	V	O	O	V	V	V	O	V	V	V	X				
6	Solid waste	V	V	O	O	A	A	A	A	O	O	X					
7	Air emission	V	V	O	O	A	A	A	A	O	X						
8	Waste reduction	V	V	A	A	A	A	A	A	X							
9	Overall resource effectiveness	V	V	V	V	V	V	V	X								
10	Reject rate	V	V	V	O	A	A	X									

11	Lead time	**V**	**V**	**O**	**V**	**A**	**X**										
12	Efficiency of resource consumption	**V**	**V**	**O**	**O**	**X**											
13	Accident rate	**V**	**V**	**O**	**X**												
14	Gender equity	**V**	**V**	**X**													
15	Manufacturing cost	**V**	**X**														
16	Product flexibility	**X**															

First reachability matrix is shown in table (4). To obtain last reachability matrix, the idea of transitivity is inserted, and some of the cells of the first reachability matrix are filled in by conclusion as shown in Table (5). When the last reachability matrix is generated the structural model is presented a set of partitions, which is produced by the reachability matrix on the set and subset of various variables. From these partitions it is possible to identify many attributes of the structural model. The intersection of the reachability and antecedent sets is derived for all the performance measures and various levels identified as shown in table (5). Thirteen iterations are frequent until the levels of each performance measure are detected as shown in Tables (5-a) to Table (5-m) below.

Table (4) First and Ultimate Reachability Matrix

N	Lean-Green Performance measures	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	**Driver power**
1	Value stream mapping/EVSM	**1**	**1**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	14
2	3 R (Reduce, Reuse, Recycling)	**1**	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	12
3	Overall equipment effectiveness	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	7
4	Life cycle assessment	**1**	**1**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	12
5	Process cycle efficiency	**1**	**1**	**0**	**0**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**1**	**0**	**1**	**0**	**0**	10
6	Solid waste	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	3
7	Air emission	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	3
8	Waste reduction	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	3
9	Overall resource effectiveness	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	12
10	Reject rate	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	7
11	Lead time	**1**	**1**	**0**	**1**	**0**	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	9
12	Efficiency of resource consumption	**1**	**1**	**0**	**0**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	9
13	Accident rate	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	5
14	Gender equity	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	4
15	Manufacturing cost	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	2
16	Product flexibility	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	1
Dependence power		1	1	3	3	5	7	9	4	12	10	1	4	3	9	2	1	**113**

Table(5) Reachability Matrix Iterations and their relative levels

Table (5-a) Reachability matrix (Iteration I / First Level)

L-G Performance measures	**reachability**	**antecedent**	**intersection**	**level**
1	**1234567891011121516**	**11314**	**1**	
2	**243678910111516**	**125121314**	**2**	
3	**3678101516**	**12345911121314**	**3**	
4	**34567891011121516**	**1241314**	**4**	
5	**356781011121516**	**124591314**	**5**	
6	**61516**	**1234567891011121314**	**6**	
7	**71516**	**1234567891011121314**	**7**	
8	**81516**	**1234567891011121314**	**8**	

9	3678910111213141516	12459	9	
10	67810141516	12345910111213	10	
11	36781011131516	12459111214	11	
12	36781011121516	12459121314	12	
13	38131516	12456791011121314	13	
14	8141516	123456791011121314	14	
15	1516	123456789101112131415	15	
16	16	1234567891010111213141516	16	I

Table (5-b) Reachability Matrix Iteration II / Second Level

L-G Performance	reachability	antecedent	intersection	level
1	12345678910111215	11314	1	
2	2436789101115	125121314	2	
3	36781015	12345911121314	3	
4	345678910111215	1241314	4	
5	3567810111215	124591314	5	
6	615	1234567891011121314	6	
7	715	1234567891011121314	7	
8	815	1234567891011121314	8	
9	36789101112131415	12459	9	
10	678101415	12345910111213	10	
11	367810111315	12459111214	11	
12	367811101215	12459121314	12	
13	381315	12456791011121314	13	
14	81415	123456791011121314	14	
15	15	123456789101112131415	15	II

Table (5-c) Reachability matrix Iteration III /Third Level

L-G Performance measures	reachability	antecedent	intersection	level
1	123456789101112	11314	1	
2	24367891011	125121314	2	
3	367810	12345911121314	3	
4	3456789101112	1241314	4	
5	35678101112	124591314	5	
6	6	1234567891011121314	6	III
7	7	1234567891011121314	7	
8	8	1234567891011121314	8	
9	367891011121314	12459	9	
10	6781014	12345910111213	10	
11	3678101113	12459111214	11	
12	3678111012	12459121314	12	
13	3813	12456791011121314	13	
14	814	123456791011121314	14	

Table (5-d) Reachability matrix Iteration IV/ Fourth Level

L-G Performance measures	reachability	antecedent	intersection	level
1	123459101112	11314	1	
2	24391011	125121314	2	
3	310	12345911121314	3	
4	3459101112	1241314	4	
5	35101112	124591314	5	
9	391011121314	12459	9	
10	1014	12345910111213	10	
11	3101113	12459111214	11	
12	3101112	12459121314	12	
13	313	124591011121314	13	
14	14	123456791011121314	14	IV

Table (5-e) Reachability matrix Iteration V/ Fifth Level

L-G Performance measures	reachability	antecedent	intersection	level
1	123459101112	113	1	
2	24391011	1251213	2	
3	310	123459111213	3	
4	3459101112	12413	4	
5	35101112	1245913	5	
9	3910111213	12459	9	
10	10	12345910111213	10	V
11	3101113	124591112	11	
12	3101112	124591213	12	
13	313	1245910111213	13	

Table (5-f) Reachability matrix Iteration VI /Sixth Level

L- G Performance measures	reachability	antecedent	intersection	level
1	1234591112	113	1	
2	243911	1251213	2	
3	3	123459111213	3	VI
4	34591112	12413	4	
5	351112	1245913	5	
9	39111213	12459	9	
11	31113	124591112	11	
12	31112	124591213	12	
13	313	12459111213	13	

Table (5-g) Reachability matrix Iteration VII/ Seventh Level

L-G Performance measures	reachability	antecedent	intersection	level
1	124591112	113	1	
2	24911	1251213	2	
4	4591112	12413	4	
5	51112	1245913	5	
9	9111213	12459	9	
11	1113	124591112	11	
12	1112	124591213	12	
13	13	12459111213	13	VII

Table (5-h) Reachability matrix Iteration VIII /Eighth Level

L-G Performance measures	reachability	antecedent	intersection	level
1	124591112	1	1	
2	24911	12512	2	
4	4591112	12413	4	
5	51112	12459	5	
9	91112	12459	9	
11	11	124591112	11	VIII
12	1112	1245912	12	

Table (5-i) Reachability matrix Iteration IX / Ninth Level

L-G Performance measures	reachability	antecedent	intersection	level
1	1245912	1	1	
2	249	12512	2	
4	45912	12413	4	
5	512	12459	5	
9	912	12459	9	
12	12	1245912	12	IX

Table (5-j) Reachability matrix Iteration X/ Ninth Level

L-G Performance measures	reachability	antecedent	intersection	level
1	12459	1	1	
2	249	125	2	
4	459	12413	4	
5	5	12459	5	X
9	9	12459	9	

Table (5-k) Reachability matrix Iteration X/ Eleventh Level

L-G Performance measures	reachability	antecedent	intersection	level
1	124	1	1	
2	24	12	2	
4	4	12413	4	XI

Table (5-l) Reachability matrix Iteration XII/ Twelfth Level

L-G Performance measures	reachability	antecedent	intersection	level
1	12	1	1	
2	2	12	2	XII

Table (5-m) Reachability matrix Iteration XIII/ Thirteenth Level

L-G Performance measures	reachability	antecedent	intersection	level
1	1	1	1	XIII

While Table (6) displays the final reachability matrix in the conic shape. Generally, zero variables are in the top half of the diagonal of the matrix and one (1) variable are in the bottom half. Ultimate list of level partitions is specified in Table (6) determine levels that help in constructing the ISM model. The first level is for economic performance measures placed at the upper of the model and so on, thus rearranging the performance standards, according to key performance indicators to determine the level of impact of individual weights on the Al-Kufa Cement manufacturing plant.

Table (6) Conic matrix of lean-green L-G Performance measures

N	L-G Performance measures	16	15	6	7	8	14	10	3	13	11	12	5	9	4	2	1	Driver power
1	Product flexibility	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1	Manufacturing cost	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
6	Solid waste	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3
7	Air emission	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
8	Waste reduction	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3
1	Gender equity	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	4
1	Reject rate	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	7
3	Overall equipment	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	7
1	Accident rate	1	1	0	0	1	0	0	1	1	0	0	0	0	0	0	0	5
1	Lead time	1	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	9
1	Efficiency of resource	1	1	1	1	1	0	1	1	0	1	1	0	0	0	0	0	9
5	Process cycle	1	1	1	1	1	0	1	1	0	1	1	1	0	0	0	0	10
9	Overall resource	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	12
4	Life cycle assessment	1	1	1	1	1	0	1	1	0	1	1	1	1	1	0	0	12
2	3 R (Reduce, Reuse,	1	1	1	1	1	0	1	1	0	1	0	1	1	1	1	0	12
1	Value stream	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	14
Dependence power		16	15	10	10	12	3	9	9	3	7	5	4	4	3	2	1	113

From Table (6) analysis of cross-impact matrix is conducted to with the assistance of driving and the dependence power of every variable. Computations of driving and dependence power have been utilized in the analysis to classify these variables into four sets of linkage, independent (driver),autonomous, and dependent variables are shown in Figure (2):-

- First group (autonomous variables): performance measures which have weak driving, and dependence power are;- Accident rate and gender equity.
- Second group (dependent variables): performance measures which have weak driving but strong dependence power are;- Overall equipment effectiveness, reject rate, solid waste, air emission, waste reduction, manufacturing cost, and product flexibility.
- Third group (linkage variables): performance measures that have strong driving power and strong dependence power. No performance measures variables have been identified in this research as linkage variables.
- Fourth group (independent variables) ; performance measures strong driving but weak dependence power are :- Value Stream Mapping, 3Rs, (Reduce, Reuse, Recycling), Life cycle assessment, Overall resource effectiveness ,Process cycle efficiency, efficiency of resource consumption, and shorter lead time have been specified as the driver variables.

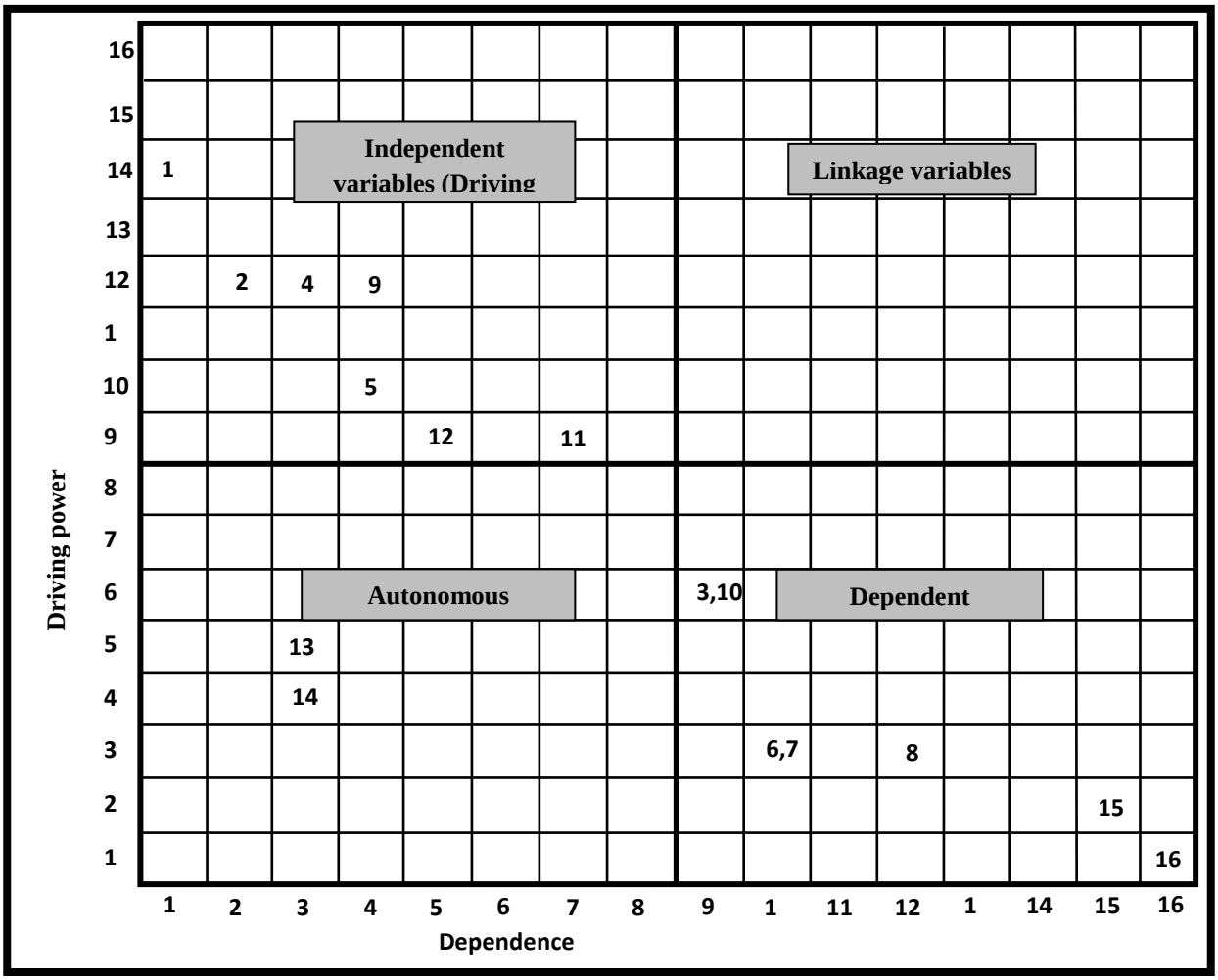

Figure (2) Driving and dependence power of lean-green management system

Therefore, two major categories are identified by seven KP measurements each these categories are:- Independent driving variables, and dependent variables.i.e lean-green management activities should be directed toward the above two categories to increase leanness and the greenness of the manufacturing system specially those dependent variable by investigating their relative affecting factors. Furthermore, key performance indicators for Al-Kufa Cement manufacturing plant are rated on a scale of 1 to 10 as shown in Table (7) below. Table (8) accordingly assesses reliability of key performance indicators Cronbach's alpha coefficient. It is very good reliability when Cronbach's alpha coefficient is (0.9143). In Table(8) the rating of operational, environmental, economic and social performance measures are about (6.60, 4.67, 2.00, 3.00) Cronbach's alpha value.

Table (7) Rating of KPIs and their Relative Details

Rate	classification	Details
0-4	Very bad	For $0 \leq$ rate < 4 then performance is very bad
4-5	bad	For $4 \leq$ rate < 5 then the performance is bad
5-6	acceptable	For $5 \leq$ rate < 6t hen performance is acceptable
6-7	medium	For $6 \leq$ rate < 7 then performance scale is medium
7-8	good	For $7 \leq$ rate < 8then performance scale is good
8-9	Very good	For $8 \leq$ rate < 9 then performance scale is very good
9-10	excellent	For $9 \leq$ rate ≤ 10 then performance scale is excellent

Table (8) Key Performance contributions

KPIs	Performance measures	Mean	Cronbach's alpha	Score	contribution
Operational performance	Overall equipment effectiveness	0.4375	0.9004	4	6.60
	Lead time	0.5625	0.9055	6	
	Process cycle efficiency	0.6250	0.9059	6	
	Overall resource effectiveness	0.7500	0.9119	8	
	Value stream mapping/EVSM	0.8750	0.9173	9	
Environmental performance	Solid waste	0.1875	0.9078	2	4.67
	Air emission	0.1875	0.9078	2	
	Waste reduction	0.1875	0.9055	2	
	Efficiency of resource	0.5625	0.9030	6	
	Life cycle assessment	0.7500	0.9108	8	
	3 R (Reduce, Reuse, Recycling)	0.7500	0.9141	8	
Economic performance	Product flexibility	0.0625	0.9133	1	2.00
	Manufacturing cost	0.1250	0.9082	1	
	Reject rate	0.4375	0.9077	4	
Social performance	Gender equity	0.2500	0.9125	3	3.00
	Accident rate	0.3125	0.9122	3	

Values in the table (8) are viewed in multivariate mode as Radar chart, Figure (3).This figure shows that VSM/EVSM operational performance as the extremely important performance indicators and followed by 3R (Reduce, Reuse, Recycling) as environmental performance and so on reaching to the least important indicator which is product flexibility. In Table (9) below reliability of KPIs performance indicators is assessed. Al-Kufa Cement plant has bad overall performance toward lean green waste management perspective. The highest individual score is for operational performance

(6.6) rated as medium. But the lowest individual score is for economic performance [very bad (2.0)].

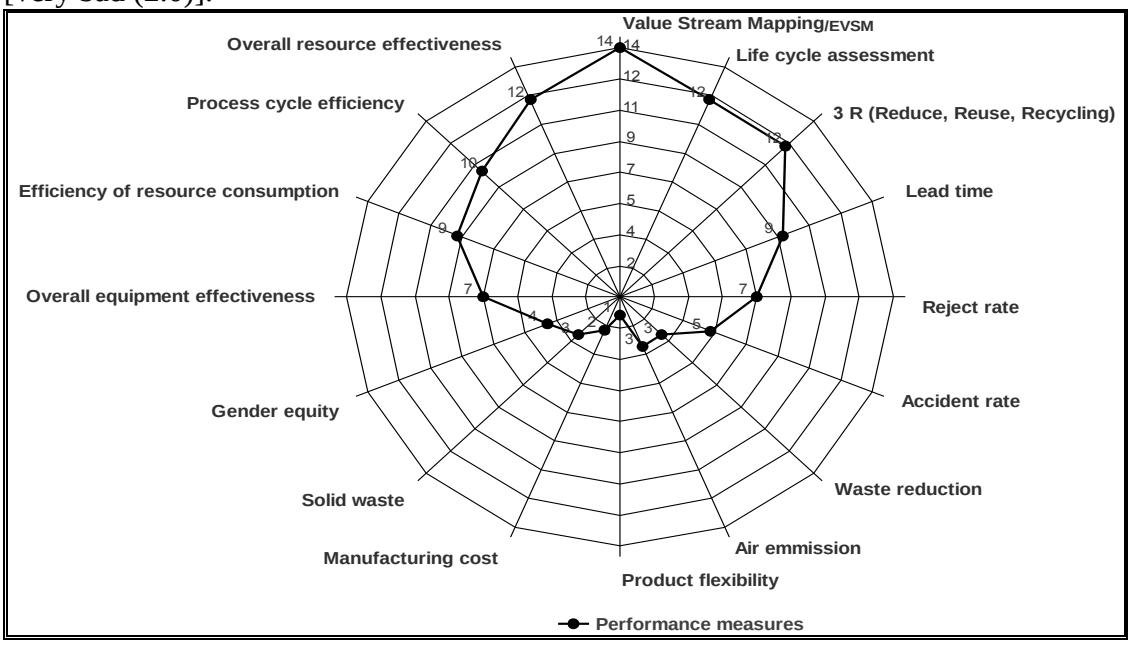

Figure (3) Radar Chart of different L-G KPIs

Table (9) Comparing among Individual and Overall KPIs Results

KPIs	Operational performance	Environmental performance	Economic performance	Social performance	Overall performance
Results	6.60	4.67	2.00	3.00	4.07
Rating	Medium	Bad	Very bad	Very bad	Bad
Reliability value	0.9082	0.9081	0.9097	0.9124	0.9096
Rating	Very good	Very good	Very good	Very good	Very good

5. Conclusions and Recommendations

1. Two major categories are identified by seven KP measurements each these categories are:- Independent driving variables, and dependent variables.i.e lean-green management activities should be directed toward the above two categories to increase leanness and greenness of the manufacturing system specially those dependent variable by investigating their relative affecting factors

2- Value Stream Mapping, and 3Rs (Reduce, Reuse, Recycling) performance measures are significant toward lean-green management of Al-Kufa Cement manufacturing plant.

3- Alkufa Cement plant has the highest individual score with an operational performance rated as medium. Whereas, the lowest individual rate is for economic performance level of very bad.

4-Alkufa Cement plant as the manufacturing system has a low overall score for the overall performance level of bad.

Therefore, it is recommended to investigate study for 3R technique as an effective KPI resulted from this study. Also to assess the overall equipment effectiveness, and resources for this plant.

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