between the two groups will be weaker. The (+) sign indicates a positive relationship, while (–) sign indicates a negative relationship. The Spearman's coefficient can be 1 not only for linearly related variables but also some types of non-linear relationship. However, Kendall's coefficient can be 1 for even a wider range of scenarios than Spearman's correlation coefficient. SPSS software was used to calculate both correlation coefficients. Figure (3) shows that there is a high degree of agreement amongst the three participant groups on the level of CWRII. Therefore, further attempts to analyze the problems faced by the different groups of participants were not necessary. All results were positive, which implied good agreements among the different groups. Consequently, the analysis was based on data from all the respondents.

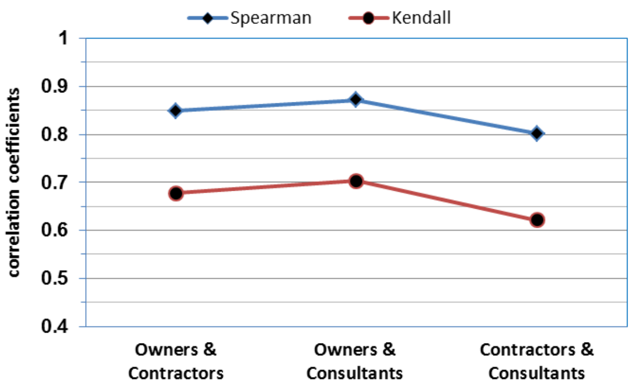

Figure 3. Spearman's and kendall correlation coefficients for ranking cwrii due to different pairs of groups.

However, referring to figure (3), it is perceived that the strongest relationship was between owners and consultants, with a coefficient value of 0.87 for spearman and 0.70 for Kendall. This result reflects the great agreement between the owners and the consultants related to identifying the causes of wastes. On the other hand, the weakest relationship was between consultants and contractors with a coefficient value of 0.80 for spearman and 0.62 for Kendall even it is still positive. These positive and high values results that obtained from both methods confirm that the results signify high agreements. Difference between any two groups does not exceed 8% and 12 % for Spearman and Kendall methods respectively.

RESULTS, DISCUSSION AND ANALYSIS

Ranking Analysis

The ranking analysis is conducted based on the results of agreement tests among the three groups that previously explained. The analysis for ranking causes of wastes in KSA construction projects was presented based on to the total number of respondents. Table (4) through Table (7) summarize the overall ranking for each cause of waste as well as ranking inside the responsibility group.

From these tables, many causes are observed to have high ranks. For example, the cause of waste No. 27 which was expressed as "Material wastes due to poor design or poor execution" appears as a first in order inside common's responsibility group as well as overall rank with a highest CWRII value of (0.78). It is followed by cause No. 6 which was "Contractor selection before consultant" with CWRII value of (0.77) which is the first in order in owner's responsibility group and second in overall rank. Causes No. 1 and 4 belong owner's responsibility group and come in third and fourth orders in overall ranking with CWRII values 0.76 and 0.75 respectively. The fifth and sixth causes of wastes in the overall rank come from the contractor and common groups respectively.

One of the most important observations that all CWRII in consultant's responsibility group have low values (from 0.45 to 0.52). In spite of their importance, they do not occupy high order in ranking (their ranks range from 21 to 31). This refers to the low responsibility of consultants if compared to other groups.

Table 4
CAUSES OF WASTES OVERALL RANK AND INSIDE GROUP FOR OWNER'S RESPONSIBILITY GROUP.

No	Ranking for Causes of Wastes based Owner's responsibility	RII due to Respondents				Rank in Group	Overall Rank
		Owners	Contractors	Consultants	Average		
6	Contractor selection before consultant	0.69	0.77	0.85	0.77	1	2
1	Client slow response and slow decision-making mechanism	0.67	0.82	0.79	0.76	2	3
4	Cleint's special needs such as additional works and change order	0.66	0.83	0.75	0.75	3	4
9	Starting execution although project documents are not completed	0.67	0.79	0.69	0.72	4	8
10	Lack in project financing	0.59	0.77	0.72	0.69	5	9
3	Delay in running bill payments to the contractor or consultant	0.53	0.66	0.62	0.60	6	14
5	Deficiencies and changes in project scope	0.46	0.63	0.51	0.53	7	19
2	problems in Client's organization such as bureaucracy and lack of specialists	0.40	0.53	0.48	0.47	8	27
8	Client's representative problems	0.35	0.49	0.39	0.41	9	33
7	Unfairness in tendering or method of contractor choice	0.25	0.33	0.41	0.33	10	37

Table5
CAUSES OF WASTES OVERALL RANK AND INSIDE GROUP FOR CONSULTANT'S RESPONSIBILITY GROUP.

No	Ranking for Causes of Wastes based Consultant's responsibility	RII due to Respondents				Rank in Group	Overall Rank
		Owners	Contractors	Consultants	Average		
12	Delay samples approval, inspections as well as making decisions	0.47	0.65	0.43	0.52	1	21
13	Lack of consultant's experience in design, supervision and quality control	0.48	0.65	0.41	0.51	2	22
11	Delay in reviewing or approving design documents	0.43	0.65	0.37	0.48	3	25
14	Poor integrated organization structure for consultant	0.49	0.51	0.36	0.45	4	31

Table 6
CAUSES OF WASTES OVERALL RANK AND INSIDE GROUP FOR CONTRACTOR'S RESPONSIBILITY GROUP.

No	Ranking for Causes of Wastes based Contractor's responsibility	RII due to Respondents				Rank in Group	Overall Rank
		Owners	Contractors	Consultants	Average		
15	Inadequate experiences of contractor	0.75	0.69	0.77	0.74	1	5
18	Unskilled workers and poor labor productivity	0.63	0.65	0.69	0.66	2	11
19	Delay in delivery of materials to site	0.63	0.60	0.58	0.60	3	15
23	Poor evaluation for contract items, tendering documents, and quantities as well as poor scope definition	0.48	0.42	0.58	0.49	4	23
22	Execution errors that lead to rework	0.45	0.49	0.53	0.49	5	24
17	Workers problems such as inadequate motivation or improper accommodations	0.45	0.42	0.54	0.47	6	28
16	Poor management team in performance such as late request for inspections or poor site management	0.45	0.40	0.55	0.47	7	29
20	Problems resulted in interference among different subcontractor's	0.52	0.42	0.46	0.47	8	30
24	Inadequate modern equipment and low productivity level	0.42	0.33	0.47	0.41	9	34
21	Delay of regulatory reporting	0.35	0.29	0.35	0.33	10	38

Table 7
CAUSES OF WASTES OVERALL RANK AND INSIDE GROUP FOR COMMON'S RESPONSIBILITY GROUP.

No	Ranking for Causes of Wastes based Common responsibility	RII due to Respondents				Rank in Group	Overall Rank
		Owners	Contractors	Consultants	Average		
27	Material wastes either due to poor design or poor execution	0.73	0.82	0.79	0.78	1	1
38	Unavailability of qualified sub-contractors	0.72	0.65	0.83	0.73	2	6
42	Inadequate definition for authority or responsibility as well as supervision overlapping	0.63	0.79	0.75	0.72	3	7
41	Scheduling errors and actual execution duration is greater than duration in tender	0.59	0.72	0.69	0.67	4	10
34	Variations of actual quantities of work compared with quantities in bidding documents and underestimation of cost	0.61	0.71	0.55	0.62	5	12
25	Dispute resolution delay or lack of dispute resolution methods	0.48	0.70	0.68	0.62	6	13
39	Truthfulness of contractor or consultant to get a big gain	0.62	0.49	0.53	0.55	7	16
26	Poor distribution of personnel	0.56	0.55	0.52	0.54	8	17
29	Delay due to administrative approvals	0.55	0.47	0.61	0.54	9	18
30	Poor site safety	0.45	0.56	0.58	0.53	10	20
35	Supplying poor quality materials	0.45	0.49	0.51	0.48	11	26
32	Changes in core team	0.38	0.47	0.46	0.44	12	32
31	Inadequate specifications and shortage of design data	0.41	0.39	0.41	0.40	13	35
37	Conflicts, poor communication and coordination among contractor and otl	0.35	0.38	0.41	0.38	14	36
28	Familiarity with site conditions, location and project complexity	0.36	0.33	0.29	0.33	15	39
33	Language barriers	0.26	0.28	0.24	0.26	16	40
40	Side effects due to project activities	0.26	0.29	0.23	0.26	17	41
36	Complete familiarity with systems and laws in KSA	0.21	0.28	0.23	0.24	18	42

Analysis Based On Responsibility

The boxplot can provide a quick visual summary that easily shows the centre, spread, range, and any outliers (Tukey, 1977). In General, The box contains 50% of the data and the upper edge of the box represents the 75th percentile, the lower edge represents the 25th percentile, while the median is represented by a line drawn in the middle of the box. The minimum and maximum values of the data set are represented by ends of the lines unless the data contain outliers values. These outliers are remarks located below the value of Q1 − 1.5(IQR) or above the value Q3 + 1.5(IQR), where Q1 is the 25th percentile, Q3 is the 75th percentile, and IQR = Q3 − Q1 (called the interquartile range). The outliers are characterized on the graph with a small circle above or below the range.

A boxplot analysis is introduced in figure (4) for the purpose of summarizing and comparing the sets of data for CWRII values in the cases of responsibilities groups. The boxplot was drawn for CWRII values and arranged side-by-side for all groups.

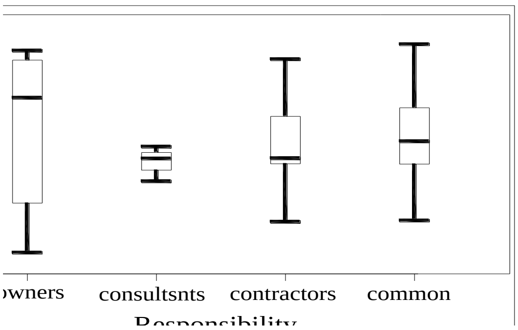

Figure 4. Boxplot analysis for CWRII values based on responsibility groups

It is clear from figure (4) that the widest range of CWRII values is for the common group with a total length of 0.54. The most important cause of waste due to CWRII value is included in this group as well as the least important one (causes No. 27 with first overall rank, and cause No. 36 with latest overall rank). Notably, the common group includes maximum numbers of causes (18). The wide range of causes' values and the number of causes refer to the common responsibility of all parties.

Referring to figure (4), there are no causes of wastes are located outliers. Once there are no outliers, a Convergence Percent (CP) can be determined for each group using equation (2)

$$CP = (CWRII_{max} - CWRII_{min}) / \text{number of causes } \% \quad (2)$$

The results using the last equation are summarized in figure (5). The CP value for the common group is only 3% which reflects a convergence of CWRII values among causes of wastes in this group. Figures (4) and (5) show that the Owner's responsibility group range is 0.44 and its CP is the maximum one with a value of 4.4%. This large percentage is due to the wide range related to its cause's numbers (10). The contractors' group occupies the third rank in responsibility due to its range (0.41) and CP = 4.07%. Although the range of contractors and owners are close in values, the length of owners is longer than contractors. Finally, the consultants' group has the least numbers of causes (only 4), with a range of 0.07 and CP = 1.58. This reflects a high convergence among the causes although their limited numbers.

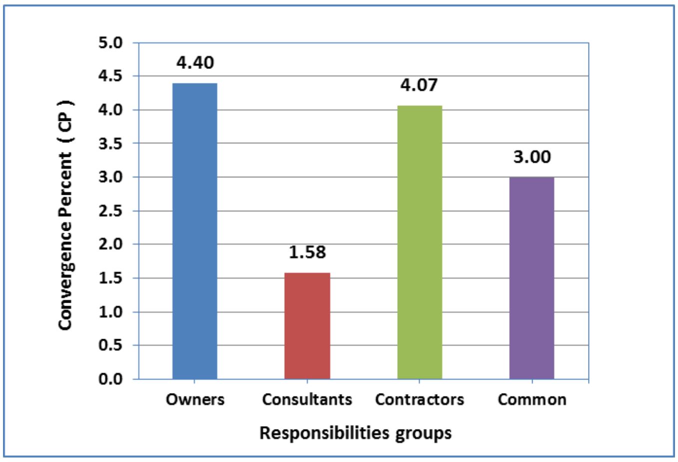

Figure 5. Convergence percent values for all responsibilities groups

The Effect of Using Lean Construction Techniques on Causes of Wastes

Not all risk factors in construction projects are affected by lean techniques (Issa, 2013). [9]. Determining causes of wastes which can be affected by lean techniques will be useful in implementing the new technique in KSA. In the third stage of the survey, three levels of lean effect on identified causes of wastes are measured through series of brainstorming sessions. The brainstorming is one of the most common identification techniques for data collection in the construction industry (Issa et al., 2014). [38]. It is selected in this phase for the purpose of explanation and discussion for lean techniques. To satisfy the research objectives, two brainstorming sessions are organized at Taif University, Taif city, KSA. The main objective of these sessions was to identify the level concerns the expected effect of lean on identified causes of wastes. The proposed levels of lean effect on causes of wastes were (Affected by lean, Partially affected by lean and, Not affected by lean). These sessions were carried out with three consultants engineers and three project managers, with practical experience in executing and supervising these types of projects. Table (8) through table (11) and figure (6) summarize the effect of lean on each identified cause of waste under its responsibility group.

Table 8. The Lean effect on causes of wastes for owner's responsibility group

No	Owner's responsibility	lean effect
1	**Client slow response and slow decision-making mechanism**	**Affected**
2	**problems in Client's organization such as bureaucracy and lack of specialists**	**Affected**
3	**Delay in running bill payments to the contractor or consultant**	**Partially affected**
4	**Cleint's special needs such as additional works and change order**	**Affected**
5	**Deficiencies and changes in project scope**	**Partially affected**
6	**Contractor selection before consultant**	**Partially affected**
7	**Unfairness in tendering or method of contractor choice**	**Not affected**
8	**Client's representative problems**	**Affected**
9	**Starting execution although project documents are not completed**	**Affected**
10	**Lack in project financing**	**Not affected**

Table 9. The Lean effect on causes of wastes for consultant's responsibility group

No	Consultant's responsibility	lean effect
11	**Delay in reviewing or approving design documents**	**Affected**
12	**Delay samples approval, inspections as well as making decisions**	**Affected**
13	**Lack of consultant's experience in design, supervision and quality control**	**Partially affected**
14	**Poor integrated organization structure for consultant**	**Partially affected**

As a result of these sessions, 24 causes are considered to be affected by lean techniques and 13 will be partially affected while the remaining 5 causes will not be affected by lean techniques. From the observations, it is noticed that the 5 causes of wastes which will not be affected by using lean techniques are: 1- Unfairness in tendering or method of contractor choice (CWRII = 0.33), 2- Lack in project financing (CWRII = 0.72), 3- Workers problems such as inadequate motivation or improper accommodations (CWRII =0.47), 4- Familiarity with site conditions, location and project complexity (CWRII = 0.33), and 5- Complete familiarity with systems and laws in KSA (CWRII = 0.24). Except "Lack in project financing" cause of waste which has high CWRII value, the remaining 4 causes of wastes have low values. This confirms the importance of using the lean techniques in minimizing wastes and increasing productivity.

Table 10. The Lean effect on causes of wastes for contractor's responsibility group

No	Contractor's responsibility	lean effect
15	**Inadequate experiences of contractor**	**Partially affected**
16	**Poor management team in performance such as late request for inspections or poor site management**	**Affected**
17	**Workers problems such as inadequate motivation or improper accommodations**	**Not affected**
18	**Unskilled workers and poor labor productivity**	**Affected**
19	**Delay in delivery of materials to site**	**Affected**
20	**Problems resulted in interference among different subcontractor's**	**Affected**
21	**Delay of regulatory reporting**	**Affected**
22	**Execution errors that lead to rework**	**Affected**
23	**Poor evaluation for contract items, tendering documents, and quantities as well as poor scope definition**	**Partially affected**
24	**Inadequate modern equipment and low productivity level**	**Affected**

Table 11. The Lean effect on causes of wastes for common's responsibility group

No	Common responsibility	lean effect
25	Dispute resolution delay or lack of dispute resolution methods	Affected
26	Poor distribution of personnel	Affected
27	Material wastes either due to poor design or poor execution	Affected
28	Familiarity with site conditions, location and project complexity	Not affected
29	Delay due to administrative approvals	Partially affected
30	Poor site safety	Affected
31	Inadequate specifications and shortage of design data	Affected
32	Changes in core team	Affected
33	Language barriers	Partially affected
34	Variations of actual quantities of work compared with quantities in bidding documents and underestimation of cost	Partially affected
35	Supplying poor quality materials	Affected
36	Complete familiarity with systems and laws in KSA	Not affected
37	Conflicts, poor communication and coordination among contractor and other parties	Affected
38	Unavailability of qualified sub-contractors	Partially affected
39	Truthfulness of contractor or consultant to get a big gain	Partially affected
40	Side effects due to project activities	Partially affected
41	Scheduling errors and actual execution duration is greater than duration in tender	Affected
42	Inadequate definition for authority or responsibility as well as supervision overlapping	Affected

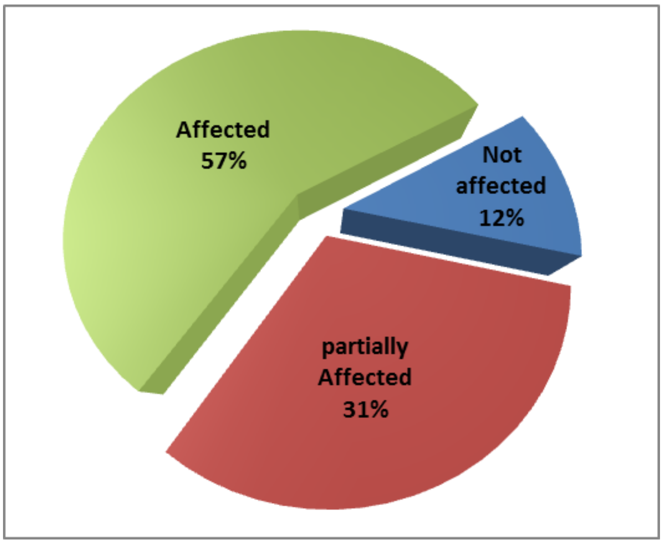

Figure 6. The percent of lean effect on causes of wastes in

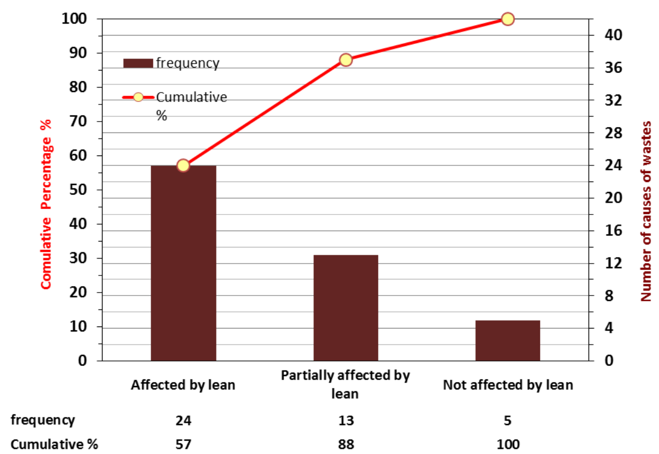

Figure 7. The cumulative percentage through pareto chart for lean effect on causes of wastes

The cumulative percentage of the lean effect is shown in figure (7). Causes of wastes that affected by lean represent about 57% from all causes, and causes of wastes that partially affected by lean signify 31%. The accumulated percentage of causes of wastes that affected completely or partially is attained 88% which confirms the importance of using lean techniques in KSA construction projects. The remaining 12% of causes which will not be affected by lean is considered low percent.

The effect of lean techniques based on responsibility groups is summarized in figure (8). It is clear that the maximum number of causes that affected by lean is under common responsibility followed by contractor, and owner. Moreover, the causes that partially affected by lean due to common responsibility represent the large number, followed by owner and contractors. Causes of wastes that not affected by lean are the same for common and owners (2 causes for each group) and one cause belongs contractors group. There are no causes of wastes will not be affected by lean under consultant responsibility.

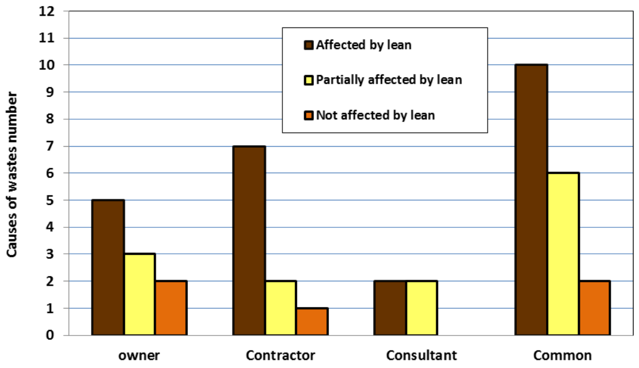

Figure 8. The effect of lean techniques based on responsibility

CONCLUSION

Where work is performed, wastes are being generated. Construction projects in KSA as a developing country with large investments faces many wastes. Not only do wastes in construction have negative impacts but also have many effects on the budget. This study aimed to identify the main causes of wastes in construction projects in KSA as well as defining the responsibility for each cause of wastes. The lean construction technique was suggested to be implemented through execution of construction projects in KSA to deal with the identified causes of wastes and increasing productivity. In addition, the study presented and discussed the results of filed surveys covering identifying the controllable and uncontrollable causes of wastes, responsibility for each group and the effect of implementing lean techniques on the causes of wastes. Based on the observations, discussions and results analysis, the conclusions can be drawn as follows:

1-Forty two causes of wastes were identified as controllable wastes in KSA construction projects. They were categorized under four responsibility groups; owner, consultant, contractor, and common. On the other hand, four uncontrollable causes were only identified.

2-An agreement analysis using Spearman and Kendall correlations was conducted for the purpose of using average responses from the participant groups. The level of agreement showed strong relationship amongst all groups. The highest agreement was between owners and consultants groups.

3-The causes of wastes were ranked due to their relative importance in overall order and inside the responsibility groups. Due to the overall ranking, the most important cause of waste was " Material wastes due to poor design or poor execution" followed by " Contractor selection before consultant".

4-The highest responsibility was shared amongst the three participants (common group) followed by owners and contractors, while the consultants' group represented the lowest responsibility.

5-Twenty four causes of wastes were expected to be affected by lean techniques if implemented in KSA construction projects while thirteen causes of wastes are expected to be partially affected. On the contrary, there is no expected lean effect on five causes of wastes.

6-The maximum number of causes that will be affected by lean was under common's responsibility followed by contractor, and owner.

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