A Behavioral Framework for Construction Waste Minimization: The Case of Jordan

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Construction waste (CW) accounts for approximately 36 percent of the total solid waste received at landfill sites around the world and, therefore, presents a significant challenge to the sustainability of the construction industry, the country's economy at large, and environmental sustainability worldwide. For Jordan, this issue is pertinent since the construction industry is still suffering from insufficient sustainability practices characterized by poor production, sub-standard performance, and a wasteful culture. Increasing attention has been placed on addressing the role of human factors in construction waste minimization (CWM), as the majority of the causes underlying CW are directly or indirectly affected by the behavior of those working in the construction industry. However, understanding CWM behavior is most challenging and complex, as adopting positive CWM behavior depends on many factors that contribute to its success or failure. This paper describes the development of a behavioral framework (BF) that aims to address this research gap. The Delphi technique, incorporating a series of semi-structured interviews, was chosen as the primary research investigative method, for the discovery and building of the BF. Twelve respondents (the experts' panel), with extensive knowledge of and experience in the Jordanian construction industry, participated in two rounds of the Delphi study. They were able to offer a well-informed look at the current and potential status of the adoption of CWM behavior among Jordanian contractors. The resulting BF advances a more holistic understanding of the factors influencing the behavior of contractors toward CWM, which will support the adoption of waste minimization in Jordanian construction projects.

Keywords: Construction Waste, Construction Waste Minimization, Construction Stage, Behavior, Behavioral Framework.

Introduction

Waste is a colossal problem in the world of construction. It accounts for approximately 36 percent of the total solid waste received at landfill sites around the world (ISWA 2015), and, therefore, presents a significant challenge to the sustainability of the construction industry, the country's economy at large, and environmental sustainability worldwide. For Jordan, this issue arises at a time when the built environment is failing to meet the increasing demands on scarce resources (Royal Scientific Society of Jordan 2013). Jordan imports 97 percent of its energy needs (The Ministry of Energy & Mineral Resources 2017), and is ranked as the fifth most water-scarce country in the world (Waste Atlas 2014). Additionally, the increase in pollution resulting from CW is particularly problematic in Jordan, given that waste landfilling and illegal dumping are commonly pursued disposal practices (UNEP 2015; Aldayyat et al. 2019). Around 90 percent of the total generated waste in construction sites is disposed of in landfill sites in Jordan (Batayneh, Marie, and Asi 2007).

Waste is also a key contributor for cost overruns in the Jordanian construction industry as the percentage of wastage materials (by value) accounts for 15 to 21 percent in construction projects (Bekr 2014). Building material prices are very high given Jordan's limited and costly supply of natural resources, and the ever-increasing price of importing raw materials from neighboring countries (Royal Scientific Society of Jordan 2013; Bekr 2014). The escalating price of imported fossil energy in Jordan amounts to 4.6 billion Jordanian dinar (JOD) per year (Ministry of Energy & Mineral Resources 2017) with the construction industry being a major contributor to national energy consumption levels (Tewfik and Ali 2014; El Hanandeh 2015). Therefore, waste minimization has become a pressing issue in the construction industry of Jordan.

The well-known waste management hierarchy (Council Directive 2008/98/EC 2008) focuses on the 3Rs of waste minimization (i.e., reduction, reuse, and recycling) for addressing CW generation. Such waste minimization measures usually result in the least environmental and economic costs, starting from the optimal situation of CW (source reduction), then reuse and recycling. Therefore, the scope of this study focuses on the 3Rs of waste minimization. While it is acknowledged that the design-out practices are importance measures in terms of their benefits toward CWM (Ajayi and Oyedele 2018), the amount of waste generation can still be significant, if poorly executed, during the construction process. CW is generated throughout the construction stage where there is site clearance, onsite operation, material use, material handling, material non-use, human error, on-site management and planning, transportation, and finally residual waste (Nagapan et al. 2012; Najafpoor et al. 2014; Bakshan et al. 2015; Ajayi et al. 2017; Kolaventi et al. 2020). Thus, waste minimization is an essential aspect during the construction stage. The behavior of contractors is a crucial element in the implementation of successful CWM measures (Kulatunga et al. 2006; Li et al. 2018; Liu et al. 2019). However, understanding their behavior toward such an issue is most challenging and complex, as adopting positive CWM behavior depends on many factors that contribute to its success or failure, as explained in the following section.

This article discusses the behavior of contractors toward waste minimization during the construction stage with the aim of the development of a behavioral framework (BF) to support the adoption of waste minimization behavior by contractors in Jordanian construction projects. Accordingly, the study's objectives are: (a) to investigate and identify the factors influencing the behavior of Jordanian contractors toward waste minimization during the construction stage; (b) to explore existing behavioral theories and frameworks and their effective application in a CWM context; and (c) to develop a BF to support the adoption of waste minimization in the construction stage of projects using Jordan as a case study.

Literature Review

Construction Waste Minimization Behavior of Contractors

In the past two decades, increasing attention has been placed on addressing the behavioral cause of CW, as many researchers have noted that human factors have a major effect on the generation and minimization of waste in construction projects (Bakshan et al. 2017; Wu, Yu, and Shen 2017; Li et al. 2018; Liu et al. 2019; Luangcharoenrat et al. 2019). Their studies revealed that the most common causes

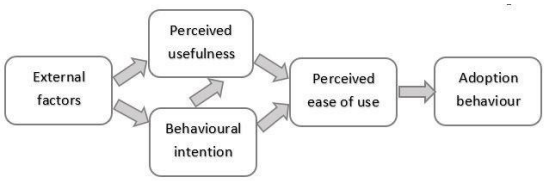
of CW generation are directly or indirectly affected by the behavior of those working in the construction industry and, consequently, negative behavior toward CWM could lead to significant waste generation. Kulatunga et al. (2006) have argued that CW occurs onsite for a number of reasons, most of which can be prevented, particularly, by changing attitudes. Udawatta et al. (2015) suggested that behavioral approaches require improvement to minimize waste generation in construction projects. Therefore, it is important to focus on the behavior cause of CW generation with regards to achieving effective CWM. This is particularly important with regards to the behavior of contractors, from management to laborer level, as they are directly involved in construction activities on-site (i.e., the construction stage).

Despite the growing need, previous studies have not fully addressed the role of the 'human factor' in CWM. To date, there has been a lack of structured research that has fully addressed the behavior role in CWM, as understanding CWM behavior has proven to be most challenging and complex. This is because adopting positive CWM behavior is dependent on many factors that contribute to its success or failure such as: insufficient relevant knowledge and lack of experience in construction, lack of awareness and understanding of the negative effects of CW, absence of senior management support, lack of interest and motivation toward CWM, technical difficulties, and lack of rules and regulations concerning CW (see Table 2). More importantly, each of these factors has different levels of influence in differing contexts (Osmani, Glass, and Price 2006). Therefore, it is important to identify and understand the factors influencing the behavior of contractors and their level of impact with regard to achieving effective CWM.

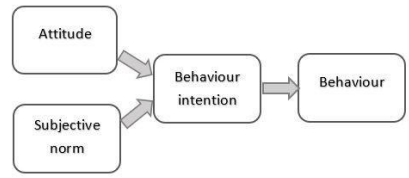
For that reason, significant behavior adoption studies such as Morris et al. (2012), have recommended, a review of existing well-known behavioral adoption theories and frameworks is needed in order to understand the human behavior in a certain context. This will provide a body of literature that may aid the researcher's attempt to explore and understand the potential factors influencing the behavior of contractors toward CWM.

Behavioral Adoption Theories and Frameworks

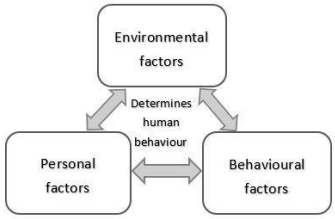
"Behavior theories and frameworks" are theories in psychology that try to predict human behavior toward a certain subject through investigating the factors that influence individual behavioral choices (Morris et al. 2012). They have been utilized in various disciplines, such as technology adoption, construction, education, health, and environmental sustainability, and have been proven to be valid and reliable in the prediction of human social behavior (see Figure 1). According to these theories and frameworks, CWM behavior is viewed as a consequence of a set of perceptions and attitudes which have different levels of influence in differing contexts. The most popular behavioral theories include: the Technology Acceptance Model (TAM) proposed by Davis (1985); Social Cognitive Theory (SCT) by Bandura (1986); Theory of Reasoned Action (TRA) suggested by Fishbein and Ajzen (1975); and the Theory of Planned Behavior (TPB) proposed by Ajzen (1991).



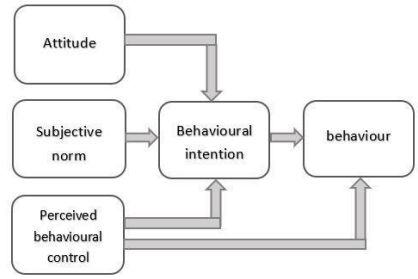
Technology Acceptance Model (TAM)



Theory of Reasoned Action (TRA)



Social Cognitive Theory (SCT)



Theory of Planned Behaviour (TPB)

Figure 1: The Most Popular Theories in the Prediction of Human Behavior
Source: Davis 1985; Bandura 1986; Fishbein and Ajzen 1975; Ajzen 1991

These behavioral theories are the most applicable and practical theories and frameworks available to support the prediction of human behavior However, despite the numerous attempts to provide accurate predictions of human behavior, nearly all of these have attracted strong criticism from researchers for being too simplistic and inadequate in successfully predicting behavior. Their studies argue that although such theories and frameworks are undoubtedly valuable, their implementation often has certain constraints. Table 1 illustrates a comprehensive critique, highlighting the limitations to the adoption of these theories and frameworks.

Table 1: Limitations of the TAM, SCT, TRA, and TPB

Theory	*Critique as a Generic Framework*	*Reference*
TAM	▪ Ignores the importance of subjective norms (e.g., social influence and voluntariness) which were found to have provided better explanatory power ▪ Ignores the importance of organisational factors (e.g., job requirements and facilitating conditions) which have been found to have a significant effect on the usage behavior of a technology	Venkatesh and Davis (2000), Lee, Kozar, and Larsen (2003), Bagozzi (2007). Venkatesh and Bala (2008), Chuttur (2009), Otieno et al. (2016), Olushola and Abiola (2017), Ajibade (2018).

SCT	▪ Mostly concerned with the social influence on the individual's behavior ▪ Assumes that behavior is primarily influenced by the surrounding environment which is not always the case, because people move through life and their behavioral patterns can change drastically with little change in their environment ▪ Developed and tested largely in face-to-face settings without advanced technology such as online media ▪ Does not focus on emotion or motivation (perceived usefulness), other than through reference to past experience	Kippax (1993), Montaño and Kasprzyk (2015), Paul, Modi, and Patel (2016), Hagger (2019).
TRA	▪ Neglects the perceived behavioral control factor when predicting behavior and assumes that individuals have full volitional control of themselves ▪ Focuses on behaviors that people decisively enact, and it is limited in terms of being able to predict behaviors that require access to certain opportunities, skills, conditions and/ or resources ▪ Behaviors and attitudes may not always be linked with intentions, particularly when the behavior does not require much cognitive effort.	Kippax (1993), Montaño and Kasprzyk (2015), Paul, Modi, and Patel (2016), Hagger (2019).
TPB	▪ More variables should be incorporated to enhance its explanatory power in predicting behavior ▪ Neglects moral considerations as sometimes moral norms can have a larger impact than attitude on intention to perform the behavior ▪ Ignores the importance of the technological factors (e.g., ease of use and perceived usefulness), as such factors can better predict the attitude toward the adoption of a technology	Davies, Foxall, and Pallister (2002), Kaiser (2006), Sniehotta, Presseau, and Araújo-Soares (2014), Montaño and Kasprzyk (2015), Botetzagias, Dima, and Malesios (2015), Conner (2020).

Source: Alhawamdeh and Lee

Behavior Adoption Theories and Frameworks in a Construction Context

Various studies have analyzed the use of the aforementioned behavioral adoption theories and frameworks in the understanding of contractors' behavior and their work performance (e.g., CWM) in the construction industry (e.g., Teo and Loosemore 2001; Lee, An, and Yu 2012; Yuan 2013; Lorente et al. 2014; Sepasgozaar, Shirowzhan, and Wang 2017; Li et al. 2018; Liu et al., 2019). However, based on the extensive review of the relevant literature, key weaknesses were found regarding the adoption of such theories and frameworks toward understanding CWM behavior.

- First, there was a lack of variety of regions, such as in the Middle East, with regard to the studies conducted using behavioral adoption theories and frameworks for the predication of CWM behavior. Based on the extensive review of the relevant behavioral adoption literature, the majority of studies that utilized these four theories have been conducted in developed counties, such as the United States, Europe and in China, and therefore authors (e.g., Hong and Chiu 2001; Wu, Yu, and Shen 2017; Liu et al. 2019) have argued that the results of these studies are less open to generalization in other cultural contexts, such as in the Middle East region. Accordingly, the adoption of these theories and frameworks may be inappropriate for developing countries, as it differs from one culture to another because of different prevailing factors. Wu, Yu, and Shen (2017) noted that the adoption of a certain behavior is perceived and

valued differently by different cultures.

- Second, the application of these theories and frameworks in the context of construction confirmed what was reported by the critics in Table 1, in terms of their inadequate and simple construct which lacked additional important factors for the effective prediction of CWM behavior. For instance, the findings of Lee, An, and Yu's (2012) study revealed that TAM neglects the effect of social pressure toward the adoption of low- waste technologies (i.e., BIM), while Lorente et al. (2014) indicated that incorporating organizational factors, such as the provision of requisite opportunities and resources, is extremely significant in predicting construction employee's engagement in work. With regard to Liu et al.'s (2019) study, their application of TPB failed to consider the technological factors which can significantly help to explain the lack of utilization of waste minimization technologies in the Chinese construction industry.

In conclusion, in reviewing the existing key behavior adoption theories and frameworks, used in understanding CWM behavior, it has been observed that all have their relative benefits and limitations in successfully predicting the factors impeding the adoption of CWM behavior. Consequently, this study attempts to bridge the gap in the CW literature through the development of a BF that can address the weaknesses of existing theories and frameworks in order to enhance the explanatory power in the prediction of CWM behavior. The BF will advance a more holistic understanding of the key factors influencing the behavior of contractors toward CWM, especially as there is a lack of extensive and empirical research dedicated to investigate CWM behavior in the Middle East region and particularly in Jordan, where the circumstances and culture are different from other countries. The theoretical basis of the BF is developed using best practice with regard to existing behavioral adoption theories and frameworks to enhance the explanatory power in the prediction of CWM behavior. This was confirmed by Morris et al. (2012) who suggested that factors found in behavioral adoption literature are the starting point for any study in order to build up a theoretical base for the fieldwork investigation. Therefore, Table 2 presents the important factors influencing the behavior of contractors toward CWM. These factors are considered to be the most common behavioral factors which occur on construction sites, as reported by numerous studies.

Table 2: Common Factors Influencing the Behavior of Contractors Toward CWM

Factors	*Description*	*Reference*
Construction-related knowledge	Knowledge helps to raise the construction workforces' perception and understanding in the CW subject, additionally it helps raise their consciousness of the longer term social and ethical implications of their activities in the project.	Yuan (2013), Bakshan et al. (2017), Li et al. (2018), Luangcharoenrat et al. (2019).
Personal norms	CWM behavior can be perceived as a form of moral behavior since the benefits of such behavior are shared within the society in addition to the person involved, hence, is a key motivation factor for minimizing waste.	Li et al. (2018), Mak et al. (2019).
Perceived usefulness	CWM behavior can be affected by the degree to which an individual believes that minimizing CW would reap benefits for the local community, organization and the person involved.	Park and Tucker (2017), Yuan, Wu, and Zuo (2018), Hao et al. (2019).
System ease of use	There is a strong correlation between the ease of use of low-waste technologies and the likelihood of their adoption. technologies that are simpler to understand are adopted faster than those requiring the adopter to develop new skills and understanding.	Lee, Yu, and Jeong (2015), Sepasgozar, Loosemore, and Davis (2016), Sepasgozaar, Shirowzhan, and Wang (2017).

Descriptive norms	Being influenced by surrounding persons, coupled with the willingness to follow the trend, have a significant effect on the individual's behavior toward CWM.	Lorente et al. (2014), Yuan, Wu, and Zuo (2018).
Injunctive norms	The regulatory environment plays a crucial role in promoting CWM practices by enforcing policies for the whole industry	Wu, Yu, and Shen (2017), Hao et al. (2019).
Project constraints	CWM behavior depends to some degree on non- motivational factors such as availability of requisite opportunities and resources (e.g., time, money).	Simpson (2012), Abarca- Guerrero, Maas, and van Twillert (2017).
Facilitating conditions	Intention in conjunction with appropriate opportunities and resources enable attainment of a behavioral goal in CWM.	Wang, Kang, and Wing·Yan Tam (2008), Lee, An, and Yu (2012), Ajayi et al. (2017).
System compatibility	The fit between a particular technology adoption and the work environment, current methods of construction and overall objectives, can have a significant influence on both user behavioral and organization intention to adopt that technology	Sepasgozaar, Shirowzhan, and Wang (2017), Shirowzhan et al. (2020).

Source: Alhawamdeh and Lee

Method

As the nature of this study required the researcher to understand, explore and elicit opinions, views and perceptions of the Jordanian contractors toward the adoption of CWM, it is clear that the research falls mainly within the interpretivist philosophy paradigm. This is because such a paradigm which is governed by the qualitative inquiry of "what" and "how" questions allows the researcher to investigate in-depth and insightful information and explanations of the data to be collected: factors influencing the behavior of contractors toward CWM. Accordingly, the Delphi interview technique is chosen as the primary research investigative method because of its ability to offer a well-informed look at the current and potential status of the adoption of CWM behavior among Jordanian contractors. Such a technique is undoubtedly invaluable allowing the Delphi experts' panel (interviewees) holding differing perspectives and differing cognitive abilities, to refine their views based on the results of each round of questions till consensus is reached. Figure 2 illustrates the Delphi interview process adopted in this study.

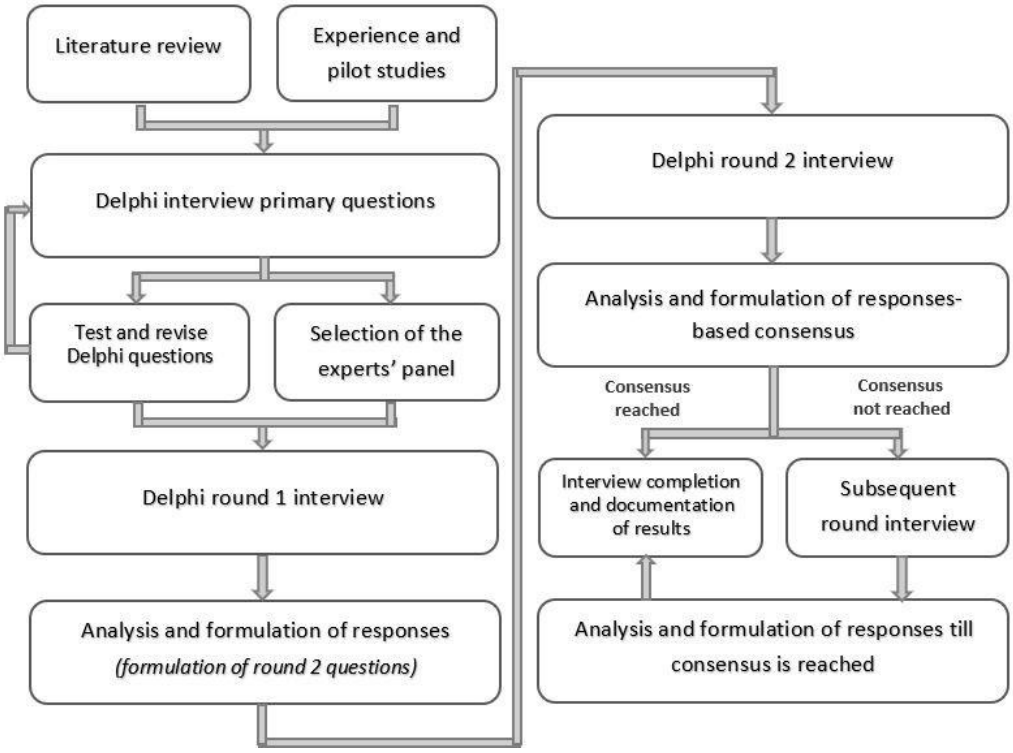


Figure 2: The Delphi Process in This Study
Source: Alhawamdeh and Lee

Sample

The experts were well balanced and included representatives from across the contractor's employees, including lead construction managers, project managers, site managers, foremen and laborers, would appear to have the required knowledge and/ or experience in the Jordanian construction industry. The project type and location were not considered as part of the inclusion criteria. This is because the nature of the built environment is labor-intensive and, consequently, waste is generated in all types of projects. Additionally, Jordan is a small country and the culture, uptake and challenges in the built environment are similar across the different parts of the country. The researcher determined two main conditions regarding the inclusion criteria for the panel of experts:

- Experience of working in the Jordanian construction industry must be greater than five years and the expert must have worked in both private and public projects. This is to ensure that the selected experts had adequate knowledge and experience of the subject in a variety of projects, as each private/public sector project sometimes requires different construction techniques and standards.
- Experience of working in medium to large-size projects in terms of budget. According to the Ministry of Public Works and Housing of Jordan (2020), medium and large-size projects are defined as those that have a budget exceeding 400,000 JOD. This is to ensure that the selected experts had experience in construction projects which involve technological methods, as most medium to large projects in Jordan depend to some extent on technological construction methods (i.e., low-waste technologies) in addition to the traditional ones. In addition, such sized projects have a greater impact on the production of CW than small projects. Accordingly, a total of twelve were chosen to participate in this Delphi study. Due to issues of confidentiality and anonymity, the experts are not named in this study and are instead given codes (e.g., E1, E2, etc.) to aid identification, Table 3.

Table 3: Profiles of the Twelve Participating Experts in the Delphi Study

Name	*Education Level*	*Experts Discipline Group*	*Experience (Years)*
E1	MSc in Civil engineering	Lead manager	32
E2	BSc in Civil engineering	Project manger	25
E3	MSc in Material engineering	Project manger	15
E4	BSc in Architect	Project manger	10
E5	BSc in Civil engineering	Site manager	7
E6	BSc in Structural engineering	Site manager	9
E7	BSc in Quantity surveying	Foremen/supervisor	7
E8	BSc in Quantity surveying	Foremen/supervisor	8
E9	High school	Laborer	12
E10	Industrial Diploma	Laborer	10
E11	Technician Diploma	Laborer	10
E12	High school	Laborer	5

Source: Alhawamdeh and Lee

Round 1 and 2 Design (Questions and Analysis)

The aim of the first round of the Delphi study is to gather and elicit the opinions of the experts' panel on the factors influencing the behavior of contractors toward CWM in Jordan. The first- round questions design draws on the factors identified in the behavioral adoption literature (Table 2) as well as the variables/factors of the theories and frameworks discussed earlier. Yin (2009) revealed that a literature review allows theories or models that have been previously used by researchers within the discipline to be identified and understood. This facilitates the process of identifying an issue in the field that has not been resolved, which will subsequently become the primary concern of the research. Accordingly, a combination of eleven open-ended questions (see Appendix) were formulated and designed to collect the required data for the development of the BF. These questions allow the experts to elaborate on the list of the factors, in addition, it aids in identifying additional factors influencing the behavior of contractors toward CWM in Jordan.

With regard to the second round of the Delphi study, it aims to verify the factors, acquired from the first round, influencing the behavior of Jordanian contractors toward CWM. The second- round questions are constructed from the results acquired from the first-round responses (Skulmoski, Hartman, and Krahn 2007). Accordingly, all the factors that were identified through the discussions of the experts in the first round were then presented to the experts during the second round in rank order, according to the frequency of occurrence (indicating their importance), for reconsideration and validation until consensus is reached. The minimum percentage that is considered a consensus in this study, as recommended by Giannarou and Zervas (2014) and Heiko (2012), is 70 percent of the number of experts. The results of the second-round will then be used to develop the proposed framework (BF). It should be noted that only two rounds of the study were deemed necessary for the experts' panel to reach a consensus.

The data is analyzed based on the Template Analysis method proposed by King (2004). A number of codes were identified based on their frequency of occurrence in the first-round responses, which were then categorized under main themes. For instance, the responses of the experts in Round 1 were categorized into four main variables (themes), namely: personal, technological, social and organizational. Within each of these variables a number of factors (i.e., codes) were identified, and corresponding subfactors; for example, in the technological variable (theme), two factors (codes) of system ease of use and system

compatibility were identified, and within each of these factors there were a number of subfactors.

Data Collection

Face-to-face semi-structured interviews were conducted with the twelve experts in both rounds. The interview schedule was first translated from English into the Arabic language in order to support the experts' convenience and full understanding of the content as Arabic is their first language. The interview sessions in both rounds lasted between forty-five and sixty minutes. During this time, the researcher recorded the interviewees' responses by taking hand-written notes supplemented with a tape-recording, with the interviewees' consent, which would be transcribed afterwards to ensure no findings were missed in the analysis.

Results and Discussions

Discussion of Results from Delphi Round 1 and 2

Findings from the interview data, interestingly, did not appear to contradict the factors within the literature (Table 2), since all of them were confirmed by the experts' panel. However, there were distinct variations in the level of influence of these factors on the behavior of Jordanian contractors toward CWM. Additionally, some distinct variations between the perceptions of the experts from different levels of the hierarchy emerged, in particular, between managerial level employees who were mainly involved in the planning and supervision of projects, and the employees who were essentially on the front line and responsible for the implementation of work on construction sites.

The resultant two-round Delphi study concluded with a total of thirty-one consensuses (i.e., subfactors) achieved with regard to the factors influencing the behavior of Jordanian contactors toward CWM. Two issues did not reach consensus namely: manager's encouragement and the influence of difficult employees. Both issues respectively reached a consensus of 50 percent and 30 percent in the second round. The main reason behind this is that the majority of experts were not certain that such issues would have a significant direct influence on the behavior of the Jordanian contractors toward CWM. However, this matter is debatable; some experts believed that encouragement from managers helps to build loyalty to their work and organization, and this can significantly enhance work performance, including CWM. Moreover, the negative effect of difficult employees in the work environment, creating a negative working atmosphere, can diminish productivity, which in turn results in poor work performance and a higher chance of CW generation. Thus, it is worth taking these two issues into consideration for future research, or indeed, they may not be applicable to the Jordanian construction industry at this particular time. Therefore, it was decided that it was not necessary to undertake a third round of Delphi for just these two issues. Table 4 demonstrates the results of the two rounds Delphi study regarding the factors influencing the behavior of contractors toward CWM in the Jordanian construction industry.

Table 4: The Delphi Results–Factors Influencing the Behavior of Contractors Toward CWM

Factors	*Issues Affecting CWM Behavior (Subfactors)*	*Round 1 (Frequency of Occurrence)*	*Round 2 (Consensus)*
Construction-related knowledge	Awareness of the causes and types of CW	7 experts	100%
	Knowledge and awareness of low-waste technologies	6 experts	100%
	Skills and expertise in the handling of construction errors	3 experts	100%
	Awareness of the financial gains of CWM	4 experts	90%
	Awareness of the negative environmental impacts of CW	2 experts	70%

Personal norms	Courtesy between the different levels of employees	9 experts	100%
	Religious obligations	4 experts	70%
Perceived usefulness	Cost reduction incentives	11 experts	100%
	Enhanced work performance incentives	7 experts	100%
	Health and safety incentives	6 experts	100%
	Rewards incentives	5 experts	100%
	Environmental benefits incentives	2 experts	70%
System ease of use	System complexity and learning difficulties	10 experts	100%
	Technical support from vendor	5 experts	100%
System compatibility	Compatibility with the existing construction practices	9 experts	100%
	Compatibility with the project nature	6 experts	100%
Descriptive norms	The practices of peer-practitioners	8 experts	100%
	Interest of managers in CWM	5 experts	100%
	Wasteful culture	4 experts	70%
	Influence of difficult employees	2 experts	30%
Injunctive norms	Financial charges and penalties	9 experts	100%
	Governmental supervision	5 experts	100%
	Green construction practices	3 experts	80%
Project constraints	Time constraints	12 experts	100%
	Cost constraints	11 experts	100%
Facilitating conditions	On-site planning and management	10 experts	100%
	Technical support	8 experts	100%
	On-site supervision	4 experts	100%
	Training and information support	5 experts	90%
	Management change	3 experts	80%
Additional factors	Perceived increased workloads	6 experts	100%
	Belief that waste is inevitable	6 experts	90%
	Manager’s encouragement	3 experts	50%

Source: Alhawamdeh and Lee

BF Development

The development of the BF is based on the discussion and tabulation of the results of the literature review as well as the results of the Delphi study. The literature review identified a list of key factors (see Table 2) influencing the behavior of contractors toward CWM adoption. Subsequently, secondary data from the literature review is combined with primary data (i.e., the Delphi results) in order to ensure that it is comprehensive, up-to-date and appropriate for the precise needs of this study, which in this particular case is to ensure that it is relevant to Jordan. The BF consists of four constituent variables that work together to explain and predict factors influencing the behavior of Jordanian contractors toward CWM behavior. These are: personal, technological, social and organizational variables, as illustrated in Figure 3.

- Personal variable incorporates factors which refer to the perceptions and beliefs which influence the adoption of CWM behavior. Self-efficacy beliefs function as an important set of proximal determinants of human motivation, affect and action; self- efficacy operates on action through motivational, cognitive and affective intervening processes (Bandura 1989; Davies, Foxall, and Pallister 2002). In other words, people will take the lead role in driving sustainability forward and bringing about the necessary changes in an organization with regard to CWM. According to the Delphi results, a number of key personal factors affect the behavior of contractors in Jordan toward CWM. These are: construction-related knowledge, personal norms, perceived usefulness, perceived increased workloads and belief that waste is inevitable.
- Technological variable incorporates factors which refer to the nature and characteristics of technologies which are associated with the level of acceptance and usage of these technologies from potential adopters (Davis 1993). In a similar way, the implementation attributes of low-waste technologies function as an important set of determinants for its adoption. According to the Delphi results, a number of key technological factors encourage/ inhibit the willingness of contractors in Jordan toward the acceptance of low-waste technologies. These are: system ease of use and system compatibility.
- Social variable incorporates factors which refer to the cultural issues that reflect a sense of social pressure, either voluntarily or mandatorily, toward the adoption of CWM behavior. It reflects an individual's sense of social pressure to behave in a certain way (Ajzen 1991). According to the Delphi results, a number of key social factors influence the behavior of contractors in Jordan toward CWM. These are: descriptive norms and injunctive norms.
- Organizational variable incorporates factors which refer to the organizational internal issues that influence the degree of ease or difficulty of performing CWM behavior. In a similar way, the objective issues in the work environment can make an act easy to accomplish (Thompson 2003). Consequently, the effective adoption of CWM behavior depends heavily on the support of a well-balanced infrastructure consisting of an interaction between the factors in the work environment. According to the Delphi results, a number of key organizational factors affects the controllability of employees toward their engagement with CWM in Jordanian construction projects. These are: project constraints and facilitating conditions

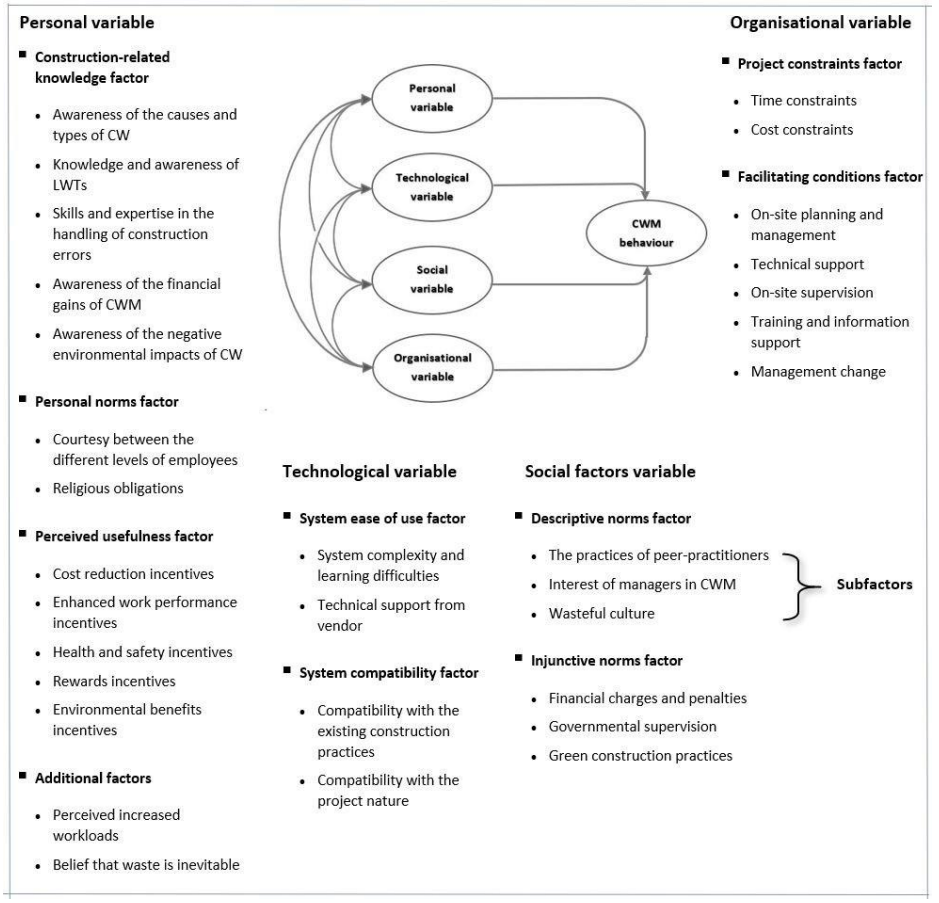


Figure 3: The BF Structure and Factor Influencing Contractors' Behavior toward CWM
Source: Alhawamdeh and Lee

In light of Figure 3, the researcher argues that the BF adoption is based on a dynamic interaction between the four variables (personal, technological, social, and organizational) influencing CWM behavior. This is because there is a clear cause-effect relationship between the integrated factors within the aforementioned variables and, thus, failure to consider any one of them will lead to failure for achieving successful CWM behavior. For example, if a worker has the necessary construction-related knowledge, he/ she may not be able to successfully implement CWM without senior management support, or without adequate time and money resources, and vice versa. According to the cross-referencing of the findings from the literature review with the Delphi study (see Table 5), ten main factors, which includes thirty-one subfactors, are identified and have been combined in order to develop the BF to support the adoption of the waste minimization behavior by contractors in Jordanian construction projects. All the issues in the literature review have been substantiated by the Delphi study except for seven interesting subfactors that emerged from the Delphi study and are foreseen to have a major impact on the behavior of Jordanian contractors toward CWM. These are: (I) skills and expertise in the handling of construction errors, (II) courtesy between the different levels of employees, (III) religious obligations, (IV) health and safety incentives, (V) perceived increased workloads, (VI) wasteful culture, and (VII) management change.

Table 5: Cross-referencing of the BF Factors Based on the Tabulation of Findings from the Literature Review and the Delphi Study

Factors	*Subfactors*	*Delphi Study*	*Literature*	*Reference*
Construction-related Knowledge	Awareness of the causes and types of CW	✓	✓	Abarca-Guerrero, Maas, and van Twillert (2017), Luangcharoenrat et al. (2019).
	Knowledge and awareness of green construction technologies	✓	✓	Sepasgozaar, Shirowzhan, and Wang (2017).
	Skills and expertise in the handling of construction errors	✓	✗	-
	Awareness of the financial gains of CWM	✓	✓	Bakshan et al. (2017), Mahpour and Mortaheb (2018).
	Awareness of the negative environmental impacts of CW	✓	✓	Wang, Kang, and Wing-Yan Tam (2008), Yuan (2013).
Personal norms	Courtesy between the different levels of employees	✓	✗	-
	Religious obligations	✓	✗	-
Perceived usefulness	Cost reduction incentives	✓	✓	Udawatta et al. (2015), Park and Tucker (2017), Hao et al. (2019).
	Enhanced work performance incentives	✓	✓	
	Health and safety incentives	✓	✗	-
	Rewards incentives	✓	✓	Mahpour and Mortaheb (2018).
	Environmental benefits incentives	✓	✓	Yuan, Wu, and Zuo (2018).
System ease of use	System complexity and learning difficulties	✓	✓	Lee, Yu, and Jeong (2015), Sepasgozaar, Shirowzhan, and Wang (2017).
	Technical support from vendor	✓	✓	
System compatibility	Compatibility with the existing construction practices	✓	✓	Lee, An, and Yu (2012), Shirowzhan et al. (2020); Sepasgozaar, Shirowzhan, and Wang (2017).
	Compatibility with the project nature	✓	✓	
Descriptive norms	The practices of peer-practitioners	✓	✓	Lorente et al. (2014).
	Interest of contractors in CWM	✓	✓	Li et al. (2018).
	Wasteful culture	✓	✗	-
Injunctive norms	Financial charges and penalties	✓	✓	Hao et al. (2019).
	Governmental supervision	✓	✓	Wu, Yu, and Shen (2017).
	Green construction practices	✓	✓	Yukalang, Clarke, and Ross (2017).
Project constraints	Time constraints	✓	✓	Abarca-Guerrero, Maas, and van Twillert (2017), Yuan, Wu, and Zuo (2018).
	Cost constraints	✓	✓	
Facilitating conditions	On-site planning and management	✓	✓	Mäki and Kerosuo (2015).
	Technical support	✓	✓	Lee, An, and Yu (2012).
	On-site supervision	✓	✓	Ajayi et al. (2017).
	Training and information support	✓	✓	Wang, Kang, and Wing-Yan Tam (2008).
	Management change	✓	✗	-
Additional factors	Perceived increased workloads	✓	✗	-
	Belief that waste is inevitable	✓	✓	Teo and Loosemore (2001).

Source: Alhawamdeh and Lee

Construction-related Knowledge

The opinion of experts accentuates the importance of construction-related knowledge with regards to CWM. Adequate knowledge and experience of laborers and supervisors regarding the proper and effective implementation of work will raise their level of understanding of the different types and causes of CW; this can help them complete the job more efficiently with minimal resources and time wasted. Further, understanding the different types of low-waste technologies can promote their adoption more efficiently in order to achieve improved CWM results. This is due to the fact that the majority of Jordanian contractors are adopting the familiar conventional methods of construction with minimal technology adoption.

In terms of awareness and knowledge of the resulting benefits of CWM, the experts noted that there is a general lack of awareness of the significant environmental impact of CW, particularly among laborers. This is because most of the construction laborers in Jordan have low educational attainment and, therefore, are less informed about such an issue. One issue was emphasised by the experts regarding the skills and expertise in the handling of construction errors. Such issue is a key requirement for onsite management in order to control the level of waste production. Errors and design changes in construction are inevitable and can adversely affect work performance resulting in waste generation, particularly when they are mishandled by site supervisors and managers who should be competent in dealing with such circumstances. This is particularly important since rework resulting from design changes and construction errors are common issues facing contractors in Jordanian construction projects.

Personal Norms

Religious obligation of some employees can provide moral guidance and rules regarding the implementation of their work. This is because some employees' actions are derived from their religious beliefs when performing construction work, and they feel obliged in performing their work in the best way possible with minimum negative consequences such as generating CW. According to the experts' panel, Jordan is highly influenced by religious and cultural traditions when it comes to their actions and, therefore, religious obligation is an important issue when it comes to the job performance. Courtesy between managers and employees is another interesting issue which seems to have a major impact on the behavior of Jordanian contractors toward CWM. This is because such issue helps to build a strong relationship between both parties and create a positive working atmosphere. This will encourage employees to be more loyal to the organization and, therefore, increase productivity.

Perceived Usefulness

There were no doubts among the panel of experts about the value of CWM in terms of its resulting benefits. Cost reduction in construction project is considered as a key advantage that highly incentivizes Jordanian contractors toward CWM. In addition to the reduction in the materials purchasing costs, CWM can enhance the quality of work and increase the productivity and efficiency of the construction process through saving time and costs dealing with waste. CWM can also improve the workflow on construction sites by avoiding obstacles occurring during the construction process—such as CW. This helps make the work of on-site workers much easier, which in turn will increase their motivation toward avoiding waste generation. Therefore, CWM can benefit both managers and workers by maximizing the profit and enhancing the workflow in the construction project.

With regard to rewards, experts indicated that benefits which can be gained through involvement in CWM (e.g., bonuses and promotions) can encourage managers, supervisors, and laborers in minimizing CW. However, the experts took the perspective that such issue can also push employees into taking the initiative and being creative to ensure that the job is done properly with minimum wasted materials. In other words, employees may start to suggest new ideas, look for better solutions and generally work harder to get a reward. Another motivational benefit of CWM is the health and safety of on-site workers. This is particularly important because CW usually contains dangerous and hazardous materials which are a serious threat to on-site workers. Therefore, through minimizing CW and better management of construction sites, obstructions and accidents can be largely avoided. Notably, the health and safety standards for construction projects in Jordan are mostly focused on large construction projects, whereas small to medium

size projects do not often comply with such standards.

System Ease of Use

Concern was voiced by both managers and employees that the complexity of a technology is a strong inhibitor to managers' willingness to adopt such technology instead of using traditional methods of construction. Working with complex equipment and a complicated operation process can strongly decrease the likelihood of technology adoption in construction projects. Some experts argued that difficulties may exist in integrating the outcome of some complex technologies with other components of the project and, therefore, there was a strong chance of errors and mistakes occurring which would result in waste. It was also clear that technical support from vendors was considered a major issue that would facilitate the adoption of low- waste technologies in construction projects. The availability of technical support from vendors can strongly restrict technology usage, as guidelines and directions may be required when utilizing certain technology. This issue is unique to the Jordanian construction sector due to the fact that there is a lack of professional bodies that provide technical assistance and support in the utilization of low-waste technologies and especially those that are perceived as complex.

System Compatibility

Integrating low-waste technologies with existing construction practices can sometimes prove challenging and difficult as some of these technologies may not be compatible with the traditional methods of construction practiced by contractors. For instance, some of the traditional construction methods are simple and depend on basic resources and are, consequently, incompatible with advanced technologies. This issue was expressed with great concern as the current status of the Jordanian construction industry is still suffering from insufficient adoption of contemporary technologies. This is because many contractors (particularly small or medium-sized contractors) are still using the old traditional methods of construction that often do not contribute to sustainability. Further, the compatibility of some low-waste technologies with the type, size and budget of a construction project may not fit, as some construction projects are very simple or have limited budgets and do not necessarily require advanced technologies. However, such a scenario can work in both directions as some construction projects may be too large or complex, therefore the utilization of certain low-waste technologies that are unsuitable for the project can be too expensive.

Descriptive Norms

There is a significant effect of the practices of co-workers on the individual's engagement with CWM, in the sense that the individual is largely influenced by the actions and attitudes of their workplace peers. However, such an issue can work in both ways; while the poor and unproductive work performance of co-workers can affect individual engagement in CWM, the professionality and perfectionism of colleagues can also incentivize the worker to perform high standards of work performance and therefore promote CWM. The performance of CWM can also be influenced by the level of interest from managers toward CW. This is usually because the employees, particularly foremen and laborers, are less likely to adopt waste minimization behavior when they perceive that the managers are not that concerned about CW. The experts' panel emphasized that a wasteful culture can significantly influence the behavior of Jordanian contractors toward CWM, being affected by the society's morals in addition to the surrounding work environment. This is because Jordan's society is strongly influenced by consumerism and materialism which encourages wasteful habits in people, including those in the construction industry.

Injunctive Norms

Waste disposal charges and penalties for illegal dumping can increase the likelihood of the recycling and safe disposal of CW. They can also increase the likelihood of contractors reusing excavated soil which is considered as one of the highest proportions of dumped materials in the Jordanian construction sector. Illegal dumping of CW is a very common practice in Jordan's construction industry. Therefore, through inspections and the strict monitoring of CW handling, transportation and disposal, the practice of illegal dumping will be more controlled and CW disposal can be better managed. The provision of effective waste

management plans can exert a sense of obligation on managers toward adopting CWM. However, the experts emphasized the aspect of regulation implementation of such plans. For instance, the green construction concept had already been introduced in the Jordanian construction sector; nonetheless, the adoption of such a system is still very minimal. A possible reason for this is that apartment buildings account for the majority of construction projects in Jordan (Jordan Strategy Forum 2019) and, therefore, according to the experts, most of the project stakeholders are mainly interested in profit maximization; this interest overcomes any interest in adopting green practice.

Project Constraints

When more resources are put into construction projects, it will increase the opportunities for employees, particularly site supervisors and laborers, toward achieving CWM. The ability of on-site workers to contribute to waste minimization in construction activities is dictated largely by the managers' interest and willingness to commit financial resources to such issue. Assigning adequate numbers of laborers for waste sorting, collecting, and reuse on construction sites and the use of low-waste technologies is common among Jordanian contractors in order to increase their profits. Time pressure also prevents employees from performing high standards of construction work, as such issue forces the workers to rush in their work which. This can significantly result in huge amount of wasted materials and is considered one of the main barriers to CWM in Jordan.

Facilitating Conditions

There was no doubt from the experts' panel that organizational support is an important issue that can strongly influence the feasibility of the work. Good on-site planning and management is a key issue that strongly influences and streamlines the construction process toward being well managed and more productive and which leads, ultimately, to CWM. For instance, good on-site planning helps make effective decisions toward the efficient management of construction materials including salvaging waste, avoiding excess material use, minimizing the risk of materials damage and consequently reducing wastage. Cooperation between managers, supervisors and laborers is also a significant advantage resulting from good planning and management, which in turn helps reduce CW through improving job performance and managing risk and uncertainty. With regard to technical support, equipment maintenance, repairs, or software support and updates are key issues that an organization should provide in order to maintain good performance resulting in CWM. For instance, old and worn out equipment produces poor work quality and therefore increases waste materials—especially as such equipment is still being utilized by many small-size contractors in the Jordanian construction sector.

Clearly, company policies such as on-site supervision are an important aspect in ensuring the implementation of standard work performance. By setting out standard work procedures and monitoring the work performance, construction can be more controlled. Furthermore, it is vital that a company supports its staff by providing education and training on CW types, causes, the negative impacts of CW and CWM methods, in order for the company to achieve its targets for reducing waste. One interesting new issue that was emphasised by the experts is effective change management, as such an issue, which can be frequent, can heavily impact waste minimization. This is due to the fact that well-organized management changes help in maintaining the workflow of the construction process, avoid any interruptions and reduce difficulties for workers in following up with new plans. If these changes do not occur, it will result in confusion among workers and tasks overlapping which can increase the chance of generating CW.

Additional Factors

Beliefs among Jordanian contractors about waste being inevitable in construction projects can have a huge negative impact on CWM. In fact, the panel of experts indicated that the introduction of courses intended to raise the awareness of contractors, especially laborers, regarding this issue had been proposed by a number of firms in the Jordanian construction industry. This is because there is a widespread perception among some site supervisors and laborers that waste minimization efforts will never be sufficient to completely eliminate waste in construction activities. This can result in careless acts (not necessarily

intentional) from such employees when performing their work which can significantly affect CWM. The perception that CWM will increase the workload has also a major influence on employees' attitudes toward minimizing waste in Jordanian construction projects. Such perceptions can result in workers neglecting the aspect of minimizing waste as they believe that it requires more time and effort in terms of waste sorting, collection or even source reduction measures and, therefore, will increase the workload.

Conclusion

CWM has become a pressing issue due to the scarcity of resources and subsequent unsteady energy supply, which are two serious challenges facing Jordan today. To date, there has been a lack of structured research that has fully addressed the role of the "human factor" in CWM, as understanding CWM behavior has proven to be most challenging and complex. This is because adopting positive CWM behavior is dependent on many factors that contribute to its success or failure. An extensive review of existing well-known behavioral adoption theories and frameworks revealed that nearly all of them have attracted heavy criticism from researchers for being too simplistic and inadequate in successfully predicting behavior. It has also been observed that the application of these behavior theories and frameworks in the context of construction confirmed what was reported by those researchers in terms of their inadequate and simple construct which lacks additional important factors for the effective prediction of CWM behavior. Consequently, it was concluded that there is a real need for a BF that will address the limitations of the existing behavioral adoption theories and frameworks in order to enhance the explanatory power in the prediction of CWM behavior in the Jordanian context. The need for the BF was also necessitated because, to date, there is a lack of studies dedicated to identifying and understanding the factors influencing the behavior of Jordanian contractors toward CWM.

The BF was developed using existing best practice behavioral adoption theories and frameworks to enhance the explanatory power in the prediction of CWM behavior in the Jordanian context. All the factors influencing CWM behavior identified in the literature review were confirmed in the BF. However, seven important issues emerged from the Delphi study that seem to have a major impact on the behavior of Jordanian contractors toward CWM. These are:

(I) skills and expertise in the handling of construction errors, (II) courtesy between the different levels of employees, (III) religious obligations, (IV) health and safety incentives, (V) perceived increased workloads, (VI) wasteful culture, and (VII) management change. The developed BF consisted of four constituent variables that work together to explain and predict CWM behavior: personal, technological, social, and organizational variables; each of these variables include several factors influencing the behavior of Jordanian contractors toward CWM. The successful application of the BF is based on a dynamic interaction between the aforementioned variables influencing CWM behavior. This is because it was clear that there is a cause-effect relationship between the factors within the framework and, thus, failure to consider any one of them will lead to failure in achieving successful CWM behavior.

Future Research

This article promotes a more holistic understanding of the factors influencing the behavior of Jordanian contractors toward CWM. The process for developing the BF can be a useful reference for other studies which attempt to understand CW and its related issues in other socio- economic contexts, as researchers can conduct their investigations to structure future research and provide further improvement. Future studies could be conducted to investigate the application of the BF in various real life social contexts, in different groups of decision makers, in different periods and stages of the construction project, and in using different methods of evaluation and testing

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APPENDIX

Q1) Construction waste minimization has become a major focus nowadays in many countries around the world, why do you think it is needed in the Jordanian construction sector?

Q2) In your experience and opinion, to what extent do these benefits you mentioned in question 1, motivate the individual towards minimizing construction waste and are there any other motivational benefits? Please explain

Q3) In your experience and opinion, in what way can construction skills and expertise affect the individual’s performance in construction waste minimization? Please explain

Q4) In your experience and opinion, in what way can personal ethics reflect the individual’s performance in construction waste minimization? Please explain

Q5) In your experience and opinion, in what way can the behavior of colleagues, managers or the surrounding society influence the individual’s performance in construction waste minimization? Please explain

Q6) In your experience and opinion, in what way can legislations pressure managers toward adopting construction waste management? Please explain

Q7) In your experience and opinion, to what extent does the availability of adequate time and money resources facilitate waste minimization in construction projects? Please explain

Q8) In your experience and opinion, to what extent does the complexity of a construction technology (tool or system) discourage its adoption? Please explain

Q9) In your experience and opinion, are there any other issues that may discourage the adoption of construction technologies (tool or system) in projects? Please explain

Q10) In your experience and opinion, what are the matters that an organization should consider, in order to facilitate waste minimization in construction projects? Please explain

Q11) In your experience and opinion, are there any other issues that may affect the performance of waste minimization in construction projects? Please explain

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