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A study on the attitudes and behavioural influence of construction waste management in occupied Palestinian territory

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Abstract

As a step towards comprehending what drives the management of construction waste in the occupied Palestinian territory, this paper quantifies construction waste generation and examines how the local contractors' waste management attitudes and behaviour are influenced. Collection of data was based on a survey, carried out in the southern part of the West Bank between April and May 2010. The survey targeted contractors who specialized in the construction of buildings. A logistic regression model was used to investigate the relationship between various attributes and the attitudes and behaviour that the local contractors demonstrate towards waste management. The results showed that during the construction of buildings, 17 to 81 kg of construction waste are generated per square metre of building floor. Although the area of a building is the key factor determining 74.8% of the variation of construction waste generation, the employment of labour-intensive techniques in the study area means that human factors such as the contractor's attitude and behaviour towards waste management, exert a key influence on waste generation. Attitudes towards the 3Rs of waste minimization and behaviour towards waste disposal are generally positive with smaller contractors exhibiting more positive attitudes and more satisfactory behaviour towards waste management. Overall, while contractors' behaviour towards waste sorting and disposal tends to be more satisfactory among contractors who are more conscious about the potential environmental impacts of construction waste, it was generally observed that in the absence of a regulatory framework, the voluntary attitudes and behaviour among the local contractors are mostly driven by direct economic considerations.

Keywords

Construction waste generation, waste management, attitude, behaviour, West Bank, the occupied Palestinian territory

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Introduction

The construction of a new building (fixing of steel load-bearing frames or reinforcement, mixing and casting of concrete, tiling and plastering etc.) generates a growing stream of waste which absorbs significant parts of the landfill capacities in many parts of the world (Dong et al., 2001; Hsiao et al., 2002; Ingalls, 2000; Ortiz et al., 2010; Stokoe et al., 1999; Wang et al., 2008). In this context, the management of this waste stream emerges as one of the key environmental priorities for developed and increasingly for developing countries.

The well known hierarchy of waste management, listed in order of importance, comprises the 3Rs of waste minimization, i.e. source Reduction (also referred to as prevention), Reuse and Recycling (Tam, 2009; Wang et al., 2010), followed by incineration with energy recovery and safe disposal.

Indisputably the top 'R' of the hierarchy, Reduction, is the most desirable form of waste management and construction waste is not an exception to this rule as source reduction offers not only environmental advantages in comparison with other options but also direct economic ones (Begum et al., 2006; Esin and Cosgun, 2007; Guthrie et al., 1999; Poon, 2007).

Nevertheless, since construction materials have high potential for on-site reuse and off-site recycling (Hettiaratchi et al., 2010) the options of the other two 'R's: Reuse and Recycling also

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become attractive. In the European Union, the 2008 Waste Framework Directive (Anonymous, 2008) requires the EU Member States to take any necessary measures to achieve the reuse, recycling and other material recovery of construction and demolition waste to a level exceeding the target of 70% by 2020. For many developing regions, however, such ambitious recycling, reuse and recovery targets seem rather unrealistic due to several challenges faced, including the lack of a specific legislative framework, the treatment of this stream together with municipal solid waste despite the differences in physical and chemical properties (Agamuthu, 2008), financial constraints as well as the lack of public cooperation and participation (Kofoworola and Gheewala, 2009).

Background

Construction waste generation

According to Yost and Halstead (1996) estimates of the overall volumes of construction waste generated, have often been based on per capita multipliers in a similar way to municipal solid waste estimates. However, per capita construction waste generation rates vary considerably both among countries – values cited in literature illustrated in Figure 1 range from 18 kg capita^{-1} in Thailand (Kofoworola and Gheewala, 2009) to 5900 kg capita^{-1} in Luxembourg (Fischer and Werge, 2009) – but also from year to year (Yost and Halstead, 1996). Such variations do not reflect only actual spatial and temporal differences to the construction activity but also differences in the definitions and procedures for registration of this type of waste (Brodersen et al., 2002; Fischer and Werge, 2009). Due to these shortcomings, the use of per capita multipliers in extrapolations from a sample to a population has been criticized by previous research (Donovan, 1990; Keller, 1989; Yost and Halstead, 1996). According to Hettiaratchi et al. (2010) the inability to predict time-dependent and activity-specific waste generation rates is a key barrier to the successful implementation of a construction waste minimization programme.

For buildings, quantification of construction waste can typically rely upon variables which reflect the size of the project, for example, the financial value of building permits (Yost and Halstead, 1996), the quantities of input materials (Bossink and Brouwers, 1996; Solís-Guzmán et al., 2009) and the area of constructed building floor (Fatta et al., 2003; Kartam et al., 2004; Kofoworola and Gheewala, 2009; Lauritzen, 1994). Although the size of the project is the most significant variable affecting waste generation, it is not the sole factor influencing waste generation. Several authors have examined construction waste on a project basis (Bossink and Brouwers, 1996; Craven et al., 1994; Ekanayake and Ofori, 2004; Gavilan and Bernold, 1994; Innes, 2004; Keys et al., 2000) and identified several factors affecting

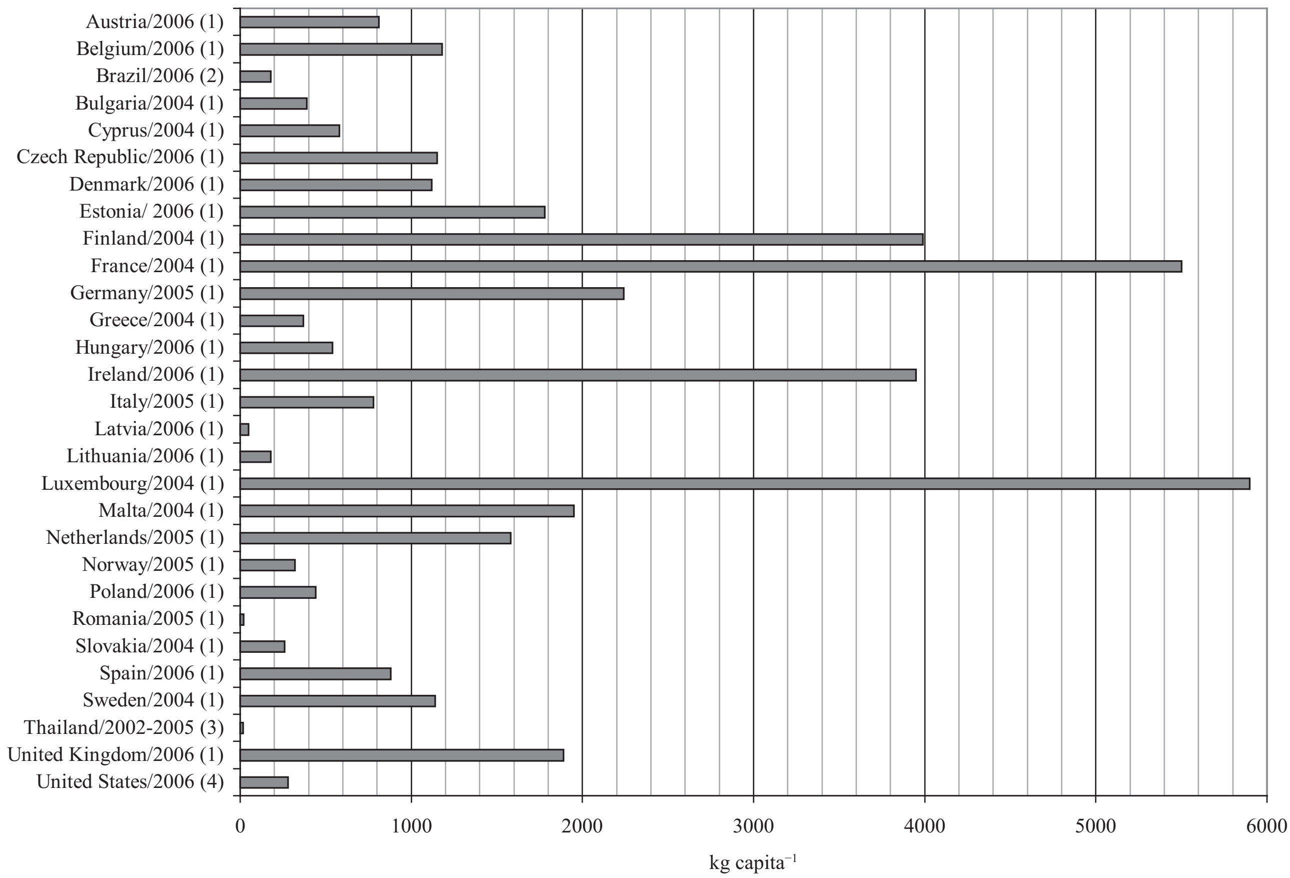

Figure 1. Summary of per capita estimates of construction waste generation in different countries from literature [Source: (1) Fischer and Werge (2009); (2) Nunes et al. (2007); (3) Kofoworola and Gheewala (2009); (4) DSM Environmental 2008].

its generation including the design, the quality of procurement, the construction techniques applied and the performance of the contractor.

The performance of the contractor is a particularly complicated element in the waste generation equation. Due to the labour-intensive nature, human factors – an emerging topic for research in this field (Yuan and Shen, 2011) – reflected by attitudes towards waste management and therefore related behavioural impediments, are likely to exert key influence to waste generation and management (Loosemore et al., 2002; Teo et al., 2000).

Attitude and behaviour

'Attitude' is the positive or negative feeling towards a specific object and 'behaviour' is an action towards that object. Attitudes are generally based upon the positive or negative evaluation of the consequences of a given behaviour and on personal beliefs about those consequences (Teo and Loosemore, 2001; Wang and Yuan, 2010). At the same time behavioural decisions are frequently based on attitudes towards that object, whether consciously or not (Begum et al., 2009). However the relationship between the two can be quite complex (Barr et al., 2001) and the empirical research on the attitude-behaviour link has been yielding contradictory results (Van Doorn et al., 2007). The attitudes of people involved in the construction industry play a critical role in controlling the waste generation. Interdisciplinary approaches between all stakeholders are essential for successful waste management practices (Graham and Smithers, 1996). The importance of human factors in waste minimization was highlighted by Loosemore et al. (2002) and Skoyles and Skoyles (1987) who argued that waste can be prevented by changing people's attitudes. According to Begum et al. (2009) factors such as the contractor's size, the education and training background of the workers and the waste management practices applied including source reduction, reuse and recycling measures, frequency of waste collection and waste disposal, influence the attitude and behaviour of a contractor towards waste management.

The specific situation of the occupied Palestinian territory

Over the last decade, the occupied Palestinian territory has been subject to intense construction activity, mainly a result of extensive damage to private and public buildings suffered in the context of the ongoing conflict. Construction of new buildings in the West Bank of the occupied Palestinian territory accounted for 85% of the total new surface area licensed for construction activities in 1999 (United Nations, 2004). This cycle of destruction and upgrading activities produces large amounts of construction waste. However, no sanitary landfills currently exist in the occupied Palestinian territory, construction waste is not subject to a specific regulatory framework and no published research has looked into construction waste management in this region.

Table 1. Main fields of information covered by the questionnaire.

District; age group; income group; level of education (contractor's representative).
Classification; legal status; project history; number and education level of different types of staff (contractor).
Waste collection arrangements; waste sorting arrangements and reasons; waste disposal frequency and arrangements; challenges faced.
Criteria for material selection, purchasing and use.
Perception about impact of waste to environment/health.
Quantified data on waste generation for different projects.

In comparison with other construction activities, building construction is highly labour intensive and thus more likely to be influenced by attitude and behaviour. The present paper quantifies waste generation from building construction in the West Bank of the occupied Palestinian territory and, by considering factors which can potentially affect the related attitude and behaviour of the local contractors, examines how the local contractors' waste management attitudes and behaviour are influenced.

Research methods

Data collection and sampling

A structured questionnaire was designed to determine whether contractors attitudes towards the 3Rs of waste minimization, are positive or not and whether their behaviour towards waste sorting and disposal are satisfactory or not, while allowing a quantification of construction waste generation and a determination of disposal practice in the occupied Palestinian territory. The questionnaire also included targeted questions to collect information on those factors which, according to Begum et al. (2009), influence a contractor's attitude and behaviour towards waste management: contractor's type, size and experience, education and training background of the workers and waste management practices applied (Table 1).

A survey was carried out among building contractors operating in the area under study. For sampling purposes, the population of 103 relevant contractors registered at the Palestinian Contractors Union (PCU) (PCU, 2009) at the study's cut-off date (1 February 2010), was stratified into three groups, each covering two consecutive categories of the PCU's classification system for building construction specialization. Hence the sample stratification was based on the same criteria used for this classification: contractor's capital; work experience; professional licence; human resources and their qualifications; office infrastructure.

A total sample size of 83 contractors (Table 2) was determined from the population of 103, using the following formulae (Hogg and Tannis, 1997) for each stratum:

$$m = \frac{Z^2 * P(1-P)}{\varepsilon^2} \tag{1}$$

Table 2. Stratified sample size of survey.

Sample group (Palestinian Contractors Union classification)	G1 (Cat. 1A–1B)		G2 (Cat. 2–3)		G3 (Cat. 4–5)		Total
Palestinian Contractors Union classification Category (PCU, 2009)	1 A	1 B	2	3	4	5	
Number of registered contractors	4	11	31	35	11	11	103
Sample size	3	9	25	28	9	9	83

$$n = \frac{m}{1 + ((m-1)/N)} \tag{2}$$

where m is the sample size of unlimited population; n is sample size of limited population; Z is the standardization value corresponding to confidence level (Z = 1.95 for 95% confidence level); P is the proportion of success (assumed 50%); and ε is the maximum error of the point estimate.

The questionnaire was completed through direct interviews of the targeted sample population. The contractors were represented by persons familiar with onsite practices, in most cases the project managers. Prior to the interviews, contractors in the sample were contacted in person and briefed about the survey and its objectives. This contributed to achieving a survey response rate of 100%.

Data analysis

The statistical analysis was carried out using the statistical package for social sciences software (SPSS Inc., Chicago, IL, USA.), version 15. The cross tabulation and frequencies tests were applied to determine the contractors' attitudes and behaviour. Furthermore, a logistic regression model (LRM) was used to identify the most significant factors affecting the contractors' attitudes and behaviour towards construction waste management. The same model was also used to determine the direction of the relationship between these factors and the attitude and behaviour of the contractors in the study area (Begum et al., 2009).

$$\log \frac{P_i}{1 - P_i} = \beta_0 + \beta_i X_i + e \tag{3}$$

where P_i = 1 if contractor's attitude or behaviour towards construction waste management is positive or satisfactory respectively, and P_i = 0 if not; X_i are the independent variables, listed in Table 3; β_0 is a constant term, assumed zero; β_i are the coefficients of the independent variables; e is the error term; and i = 1, 2, …, n is the number of variables in the model. The direction of the relationship between the dependent variable P_i (attitude or behaviour) and the independent variable X_i is determined by the sign of the coefficient β_i.

Once the dependent variables were transformed into logistic variables, the maximum likelihood method was used (Gujrati (2003), cited in Begum et al. (2009); Thomas, 1985) to estimate the parameters in the LRM. The probability of certain event occurring was estimated by logistic regression through calculating the changes in the logarithm of the dependent variable. The likelihood function expresses the values of β in terms of known and fixed values for y (β is related to P) and is derived from the probability distribution of the dependent variable so that the values of β that maximize the output of this equation are the maximum likelihood estimates (Begum et al., 2009).

$$L\left(\frac{\beta}{y}\right) = \prod_{i=1}^{N} \frac{n_i!}{y_i!(n_i - y_i)!} P_i^{y_i} (1 - P_i)^{(n_i - y_i)} \tag{4}$$

The Wald test was used to evaluate the significance of each coefficient in the model (Begum et al., 2009).

$$W_i = \left(\frac{\beta_i}{S.E_{\beta_i}}\right) \tag{5}$$

where i = 1, 2, …, n and $S.E$ is the standard error.

The model was evaluated using five different tests: the log-likelihood function, the omnibus test, Cox and Snell R^2, Naglekerke $\check{R}^2$, and the Hosmer–Lemeshow test.

The log-likelihood function, used to measure how the model fits the data, is defined as (Begum et al., 2009)

$$\text{Log} - \text{likelihood} = \sum_{1}^{n} [Y_i \ln(\hat{Y}_i) + (1 - Y_i)\ln(1 - \hat{Y}_i)] \tag{6}$$

where Y_i is the actual result; $\hat{Y}_i$ are the predicted probabilities of this result. This is also quoted as −2log-likelihood because it has an approximate chi-squared distribution.

The omnibus test was employed to test the coefficients in the model. This test indicates goodness-of-fit if the observed chi-squared is greater than the tabulated one (i.e. the assumption of all coefficients equal zero is refused if the significance value is less than 0.05), which in turn indicates the adequacy of the model for such data type.

Cox and Snell R^2 was used to evaluate the goodness-of-fit because it determines the proportion of the variation in the dependent variable made by the independent variable of the model.

As Cox and Snell R^2 cannot achieve a maximum value of 1, Nagelkerke $\check{R}^2$ was also used. This also determines the variation proportion in the outcome made by the independent variables of the model.

Table 3. Summary of independent variables in the LRM.

No	Description of the variables	Definition of the variables in the LRM
X_1	Level of education of person interviewed	1 = others; 2 = secondary; 3 = diploma; 4 = university
X_2	Category of the contractor	1 = group 3; 2 = group 2; 3 = group 1
X_3	Number of completed projects by the contractor	1 = less than 5; 2 = 6 to 10; 3 = 11 to 20; 4 = 21 to 30; 5 = 31 to 40; 6 = more than 40
X_4	Frequency of waste collection and disposal	1 = no schedule; 2 = other; 3 = once per month; 4 = twice per month; 5 = once per week
X_5	Purchasing durable, refillable and repairable materials	0 = not practiced; 1 = otherwise
X_6	Purchasing appropriate quantities of material resources for an activity	1 = sufficient; 2 = slightly more than required; 3 = more than required
X_7	Ensuring the use of construction materials before their expiry date or damage	0 = not practiced; 1 = otherwise;
X_8	Perception about the impact of construction waste on the environment	1 = not harmful; 2 = don't know; 3 = harmful
X_9	Perception about the impact of construction waste on human health	1 = not harmful; 2 = don't know; 3 = harmful
X_{10}	Number of skilled workers employed by the contractor	1 = less than 10; 2 = 10 to 20; 3 = 21 to 30; 4 = 31 to 50; 5 = 51 to 100
X_{11}	Number of unskilled workers employed by the contractor	1 = less than 10; 2 = 10 to 20; 3 = 21 to 30 ; 4 = 31 to 50; 5 = 51 to 100; 6 = 101 to 200
X_{12}	Level of construction related education among field supervisors (most frequent)	1 = other; 2 = course certificate; 3 = diploma; 4 = university
X_{13}	Number of field supervisors who followed training related to construction waste management	1 = none of them; 2 = some of them, 3 = all of them
X_{14}	Experience of field supervisors in construction (including experience gained from previous employment)	1 = low; 2 = medium; 3 = high

Finally, the Hosmer–Lemeshow test was employed. This test indicates that the model fits the data well if the significance value corresponding to chi-squared is greater than 0.05 (i.e. the null hypothesis of the model that means there is no difference between observed and predicted values, will not be rejected). As such, the larger the chi-squared is, the better the model fits the data.

Results and discussion

Construction waste generation

The quantification of waste generation was based on the data provided by the 83 contractors in the survey sample. That data related to 47 construction sites of residential, commercial, and public building projects of different sizes. On the basis of this data the quantity of waste generated during the construction of buildings in the study area ranged between 17 and 81 kg m^{-2} of building floor. This generation rate range is comparable to the 20 to 50 kg m^{-2} estimated by Lauritzen (1994), to the 21.4 and 45 kg m^{-2} assumed by Kofoworola and Gheewala (2009) and Kartam et al. (2004) respectively, and the 75 kg m^{-2} calculated on the basis of the assumptions made by Fatta et al. (2003) is also within this range, albeit closer to the maximum value.

The values were also plotted in a graph, as shown in Figure 2. The data fitted the following linear relationship

$$Q = 0.0516A - 0.4418; \quad (R^2 = 0.7475) \qquad (7)$$

where Q is the quantity of construction waste (excluding any demolition or excavation waste) in metric tonnes and A is the building floor area in m^2.

A strong relationship between the quantity of waste and the area of the building floor was observed with 74.8% of the variation in waste generation being determined by the variation in the building area. Residual variation is influenced by several other factors, as previously identified, including human factors reflected by the attitude and behaviour of the contractor.

Disposal practice

The survey showed that, due to the absence of regulations covering construction waste and of sanitary landfills in the occupied Palestinian territory, construction waste is mostly disposed to various types of private and municipal dumpsites. However 16.3% of contractors indicated that construction waste is disposed randomly on open land and beside public roads and 15.1%

to other inappropriate locations. These, non-negligible shares, may even be an underestimate when considering that waste disposal is often sub-contracted to truck drivers which act beyond the control of the main contractor.

Municipal solid wastes dump sites as well as private or municipal construction waste dump sites are considered to be the best available options in the study area. For the purpose of this study, disposal at those sites is considered to be a satisfactory behaviour.

Factors affecting contractors' attitudes

The analysis of the survey responses, as shown in Table 4, has shown that the attitudes of the local contractors towards the 3Rs of waste minimization are in principle positive. This is in line with the findings of other authors (Lingard et al., 2000; McDonald and Smithers, 1998; Teo et al., 2000).

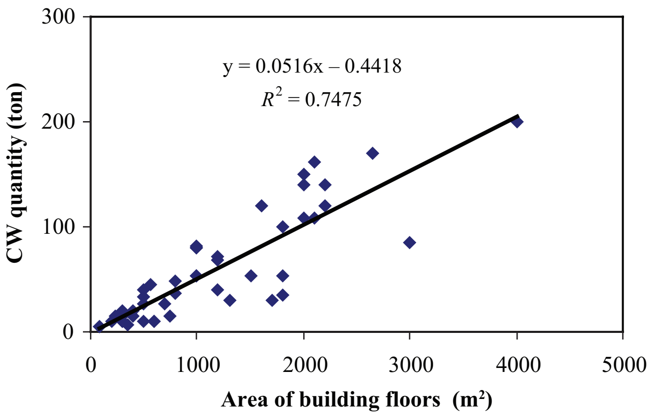

Figure 2. Quantity of waste as a function of constructed building floor area from 47 served construction sites.

The LRM was used to identify which of the investigated factors have the most significant influence to the contractors' attitudes towards waste minimization and to determine their relationship.

The model output, as shown in Table 5, suggests that material prioritization, number of unskilled employees and the category of the contractor are statistically the three most significant factors. Those contractors who are keen to optimize the use of construction materials, mostly driven by economic considerations since material waste implies loss of profit and competitiveness (Ekanayake and Ofori, 2004), have also more positive attitude not only towards reduction of waste at source but also for reuse and recycling. On the other hand, higher numbers of unskilled workers contribute to less positive attitudes towards waste minimization, possibly as a result of lower awareness of the impacts of construction waste amongst the workforce, misconception of the quality of recycled products, lower motivation linked to lower wages and less effective supervision. Furthermore, in contrast to Begum et al. (2009) who found that larger Malaysian contractors had more positive attitudes towards waste management, this study showed a reverse relationship between the size of Palestinian building contractors, reflected by their category, and their attitudes, with smaller contractors demonstrating more positive attitudes towards waste minimization than medium and large size contractors. The authors attribute this relationship to the higher competition among low-category contractors in the study area which results to lower profit margins: smaller contractors tend to be more vigorous towards the net economic benefits from waste minimization. The model summary and the

Table 4. Contractors with positive attitudes towards the 3Rs of waste minimization.

No.	Description	Label
Variable for reduction at the source		
V20	Do you follow waste reduction at the source practices?	Yes = (positive attitude), No = (negative attitude)
V21	Do you buy durable, refillable and repairable materials?	Frequently and occasionally = Yes (positive attitude), not practiced = No (negative attitude).
V23	Do you use construction materials before expiry date or damage?	
Variables for reuse and recycling		
V24	Do you use construction materials onsite that can be reused?	Frequently and occasionally = Yes (positive attitude), not practiced = No (negative attitude).
V25	Do you buy materials that have reuse packing?	
V26	Do you use recyclable materials in construction?	
Attitudes toward reduction at the source, reuse and recycling		
Sample group	Reduction at source	Reuse and recycling
G1	78.6%	57.1%
G2	90.7%	88.9%
G3	100.0%	100.0%
All	90.7%	86.0%

Table 5. Influence of selected variables on contractor attitudes as analysed by the LRM.

Variable	Abbreviation	Estimated coefficient (β)	Standard error (S.E)	Wald statistics	df	Significance (P-value)
X_1	education	0.447	0.765	0.341	1	0.559
X_2	category	−3.272	1.573	4.326	1	0.038
X_3	portfolio	1.104	0.613	3.243	1	0.072
X_4	frequency	0.559	0.509	1.207	1	0.272
X_6	mat. quantity	−0.337	0.921	0.134	1	0.714
X_7	ma. priority	4.535	2.014	5.073	1	0.024
X_{11}	unskilled work	−1.353	0.644	4.419	1	0.036
X_{14}	experience sup	1.452	0.957	2.300	1	0.129

Table 6. Attitude model summary and other goodness-of-fit tests.

Test	Result		
Model summary	−2 log-likelihood	Cox & Snell R^2	Nagelkerke R^2
	20.910	0.680	0.907
Omnibus tests of model coefficients	chi-squared	df	Sig.
	96.925	8	0.000
Hosmer–Lemeshow test	chi-squard	df	Sig.
	1.125	7	0.993
Tabulated chi-squared	90.53		

results of the tests used to measure how the model fits the data are summarized in Table 6.

Factors affecting contractors' behaviour

The results showed that the number of contractors demonstrating satisfactory and unsatisfactory behaviour towards waste sorting is relatively balanced among all three sample groups. With regards to waste disposal, behaviour, as shown in Table 7, is generally positive although the number of contractors demonstrating unsatisfactory behaviour and dispose waste on open land and beside roads is not negligible.

The LRM output (Table 8) suggests that the contractor's perception of the impact of construction waste to the environment, the number of skilled employees, and the contractor's attention to optimization of material purchasing, are statistically the most significant factors which influence contractors' behaviour towards waste sorting and disposal. In particular, contractors' behaviour towards waste sorting and disposal tends to be less satisfactory amongst contractors that are less conscious about the potential environmental impacts from construction waste. Furthermore the data analysis showed that contractors with higher numbers of skilled workers tend to show less satisfactory behaviour towards waste sorting and disposal. Finally those contractors who are keen to optimize the purchasing of construction materials also exhibit more positive behaviour. These findings support the presumption that, in the absence of a regulatory framework, the voluntary attitudes and behaviour among the contractors is motivated by the occurrence or not of a direct economic benefit. The model summary and the results of the tests used to measure how the model fits the data are summarized in Table 9.

Conclusion

This study estimated that the quantity of waste generated during building construction in the southern part of the West Bank ranged between 17 and 81 kg m^{-2} of building floor. Although the area of the building determines 74.8% of the variation of construction waste generation, human factors such as the contractor's attitude and behaviour towards waste management exert key influence to waste generation especially since labour-intensive techniques are employed.

The attitudes of the Palestinian contractors towards the 3Rs of waste minimization are generally positive. Taking into account the absence of sanitary landfills in the occupied Palestinian territory and of regulations covering construction waste, the overall behaviour of contractors towards waste disposal is considered satisfactory although the number of contractors disposing waste on open land and beside roads is not negligible. In general, smaller contractors, facing greater competition and lower profit margins, exhibit more positive attitudes towards waste minimization and more satisfactory behaviour towards waste sorting and disposal, in comparison with medium and large contractors.

The contractor's approach with regards to the purchasing and use of construction materials has significant influence to the contractor's attitude and behaviour towards waste management. Material waste implies loss of profit and competitiveness for the contractor. Hence contractors who are more eager to optimize

Table 7. Contractors with satisfactory behaviour towards construction waste sorting and disposal.

No.	Description	Label
Variables for waste sorting behaviour		
V11	Do you sort CW onsite?	Frequently and occasionally = yes (satisfactory), not practiced = no (unsatisfactory).
Variables for waste disposal behaviour		
V14	Which of the following disposal sites you are using?	Municipal domestic solid waste dumpsite, private dumpsite and municipal CW dumpsite = satisfactory behaviour, randomly (beside roads … etc.) and others = unsatisfactory behaviour.
Waste sorting and disposal behaviour		
Sample group	Frequent or at least occasional waste sorting	Waste disposed at municipal solid wastes dump sites, private or municipal construction waste dump sites
G1	50.0%	78.6%
G2	46.3%	63.0%
G3	55.6%	77.7%
All	48.8%	68.6%

Table 8. Influence of selected variables on contractor behaviour as analysed by the LRM.

Variable	Abbreviation	Estimated coefficient (β)	Standard error (S.E)	Wald statistics	df	Significance (P-value)
X_2	category	−1.810	1.013	3.194	1	0.074
X_3	portfolio	0.297	0.276	1.161	1	0.281
X_5	lifetime	2.207	1.344	2.697	1	0.101
X_6	mat quantity	2.343	1.003	5.456	1	0.020
X_7	mat priority	−2.590	1.661	2.430	1	0.119
X_8	environment	−2.485	0.972	6.532	1	0.011
X_9	health	1.145	0.653	3.072	1	0.080
X_{10}	skilled work	−1.508	0.602	6.275	1	0.012
X_{11}	unskilled work	1.415	0.638	4.915	1	0.027
X_{12}	education sup	0.574	0.407	1.996	1	0.158
X_{13}	training sup	3.389	1.531	4.901	1	0.027

Table 9. Behaviour model summary and other goodness-of-fit tests.

Test	Result		
Model summary	−2 log-likelihood	Cox and Snell R^2	Nagelkerke R^2
	43.518	0.583	0.777
Omnibus tests of model coefficients	chi-squared	df	Sig.
	74.318	11	0.000
Hosmer–Lemeshow test	5.256	7	0.629
Tabulated chi-squared	96.22		

material flows have generally more positive attitude and satisfactory behaviour.

Higher numbers of unskilled workers were found to have a negative influence on the contractor's attitudes towards waste minimization and behaviour towards waste sorting and disposal. This is possibly a result of lower awareness of the impacts of construction, misconception of the quality of recycled products, lower motivation linked to lower wages and less effective supervision.

Overall, although contractors' behaviour towards waste sorting and disposal tends to be more satisfactory among contractors who are more conscious about the potential environmental impacts from construction waste, it was generally observed that in the absence of a regulatory framework, the voluntary attitudes and behaviour of the contractors are currently driven by the occurrence of a direct economic benefit.

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References

Agamuthu P (2008) Challenges in sustainable management of construction and demolition waste. *Waste Management & Research* 26: 491–492.

Anonymous (2008) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. *Official Journal* L 312: 3–30.

Barr S, Gilg AW and Ford NJ (2001) A conceptual framework for understanding and analyzing attitudes towards household-waste management. *Environment and Planning* 33: 2025–2048.

Begum RA, Siwar C, Pereira JJ and Jaafar AH (2006) A benefit – cost analysis on the economic feasibility of construction waste minimization: the case of Malaysia. Resources, *Conservation and Recycling* 48: 86–98.

Begum RA, Siwar C, Pereira JJ and Jaafar A (2009) Attitudes and behavioural factors in waste management in the construction industry of Malaysia. *Resources, Conservation and Recycling* 53: 321–328.

Bossink BAG and Brouwers HJH (1996) Construction waste: quantification and source evaluation. *Journal of Construction Engineering and Management* 122: 55–60.

Brodersen J, Juul J and Jacobsen H (2002) *Review of Selected Waste Streams: Sewage Sludge, Construction and Demolition Waste, Waste Oils, Waste from Coal-fired Power Plants and Biodegradable Municipal Waste*. (Technical report / EEA; no. 69). Copenhagen: European Topic Centre on Waste European Environment Agency.

Craven DJ, Okraglik HM and Eilenberg IM (1994) Construction waste and a new design methodology. In: Kibert CJ (ed.), Proceedings of the First Conference of CIB TG 16 on Sustainable Construction. Tampa, FL. Center for Construction and Environment, Gainesville, Florida, pp. 89–98.

Dong SS, Tong KW and Wu YP (2001) Municipal solid waste management in China: using commercial management to solve a growing problem. *Utilities Policy* 10: 7–11.

Donovan CT (1990) *Recycling Construction and Demolition Waste in Vermont: Final Report Submitted to Vermont Agency of Natural Resources*, Department of Environmental Conservation, Solid Waste Management Division, Recycling and Resource Conservation Section, C.T. Donovan Associates, Inc., Burlington, VT, USA.

DSM Environmental (2008) *Construction & Demolition Debris Industry Study for the Massachusetts Department of Environmental Protection*. Final report. Windsor, VT: DSM Environmental Services Inc.

Ekanakaye LL and Ofori G. (2004) Building waste assessment score: design-based tool. *Building and Environment* 39: 851–861.

Esin T and Cosgun C (2007) A study conducted to reduce construction waste generation in Turkey. *Building and Environment* 42: 1667–1674.

Fatta D, Papadopoulos A, Avramikos E, Sgourou E, Moustakas K, Kourmoussis F, et al. (2003) Generation and management of construction and demolition waste in Greece – an existing challenge. *Resources, Conservation and Recycling* 40: 81–91.

Fischer C and Werge M (2009) *EU as a Recycling Society. Present Recycling Levels of Municipal Waste and C&D Waste in the EU*. Copenhagen: European Topic Centre on Sustainable Production and Consumption, European Environment Agency.

Gavillan RM and Bernold LE (1994) Source evaluation at solid waste in building construction. *Journal of Construction Engineering and Management* 120: 536–555.

Graham PM and Smithers G (1996) Construction waste minimisation for Australian residential development. *Asia Pacific Building and Construction Management Journal* 2: 14–19.

Gujrati DN (2003) *Basic Econometrics*. West Point: MCGraw-Hill Higher Education, United State Military Academy.

Guthrie P, Woolveridge AC and Patel VS (1999) *Waste Minimization in Construction: Site Guide*. London: Construction Industry Research and Information Association.

Hettiaratchi JPA, Verduga BFP, Rajbhandari BK and Ruwanpura JY (2010) A statistical approach to predict waste generation rates to support recycling programmes. *International Journal of Environment and Waste Management* 6: 82–95.

Hogg RV and Tannis EA (1997) *Probability and Statistical Interferences*. New Jersey: Prentice Hall.

Hsiao TY, Huang YT, Yu YH and Wernick IK (2002) Modelling materials flow of waste concrete from construction and demolition wastes in Taiwan. *Resources Policy* 28: 39–47.

Ingalls KM (2000) *Trend Setters: Recovering C&D. Waste Age*. Atlanta, USA: Penton Media, Inc., 76–82.

Innes S (2004) Developing tools for designing out waste pre-site and onsite. In: Proceedings of Minimising Construction Waste Conference: Developing Resource Efficiency and Waste Minimisation in Design and Construction, October 21, New Engineer, London, UK.

Kartam N, Al-Mutairi N, Al-Ghusain I and Al-Humoud J (2004) Environmental management of construction and demolition waste in Kuwait. *Waste Management* 24: 1049–1059.

Keller R (1989) Quantifying construction and demolition waste: toward a conceptual framework. In: Proceedings in the Northeast Resource Recovery Conference, Newport, Rhode Island, USA. West Chester: Roy F. Weston Inc.

Keys A, Baldwin A and Austin S (2000) Designing to encourage waste minimisation in the construction industry. In: Proceedings of CIBSE National Conference, September, Dublin, Republic of Ireland. Leicestershire: Loughborough University.

Kofoworola OF and Gheewala SH (2009) Estimation of construction waste generation and management in Thailand. *Waste Management* 29: 731–738.

Lauritzen EK (1994) *Economic and environmental benefits of recycling waste from the construction and demolition of buildings*. Kingston, Jamaica: Waste Recycling, UNEP Industry and Environment, 26–31.

Lingard H, Graham P and Smithers G (2000) Employee perception of the solid waste management system operating in large Australian contracting organization: implications for company policy implementation. *Construction Management and Economics* 18: 383–393.

Loosemore M, Lingard H and Teo M (2002) In conflict with nature—waste management in the construction industry. In: Best R and Valance G (eds) *Post Design Issues—Innovation in Construction*. London: Arnold, 256–276.

McDonald B and Smithers M (1998) Implementation a waste management plan during the construction phase of a project: a case study. *Construction Management and Economics* 16: 71–78.

Nunes KRA, Mahler CF, Valle R and Neves C (2007) Evaluation of investments in recycling centres for construction and demolition wastes in Brazilian municipalities. *Waste Management* 27: 1531–1540.

Ortiz O, Pasqualino JC and Castells F (2010) Environmental performance of construction waste: comparing three scenarios from a case study in Catalonia, Spain. *Waste Management* 30: 646–654.

PCU (Palestinian Contractors' Union) (2009) List of registered contractors in the West Bank. Retrieved from http://www.pcu.ps/index.php (accessed 8 October 2009).

Poon CS (2007) Reducing construction waste. *Waste Management* 27: 1715–1716.

Skoyles ER and Skoyles JR (1987) *Waste Prevention on Site*. London: Mitchell Publishing.

Solís-Guzmán J, Marrero M, Montes-Delgado MV and Ramirez-de-Arellano A (2009) A Spanish model for quantification and management of construction waste. *Waste Management* 29: 2542–2548.

Stokoe MJ, Kwong PY and Lau MM (1999) Waste reduction: a tool for sustainable waste management for Hong Kong. In: Barrage A and Edelman Y (eds.), Proceedings of R'99 World Congress, vol. 5. Geneva, Switzerland, pp. 165–170 Geneva: EMPA.

Tam VWY (2009) Comparing the implementation of concrete recycling in the Australian and Japanese construction industries. *Journal of Cleaner Production* 17: 688–702.

Teo MM and Loosemore M (2001) Theory of waste behaviour in the construction industry. *Construction Management and Economics* 19: 741–751.

Teo MM, Loosemore M, Masosszeky M and Karim K (2000) Operatives attitudes towards waste on a construction project. In: Proceedings of the Annual Conference-ARCOM, vol. 2, pp. 509–517.

Thomas RL (1985) *Introductory Econometrics: Theory and Applications*. New York: Longman Group Limited.

United Nations (2004) Palestinian small and medium-sizes enterprises: dynamics and contribution to development. United Nations Conference on Trade and Development; UNCTAD/GDS/APP/2004/1. New York, Geneva: United Nations.

Van Doorn J, Verhoef PC and Bijmolt THA (2007) The importance of non-linear relationships between attitude and behaviour in policy research. *Journal of Consumer Policy* 30: 75–90.

Wang J and Yuan H (2010) Factors affecting contractors' risk attitudes in construction projects: Case study from China. *International Journal of Project Management* 29: 209–219.

Wang JY, Kang XP and Tam VWY (2008) An investigation of construction wastes: an empirical study in Shenzhen. *Journal of Engineering, Design and Technology* 6: 227–236.

Wang J, Yuan, H, Kang X and Lu W (2010) Critical success factors for on-site sorting of construction waste: a China study. *Resources, Conservation and Recycling* 54: 931–936.

Yost PA and Halstead JM (1996) A methodology for quantifying the volume of construction waste. *Waste Management & Research* 14: 453–461.

Yuan H and Shen L (2011) Trend of the research on construction and demolition waste management. *Waste Management* 31: 670–679

Appendix 1. Contractor's classification criteria for building construction specialization

Category	Classification requirements											
	Capital	Experience (executed projects)		Professional license	Engineers			Accountant		Administrator	Office		
1 A	JD 400 000.0	Total projects JD 6.0 million	One project of JD 2.0 million; or two projects each of JD 1.5 million.	Yes	Office engineer	Technical manager of 10 years experience	Quantity surveyor	BSc degree with 2 years experience; or diploma with 5 years experience	Work contract	BSc degree in business	Area of 150 m^2	Rent contract	Drawing
1B	JD 250 000.0	Total projects JD 3.0 million	One project of JD 650 000; or two projects each of JD 500 000.	Yes	Office engineer	Technical manager of 10 years experience	Quantity surveyor	BSc degree with 2 years experience; or diploma with 5 years experience	Work contract	BSc degree in business	Area of 125 m^2	Rent contract	Drawing
2	JD 100 000.0	Total projects JD 3.0 million	One project of JD 333 000; or two projects each of JD 250 000.	Yes	Office engineer	Technical manager of 8 years experience	Quantity surveyor	BSc degree with 2 years experience; or diploma with 5 years experience	Work contract	BSc degree in business	Area of 100 m^2	Rent contract	Drawing
3	JD 75 000.0	Total projects JD 0.5 million	One project of JD 166 000; or two projects each of JD 125 000.	Yes	Office engineer	Technical manager of 6 years experience		BSc degree with 2 years experience; or diploma with 5 years experience	Work contract	BSc degree in business	Area of 75 m^2	Rent contract	Drawing
4	JD 30 000.0	Total projects JD 150,000	One project of JD 65 000; or two projects each of JD 50 000.	Yes	Technical manager of 4 years experience			BSc degree with 2 years experience; or diploma with 5 years experience	Work contract	–	Area of 50 m^2	Rent contract	Drawing
5	JD 30 000.0	–	–	Yes	–	–	–	–	–	–	Area of 30 m^2	Rent contract	Drawing

Appendix 2. Contractors' questionnaire

Name of the company: ______________________________ Address: ______________________

Governorate: _______________________ Date of survey: _______________________________

Questionnaire ID in the Sample ☐

General information:		
V1	☐	What is your district? a- Bethlehem b- Hebron
V2	☐	Where do you live? a- village b- city or town c- refugee camp
V3	☐	How old are you? a- Between 20 – 30 years b- Between 30 – 40 years c- Between 40 – 50 years d- Between 50 – 60 years e- More than 60 years
V4	☐	How could you rate your monthly income? a- Very high b- High c- Intermediate d- Low e- Very low
V5	☐	What is your level of education? a- University b- Diploma c- Secondary d- Others ________________
Classification and experience:		
V6	☐	What is the classification of your company? a- Category 1 A b- Category 1 B c- Category 2 d- Category 3 e- Category 4 f- Category 5
V7	☐	What is the type of the company? a- Public company b- Private limited company c- Others: ________
V8	☐	How many years of experience do you have in the building construction? a- 2–5 years b- 6- 10 years c- 11 – 15 years d- 16 – 20 years e- 21 – 30 years f- More than 30
V9	☐	How many projects you have executed? a- Less than 5 b- From 5 to 10 c- From 11 to 20 d- From 21 to 30 e- From 31 to 40 f- More than 40
Attitudes and behaviour:		
V10	☐	How do you collect the waste inside the project area? a- In steel containers b- In special zone within the project area c- Anywhere within the project area d- Others:

		____________________
V11	☐	Do you sort construction waste onsite? a- Frequently b- Occasional c- Not practiced
V12	☐	Why you do not sort the wastes? a- Useless b- Costly c- It takes time d- Others: _________
V13	☐	What is the frequency of waste collection and disposal? a- Once per week b- Once per month c- Twice per month d- Others: ______________________________
V14	☐	Which of the following disposal sites you are using? a- Municipal domestic solid waste dumpsite b- Private dumpsite c- Municipal construction waste dumpsite d- Randomly (beside roads...etc) e- Others: _____________________________
V15	☐	How much waste per project you are disposing? a- Small amount b- Medium amount c- Large amount
V16	☐	How much tons of waste per project you are disposing (except excavations)?
V17	☐	How much tons of excavations waste per project you are disposing?
V18	☐	Do you think that waste reduction, reuse and recycling is a key toward construction waste minimization? a- Yes b- No c- I don't know
V19	☐	In your opinion, is reduction at the source is the best option for construction waste minimization? a- Yes b- No c- I don't know
V20	☐	Do you follow waste reduction practices at the source? a- Yes b- No
V21	☐	Do you buy durable, refillable and repairable materials? a- Frequentlyb- Occasional c- Not practiced
V22	☐	How much raw materials do you purchase per activity? a- That are just sufficient b- A bit more than required c- More than required
V23	☐	Do you use construction materials before expiry date or damage? a- Frequentlyb- Occasional c- Not practiced
V24	☐	Do you ruse construction materials onsite that can be reused? a- Frequentlyb- Occasional c- Not practiced
V25	☐	Do you buy materials that have reuse packing? a- Frequentlyb- Occasional c- Not practiced

V16 table:

Project type	Project area (m^2)	Amount of waste (ton)

V17 table:

Project type	Project area (m2)	Amount of waste (ton)

V26	☐	Do you use recyclable materials in construction? a- Frequently b- Occasional c- Not practiced
V27	☐	Do you think that the construction waste has negative environmental impacts? a- Yes b- No c- I don't know
V28	☐	What is the impact of the construction waste on human health? a- Not harmful b- Harmful c- I don't know
V29	☐	Do you have environmental management plan? a- Yes, for all projects b- Yes, for some projects c- NO
V30	☐	Have you the willingness to pay more for improved construction waste collection and disposal service? a- Yes b- No
V31	☐	What is the main challenge you are facing in the construction waste management? a- Careless of workers b- Low experience of workers c- Lack of landfills d- Absence of government incentives e- Lack of recycling facilities f- Absence of legislations and polices g- Lack of financial resources h- Projects technical specifications i- Others: ___
Workers and education:		
V32	☐	How many skilled labourers do you have? ____
V33	☐	How many field supervisors do you have? ____
V34	☐	How many unskilled labourers do you have? ____
V35	☐	Do labourers receive training or awareness in construction waste management? a- All of them b- Some of them c- None of them
V36	☐	What is their experience in construction related activities? a- Low b- Medium c-High
V37	☐	Could you please specify most frequent of the construction related education of the field supervisor employees? a- University b- Diploma c- Course certificate d- Others ________
V38	☐	Do they receive training or awareness in construction waste management? a- All of them b- Some of them c- None of them
V39	☐	What is their experience in construction-related activities? a- Low b- Medium c-High
Legislations:		
V40	☐	Do you have official instructions about how to deal with construction waste? a- Yes b- No; if yes, go to V41; if NO, go to V42
V41	☐	Who is the source of these instructions? a- Municipality b- EQA c- Others: ___
V42	☐	In your opinion, random waste disposal is due to:

		a- Absence of legislation and policies b- Poor behaviour c- lack of landfills d- Others: ____
V43	☐	Who is the responsible for improving construction waste disposal? a- Municipalities b- Contractors c- Regulator authority (EQA) d- Others: ____
V44	☐	Who is the responsible for the overall construction waste management? a- Municipalities b- Contractors c- Regulator authority (EQA) d- EQA in coordination with other PA ministries e- Others: ________________