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ORIGINAL ARTICLE

Local residents' perception of landfill impacts in Palestine: the case of Zahrat Al-Finjan landfill

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Abstract
Waste disposal sector and local landfills operation are considered one of the major sources of pollution in Palestine. This paper focuses on the determination of the main negative impacts caused by Zahrat Al-Finjan landfill operation in the northern part of the West Bank. The data were collected from seven nearby communities. Overall results showed that odor emissions, impacts on plants and animals, impacts on inhabitants' hygiene, impacts on traffic and aesthetic views and pollution due to leachate spills, presence of insects and rodents, reduction in the value of the nearby land are the most significant negative impacts. In particular home-landfill distance plays an important role to the negative impact perception in cases such as particularly odors, and quality of life. On the other hand, dust, noise, and impact on groundwater are not considered issues of major issues of concerns from the residents' point of view. This fact is highly influenced by the application of compensatory benefits to locals. The Logistic Regression Model, that was developed to assess the factors that could affect the residents' perception of impacts on traffic, aesthetics and pollution due to leachate spills, showcased that age, gender, level of education are the most significant explanatory variables.

Keywords Perception · Negative impact · Zahrat Al-Finjan landfill · Solid waste · Palestine

Introduction

Waste disposal is considered one of the major sources of environmental pollution in Palestine in general and climate change in particular. It accounts for 23% of emissions in 2011 [1]. Landfilling has been applied for numerous years as the most common method for the disposal of solid waste generated [2]. Their operation introduces adverse effects on the environmental resources, public and private properties, human amenity, fauna and flora that may be evident in the short term or on the long term [3–6].

Landfills besides being a major source of land, air, ground and surface water pollution [7], they constitute the largest source of methane (human activities), which is a greenhouse gas of 21 times more powerful than carbon dioxide [8–10]. Furthermore, their operation is interwoven with the release of obnoxious odor, noise and dust (due to onsite activities), waste littering, and traffic jams (due to waste transportation). The landfilling outcome is also the leachate generation and urgent need for its treatment [11–14]. Leachate releases contaminate the environment and introduce high risk in the quality of drinking water as documented by [15, 16]. According to World Health Organization (WHO) leachate leaks contaminate soil and water streams and produce air pollution through emissions since they bear high concentration of heavy metals and persistent organic pollutants (POPs), ultimately creating severe health hazards [17]. The Environmental Protection Agency (EPA) considers all landfill leachate leaks eventually toxic [8]. Sullivan [18] has documented the direct effect of environmental pollution in the field of reproduction from conception to parturition. Overall,

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Ozonoff et al. [19] revealed a residential health problem due to the landfill sites operation. Therefore, siting of the landfill site is a necessary step that should include a multicriteria evaluation to select the appropriate location and public consultation as well. Both activities constitute a cornerstone in waste management and contribute to social, financial and environmental sustainability. Compliance with national and international regulations and requirements is also a prerequisite [20], which needs to be combined with local parameters such as topography, geology, natural resources, social and cultural aspects, economics and safety [21].

In Europe, it is reported that 2–6% of the residents are affected by solid waste management facilities operation [22]. For a long time, there is a debate on the level of effect the solid waste management facilities have on property value near the facilities' premises [23, 24]. Of course, the effects of landfills on nearby residential properties cannot be easily identified and generalized in the long term. Some studies show no statistical relationship between proximity and house or land price [23, 25, 26] but on the other hand, citizens' witness drop in the financial value in both selling and renting market.

Waste Management is a major issue in Palestine, across the West Bank and Gaza, and waste management systems are under significant strain [1]. Mismanagement of solid waste introduces impacts similar to the ones described above [27-30]. To contribute to local sustainability, Zahrat Al-Finjan landfill (the first sanitary landfill in Palestine) was sited in 2007 in the northern part of the West Bank and in Jenin district in particular [31]. The initial objective was safe disposal of municipal solid waste in Jenin district [32]. The landfill is operated under the supervision of the Jenin JSC; its total area was 240,000.0 m^2 and the estimated capacity was 2.25 million tons in a life span of approximately 15 years [33].

Although it was constructed to manage waste generated in Jenin district, the service area was afterwards widened to include Nablus and Tulkarm districts, which are located at the northern part of the West Bank. Lately (2013), the Ministry of Local Government enlarged once again the service area by including all the remaining northern districts (Qalqilia, Tubas, and Salfit). As a consequence, the incoming waste quantity is significantly increased (compared to the planning phase), directly affecting the duration of the facility lifespan. The landfill operation impacts were enlarged (e.g. traffic, noise, littering) leading to both environmental and social impacts and residents' intense complaints and protests.

The above-mentioned effects of the landfills can negatively affect the perception of the quality of life by the local residents near the landfill site. Yang et al. [34] reported that residents living near MSW management facilities are confronted with various risk perceptions, especially odor. It has been reported that (61%) of the respondents perceived that environmental pollution has negative effects on their health status [35]. A study on residents' concerns and attitudes toward SWM facilities has been conducted in the Hebron area of Palestine showed that (48.1%) of the surveyed population were found to be extremely concerned of air pollution by SWM facilities [36]. The study also found that (61.1%) of the respondents were found to be extremely concerned about water pollution, and (47.8%) were extremely concerned about damage of fauna and flora by SWM facilities [36].

Perception of the effect of landfill and other SWM facilities can be affected by several factors including age, gender, level of education and distance from the landfill site. It was noted that those who had received a low-level education were more likely to be concerned about beliefs that the waste mismanagement may be linked to health diseases such as incorrect application of management practices [37]. Distance from the landfill site affect the residents' perception as identified by Ijanasan et al. [24], Oluranti and Omosalewa [35], and Ijasan et al. [24]. The age of the respondent's showed significant relationship with the level of concern and attitude toward SWM facilities [36]. Also sex and age found to be significantly affecting the perception of truck accidents at SWM facilities [36].

The purpose of this paper is to determine the environmental and social impacts of Zahrat Al-Finjan landfill site on the surrounding communities from the residents' point of view. Together with that, the paper also aims to assess the factors that affect the local residents' perception of the negative impacts of the landfill.

Research methods

Sample size and data collection

The study focuses on the nearby communities located within the borders of circle with radius 2.5 km from the center of Zahrat Al-Finjan landfill site. These are seven communities and included Fahma, Aja, Anza, Zawiya, Mansura, Fahma Al Jadida, and Araba as shown in Fig. 1. The data was collected via questionnaire through direct interviews with the community residents. The questionnaire was designed to include series of questions related to information about respondents in terms of age, educational level, the distance between the residents' home and the landfill, the impact of the landfill on the surrounding environment, its effect on the population and their welfare, and the most frequent problems identified by locals.

The total sample size was estimated to be 189 people taking into account the population as per the Palestinian Central Bauru of Statistics [38]. The questionnaires were distributed to the seven communities (proportional to each community population size) as per the Fig. 2.

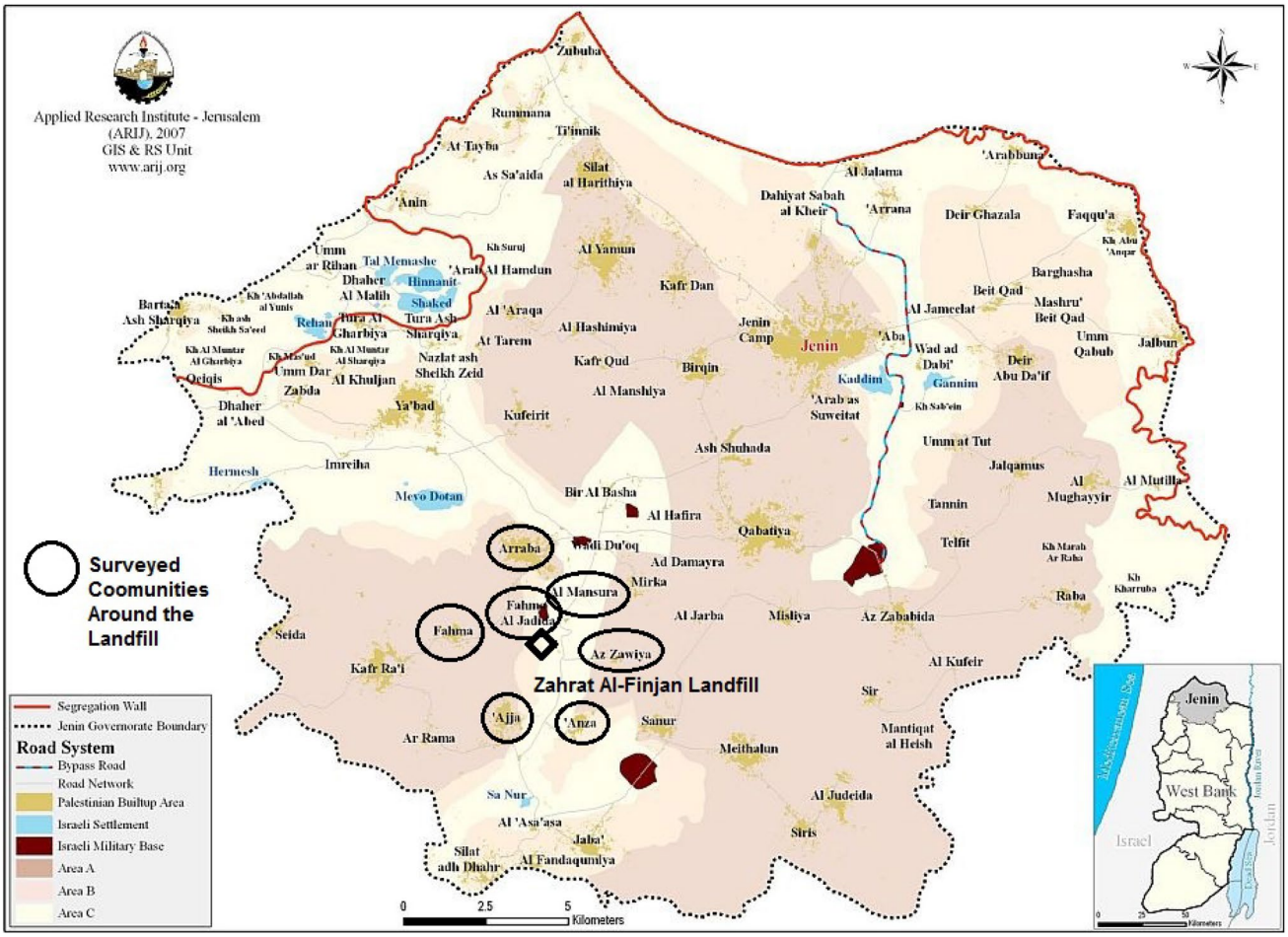

Fig. 1 Map of the landfill site and the surveyed communities

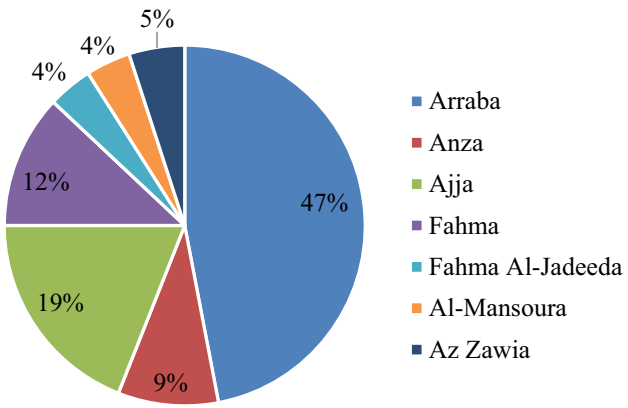

Fig. 2 Sample size distribution

Data analysis

The analysis of the data was carried out using the Statistical Package for Social Sciences software (SPSS Inc., Chicago, IL, USA), version 20. Frequency and cross-tabs tests were utilized for general statistics of the study sample. In addition, a Logistic Regression Model was developed to estimate significant effects of the explanatory variables as per [39–45]. The explanatory variables in the Logistic Regression Model are as shown in Table 1. The Logistic Regression Model used is as follows:

$$\mathrm{Log}\frac{P_i}{1-P_i} = Z_i = \beta_0 + \beta_i X_i + e \quad (1)$$

where P_i is the respondent's perception of the landfill impact; $P_i = 1$ if the respondent's perceive that the landfill has negative impacts in term of traffic, aesthetics and pollution due to leachate spill; and $P_i = 0$ if not; X_i = the independent (explanatory) variable (see Table 1); β_o = a constant term; β_i = a coefficient of the independent variable; e = the error term and $i = 1, 2, \ldots, n$ which is the number of the independent variables in the model. The direction of the relationship between the dependent variable P_i and the independent variable X_i is determined by the sign of the coefficient β_i.

Table 1 Description of explanatory variables in the logistic regression model

Variable no.	Description	Definition
X_1	Gender	1 = male; 2 = female
X_2	Age	1 = ≤20; 2 = (21–35); 3 = (36–45); 3 = ≥46
X_3	Level of education	1 = basic education; 2 = secondary education; 3 = university; 4 = master or higher
X_4	Distance from ZF landfill	1 = < 1 km; 2 = (1–2); 3 = (2–5); 4 = > 5

Coefficients in the Logistic Regression Model are estimated by the maximum likelihood method. The probability of a certain event occurring was estimated by a logistic regression model through calculating the changes in the logarithm of the dependent variable. The likelihood function as defined in Eq. (2) expresses the values of β in terms of known and fixed values of 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 Eq. (2) are the maximum likelihood estimates [40]

$$L\left(\frac{\beta}{y}\right) = \prod_{i=1}^{N} \frac{n_i!}{y_i!(n_i - y_i)!} P_i^{y_i}(1 - P_i)^{(n_i - y_i)}. \quad (2)$$

The statistical significance of each coefficient is evaluated using the Wald test [40]

$$W_i = \left(\frac{\beta_i}{\mathrm{SE}_{\beta_i}}\right)^2 \quad (3)$$

where $i = 1, 2 \ldots, n$ and SE = standard error.

The model was evaluated using four different tests: the log-likelihood function, the omnibus test, Cox and Snell R^2, and Naglekerke $\check{R}^2$ [41]. The log-likelihood function is used to measure the goodness of fit (the discrepancy between observed values and the values expected under the model in question) and is defined as presented in Eq. (4) [40]

$$\mathrm{Log} - \mathrm{likelihood} = \sum_{i=1}^{n} [Y_i ln(\hat{Y}_i) + (1 - Y_i) ln(1 - \hat{Y}_i)] \quad (4)$$

where Y_i = the actual result, and $\hat{Y}_i$ = the predicted probabilities of this result. This is also quoted as 2log-likelihood because it has an approximate chi-squared distribution. The Omnibus test, which is a likelihood-ratio chi-squared test, indicates the goodness of fit if the coefficients of the variables in the model are all jointly equal to zero. Cox and Snell R^2 and Nagelkerke $\check{R}^2$ are indicating the proportion of the variation in the dependent variable explained by the independent variable of the model. Since Cox and Snell R^2 cannot achieve a maximum value of 1, Nagelkerke $\check{R}^2$, which is an adjusted version of the Cox and Snell R^2 and covers a full range from 0 to 1, is used because it is often preferred [45].

In addition, a correlation matrix of the variables for the model was studied to ensure no multicolinearity occurrence, which means that the variables are independent and truly have no correlation in excess of 0.7.

Results and discussion

The respondents to the questionnaire's description are shown in Table 2. About 22% of the respondents were females and 78% were males. The largest respondents' group (34.5%) aged between 21 and 35 years. More than 40% of the respondents have a secondary education. About 54% of the respondents live at a distance of 1–2 km from landfill.

Table 3 shows respondents' views regarding the impacts of Zahrat Al-Finjan landfill operation, on the population and the surrounding environment. It is noticed that almost all respondents (97.5%) agree that the landfill has various

Table 2 Characteristics of the study sample

Independent categories	Number of respondents (percentage %)				Total
Gender	Male		Female		189
	147(78%)		42(22%)		
Age	< 20	20–35	36–45	> 45	189
	15 (8%)	65 (34.5%)	63 (33.5%)	46 (24%)	
Education level	Basic education	Secondary education	University	Master or more	189
	37 (19.5%)	75 (40%)	73 (38.5%)	4 (2%)	
Distance from landfill	< 1000 m	1–2 km	2–5 km	> 5 km	189
	32 (17%)	102 (54%)	43 (23%)	12 (6%)	

Table 3 Respondents' answers with the effects of Zahrat Al-Finjan landfill on the population and the surrounding environment

Independent categories	Number of respondents (percentage %)			
ZA affected my life	Yes, negatively	No		
	184 (97.5%)	5 (2.5%)		
ZA produces bad odours	Always	Sometimes	Never	
	135 (78.5%)	54 (21.5%)	0 (0%)	
ZA produces dust	Yes	No		
	10(5.5%)	179(94.5%)		
ZA produces noise	Always	Sometimes	Never	
	4 (2%)	41 (22%)	144 (76%)	
ZF affected groundwater	Yes	No		
	86 (45.5%)	103 (54.5%)		
ZA affected plants and animals	Yes, negatively	No	I don't know	
	161 (85%)	17 (9%)	11 (6%)	
ZA affected inhabitants'' hygiene	Yes	No	I don't know	
	144 (76.6%)	15 (8%)	29 (15.4%)	
ZA caused the presence of rodents and insects	Yes	Sometimes	No	
	164(87%)	25 (13%)	0 (0%)	
ZA negatively affected the value of surrounding lands and houses	Yes	Sometimes	I don't know	No
	112(59.5%)	22(11.5%)	34(18%)	21 (11%)
ZA causes waste littering	Yes	Sometimes	No	I don't know
	24 (12.5%)	31 (16.5%)	110 (58%)	24 (12.5%)
ZF affected traffic, aesthetics and cause pollution due to leachate spills	Yes	No		
	96 (50.8%)	93 (49.2%)		

negative impacts on their live status. According to list of negative impacts shown in Table 3, 78.5% of the respondents are annoyed by odors released from the landfill, 85% of them agreed that the landfill has a negative impact on plants and animals, 87% of them have noticed increased presence of rodents and insects, 76.6% declare impacts on hygiene level, 50.8% of them face increased traffic conditions and aesthetic pollution and fear potential pollution due to leachate spills, and 59.5% indicate negative impact on the value of the nearby land and houses. However, the majority of the respondents mentioned that the landfill doesn't produce dust (94.5%) or noise (76.6%), neither it affects the groundwater quality (54.5%). The low impact on groundwater is due to the fact that no incidents of water supply contamination have occurred up to date, and, therefore, the residents haven't experienced any water contamination. In addition, low impact of dust and noise could be also attributed to none or little use of cover material for waste daily coverage, and due to the long distance from community homes, the noise transmission is very limited. In comparison with others previous studies, Ijasan et al. [24] found that the respondents' highlighted that landfill operation has a negative impact on their life status (43.8%), on their health (51.4%), the air quality (71.4%), the water quality (2.9%), value of property (81%) and acceptable noise levels (5.7%). In Nigeria, Oluranti and Omosalewa [37] found that 61%of the surveyed respondents confirmed that the environmental pollution from the dumpsite has negative effects on their health status. Moreover, Nelson et al. [46] found that property values downtrend within 3.2 km of the landfill site. In addition, Ready [47] found that houses located closer to the landfill were sold in lower prices than similar houses located far away from the landfill.

Being a significant social parameter, homes-landfill distance parameter was further investigated to check its impact on the respondent's perception of landfill's negative impacts. The results showed that there is a significant relationship between both ($P \leq 0.05$) as shown in Table 4.

Similarly, previous studies showed that the homes-landfill distance is statistically significant in determining the perception of landfill operation impacts, particularly odors, property value, and quality of life. Ijasan et al. [24] found a significant relationship between the proximity of living from the landfill and impacts released such as smells, reduced property value, quality of life, and pollution caused by the landfill operation.

The most frequent negative impacts as highlighted by the residents' by Zahrat Al-Finjan landfill operation were assessed taking into account the distance between the respondent's house and the landfill as shown in Fig. 3. The results showed a significant relationship between them ($P \leq 0.05$). The majority of the respondents indicated bad odor, rodents, insects and wild animal (49.2%) as the primal negative impact of landfill operation. The closer the distance from landfill, the highest the reported negative impacts. 65.6% of those who live in a distance of less than 1 km report nuisance from bad odor, rodents, insects and wild animals but 91.7% of those who are living at more than 5 km from the landfill report nuisance only from bad smells.

The most frequent landfill problems are commonly related to site selection, design, management, and monitoring during the operation phase. This is concluded based on the respondents' answers who suffer from bad smells, rodents, insects and wild animals which link directly with the location of the landfill and the surrounding environment, the operational practices and monitoring. In addition, it has been reported that Zahrat Al-Finjan was designed to be sanitary landfill, but in fact, it is away from being a sanitary one due to poor management practices [48, 49]. The site is located in the headwaters of Hadera-Massin catchment and closed to natural running streams, which increases the vulnerability of surface water contamination due to leachate discharges into the wadi and absence of collection and treatment system [49]. Poorly operation of the site has created spread of flies, mosquitoes, bird droppings, rodents and spread of stray dogs are other negative impacts of the site [49]. The majority of

Table 4 Relationship between distance from the landfill and negative impacts

Variable	Chi-square	Sig (*P* value)
ZF landfill produces bad odors	14.647	0.002
ZF landfill produces dust	8.626	0.035
ZF landfill produces noise	46.161	0.000
ZF landfill affected plants and animals	29.566	0.000
ZF landfill affected inhabitant hygiene	19.306	0.004
ZF landfill affected groundwater	20.666	0.002
ZF landfill caused presence of rodents and insects	23.690	0.000
ZF landfill affected the values of surrounding land and houses	32.212	0.000
ZF landfill caused waste littering	49.378	0.000
ZF affected traffic, aesthetics and cause pollution due to leachate spills	28.671	0.000

Significance level at $P \leq 0.05$

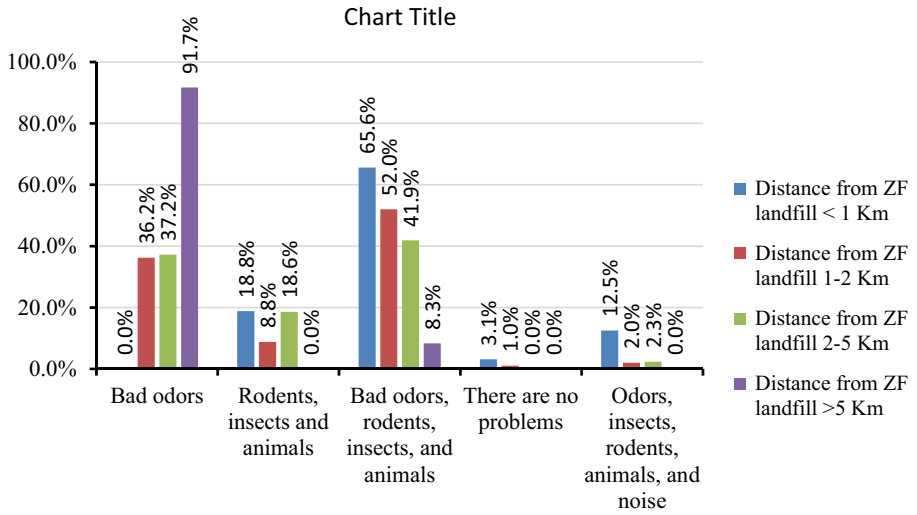

Fig. 3 Most frequent problems caused by Zahrat Al-Finjan landfill versus distance from the landfill

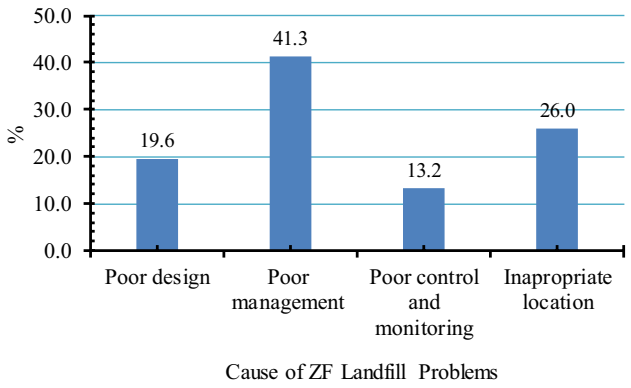

Fig. 4 Causes of Zahrat Al-Finjan landfill problems

the respondents (41.3%) attributed the negative impact they face by Zahrat Al-Finjan landfill to its poor management, 26.0% to the inappropriate location, 19.6% to poor design, and 13.2% to poor control and monitoring. Figure 4 presents the causes of the landfill problems.

Although the 71.4% residents perceived negative impacts of the landfill in accordance with the data analysis, only 28.6% of them have submitted claims to the responsible local authorities. This could be attributed to the fact that the majority of the locals (respondents included) are employed at the landfill and this counterbalances most of the negative impacts they report (mostly noise, odors, dust).

The residents' perception of the impacts of the landfill operation on traffic, aesthetic views and leachate spills related pollution, was assessed. The results showed that 50.8% of respondents perceive that the landfill has negative effect on traffic, aesthetic views and leachate spills related pollution, compared to 49.2% who perceived no impact. A logistic regression model was developed to assess the factors that could affect the respondent's perception of Zahrat Al-Finjanlandfill effect on traffic, aesthetics and leachate spills related pollution. Four independent factors were selected, including gender, age, level of education and the home-landfill distance. The estimation was conducted as per Eq. (1):

$$\begin{aligned}\text{Logit (Perception)} = {} & 1.242 - 0.990 \times \text{Gender} + 0.605 \\ & \times \text{Age} + 0.453 \times \text{Level of education} \\ & - 1.230 \times \text{Distancefrom ZF landfill}\end{aligned} \quad (5)$$

The Logistic Regression Model output and the goodness of fit are shown in Tables 5 and 6, respectively. All of the

Table 5 Logistic Regression Model output

Variable no	Description	Estimated coefficient (β)	Standard error (SE)	Wald statistics	*df*	Significance (*P* value)
X_1	Gender	− 0.990	0.413	5.730	1	0.017*
X_2	Age	0.605	0.196	9.533	1	0.002*
X_3	Level of education	0.453	0.228	3.964	1	0.046*
X_4	Distance from ZF landfill	− 1.230	0.248	24.680	1	0.000*
Constant		1.242	0.972	1.632	1	0.201

*Significance level: $P \leq 0.05$

Table 6 Model summary and goodness of fit tests

Test	Results		
Model summary	− 2 Log likelihood	Cox & Snell R^2	Nagelkerke R^2
	215.228	0.219	0.292
Omnibus tests of model coefficients	Chi-square	*df*	Sig
	46.734	4	0.000

assessed factors showed significant effect of the respondent's perception of the landfill negative impact as follows:

- Gender: females showed higher perception of the landfill negative impact than men. Women in such areas are mostly at home, while men usually go to work outside the area, therefore, women are more vulnerable to the landfill effect than men;
- Age: the higher the age the higher perception of the landfill operation negative impacts;
- Level of education: the higher the level of education the higher the perception of the landfill operation negative impact;
- home-landfill distance: people who live closer to the landfill showed higher perception of the negative impacts of the landfill operation. Concerning this, Ijanasan et al. [24] found that the residents closer to the landfill perceive less quality of life. Oluranti and Omosalewa [35] reported that those living close to the dumpsite suffer more health problems than those living farther from it. In addition, Ijasan et al. [24] reported negative correlation between the distance from the landfill and the perceived quality of life of the residents.

Conclusion and recommendation

The main impacts of Zahrat Al-Finjan landfill operation in the northern part of the West Bank were determined based on the residents' perception and assessed through population characteristics variables. Overall, dust, noise, and groundwater impacts are not considered as major impacts from the residents' point of view. The study showcased the significant relationship between the home-landfill distance and respondents' perception of the negative impacts. Respondents age is the next influencing factor. However, in the case of potential negative impacts on traffic, aesthetic and leachate spills pollution, no real difference in perception was noticed based on the distance variable. The Logistic Regression Model results showed also that age, gender, level of education and distance of living from the landfill are principal factors in the case of resident's perception. Given that in Palestine, there is no specific regulation that specifies the minimum distance between the landfill and the residential areas, this research outcome becomes handy and should be taken into consideration in the future regulation amendment. On the other hand, it was noticed that compensatory benefits (e.g. local population being employees in the facility) limit the public discontent and further increases the possibility for the public to accept the facilities operation (by frequent and long-time protest such as petition and collection at the gate of the government administration building, etc.). However, this element should not be taken advantage of and jeopardize the environmental safeguard and residents' health.

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