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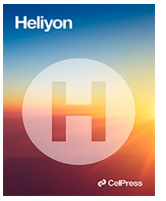

Research article

Siting of fuel stations within residential areas in Ghanaian cities: Perceptions of residents in Wa on fire disaster risks

Ibrahim Abu Abdulai [a,*], Mohammed Awal Abubakari [b], Dramani Juah M-Buu File [c]

[a] Department of Governance and Development Management, SD Dombo University of Business and Integrated Development Studies, Wa, Ghana
[b] Department of Social Policy and Management, SD Dombo University of Business and Integrated Development Studies, Wa, Ghana
[c] Department of Local Governance and City Management, SD Dombo University of Business and Integrated Development Studies, Wa, Ghana

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ABSTRACT

This paper responds to the limited literature on perceptions of fire disaster risks associated with the siting of fuel stations in dense residential areas in African cities. We address three interrelated research objectives regarding fire disaster risk and safety behaviours. First, we explore residents' perception of the reasons for the siting of fuel stations in residential areas. Second, we examine their sociodemographic characteristics and perception of fire disaster risks associated with fuel stations; and third, we examine residents' fire safety behaviours around fuel stations. We address these objectives by engaging with risk perception theory and protection motivation theory as well as an empirical review of literature worldwide. We also draw evidence from Wa in Ghana using a mixed research approach involving 182 participants. Through a questionnaire, observation checklist, a camera, and an in-depth interview guide, we elicited data from residents and relevant stakeholders to address our research questions. The quantitative data were analysed using descriptive statistics and a chi-square test, while thematic analysis was used to analyse the responses obtained from the interviews. We found that ease of access and competition motivated the siting of fuel stations in residential areas. Although residents knew the risk of living near fuel stations, measures were not implemented to reduce their vulnerability to fire disasters. People living near fuel stations should be encouraged to invest in equipment and take measures to reduce their vulnerability to fire disasters.

1. Introduction

Fire disasters are ever present in human societies since fire has natural and human origins [1,2]. According to Ref. [3], a fire disaster is an event that leads to the death of 25 people or more, while there is no consensus on the number of injuries in such accidents. Besides human deaths, fire disasters lead to material, economic, and environmental losses [2,4,5]. Most fire disasters are triggered by the interaction between flammable liquids, such as those stored and sold in fuel stations, and fire or light [3]. Although fire disasters are generally random and sudden and sometimes slow and lingering, people and communities are sometimes aware of their exposure to the risks [6]. The location of people and places makes them vulnerable to fire disaster risks and as such they must take protective measures against such potential events to shield themselves from the consequences [7,8]. One source of fire disaster risks is fuel stations located in residential areas. Fuel stations are potential sources of fire outbreaks because several disasters have been reported at

* Corresponding author.
E-mail address: iaabdulai@ubids.edu.gh (I.A. Abdulai).

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fuel stations worldwide, especially, in developing countries. In the Shaanxi Province of China, a fuel tanker refuelling at a fuel station caught fire and exploded, injuring several people [9]. Also, a fuel tanker discharging its content at a filling station close to Eke Nibo Market, Anambra State in Nigeria, caught fire leading to the loss of lives of several hundreds of people and the destruction of properties worth billions of dollars [10].

In Ghana, the flood and fire disasters that killed more than 150 people in Accra in 2015; the Trade Fair Centre fuel station disaster in 2016 that killed six people; petrol station explosion at the Atomic Junction in Accra that killed seven people in 2017 are some of the examples of fuel station disasters that have occurred. These disasters reinforce the view that fuel stations are dangerous sites, especially in densely populated urban areas. Fire disasters at fuel stations in residential areas are risky because they store and sell flammable materials that could cause human and environmental losses in fire outbreaks. Generally, many activities occur in and around fuel stations, including the arrival and departure of vehicles, discharging fuel into underground storage tanks, processing of various electrical components, public movement, and activities of customers [11]. These activities are potential sources of fire outbreaks that could lead to the loss of human lives and properties [10].

The siting of fuel stations in residential areas in cities is, perhaps, due to high population growth, urbanisation, and the accompanying increase in the number of vehicles which increases the demand for petroleum products [11–13]. Although fuel stations provide petroleum products that stimulate and drive socio-economic growth and development in contemporary societies, their presence in residential areas is a source of fire risks to inhabitants and their properties [14]. The fire risks are associated with the storage of large quantities of hazardous materials, mainly petrol, and diesel, that emit flammable vapours [13]. The vapours emitted can form an inflammable mixture in the air that can detonate when in contact with fire, heat, or light. The situation becomes precarious amid poor urban governance, high population density, and crowded living conditions common in most Ghanaian cities [14]. [15] observed that weak and fragmented urban governance arrangements coupled with limited capacities hinder the ability of city authorities to adequately address urban risk to break the cycles of disaster risk accumulation. Studies have shown that siting fuel stations in residential areas is a significant source of fire disaster risk in most cities of developing countries because they are often established without rigorous due diligence in terms of proper disaster risk planning, evaluation, and management [14,16]. This endangers the lives and properties of residents around fuel stations in urban residential areas.

As a result of this, residents and operators of fuel stations must take precautionary measures to substantially reduce the risk posed by fuel stations to avert any eventuality. Fire disaster risk is the likelihood of the event occurring and its actual or anticipated consequences [5,17]. Reducing the number of fuel stations in residential areas could help reduce the risk of fire disasters and avert potential damages and losses [5]. In this view, countries should develop zoning regulations to protect lives and properties in the siting of fuel stations. In India, for example, zoning regulations require fuel stations to be sited at least 50 m from residential areas, schools, and hospitals [18]. In Hong Kong and China, fuel stations are located at least 55 m away from high-rise residential, educational, and hospital facilities [19]. On the other hand, fuel stations sited in commercial/recreational/industrial areas must be at least 15 m away. In low-density residential locations, fuel stations must be at least 15 m away from the residential facilities [19]. In Ghana, it is required for fuel stations to be sited at least 30.8 m or 100 feet away from residential areas. This implies that fuel stations are not outrightly barred from residential areas in Ghanaian cities. Therefore, the proliferation of fuel stations in high-density population areas suggests that those living around these facilities must adopt appropriate fire safety behaviours and investments to protect them against associated fire disasters [12,13]. Following the work of [20], fire safety means fire prevention and minimising the spread of fire, quenching the fire, and the possibility of escaping from danger. On the other hand, residents can adopt appropriate actions to reduce their vulnerability to disasters associated with fuel stations in residential areas and these constitute fire safety behaviours [20].

Studies on the siting of fuel stations in residential areas in Ghana are relatively rare and with a lot of focus on pump attendants' health and safety standards, occupational hazards, and health problems [21]; pump attendants' knowledge and perceptions of siting fuel stations [22]; compliance to safety standards [14]; and land use planning and siting of fuel stations [12]. These studies have provided an understanding of the risk of fire disasters associated with living and/or working near fuel stations. However, there is still limited research on why fuel stations are sited in residential areas, the probability of fire disasters occurring, the severity of fire disaster risk, and the fire safety behaviours of nearby residents. This gap limits our understanding of residents' perception of fire disaster risk associated with siting fuel stations in dense residential areas in cities. It is, therefore, appropriate to pay attention to fuel stations located in dense residential areas regarding the reasons for locating them there, the risks, and the strategies to be adopted to reduce vulnerability. This is because any explosion at such a location could lead to heavy human casualties and massive loss of properties.

We draw evidence from Wa in Ghana to understand the nuances of residents regarding the siting of fuel stations in dense residential areas. Wa is chosen because it is one of the fastest-growing cities in Ghana [23]. As a result, it is experiencing a high rate of proliferation of fuel stations, with almost all available spaces in residential areas being converted to fuel stations. Preliminary observation shows that 12 fuel stations are in dense residential areas. Although the city has not recorded any primary fuel station-related fire incidents, their presence in residential areas continues to put the residents at risk. Through the lenses of the risk perception and protection motivation theories, this research addresses the gaps in residents' unexplored perceptions and fire safety behaviours near fuel stations. Specifically, the study seeks to:

1. Explore the reason for the siting of fuel stations in residential areas.
2. Examine the association between residents' sociodemographic characteristics and perception/incidence of risks of fire disasters at fuel stations; and
3. Examine the availability of fire safety equipment, measures, and safety behaviours.

To address the second research objective, the following hypotheses are tested:

I. HA_1: There is a statistically significant association between residents' sociodemographic characteristics and perception of the occurrence of fuel stations' fire disasters.
II. HB_1: There is a statistically significant association between residents' sociodemographic characteristics and perception of the severity of a fire disaster.

Testing the hypothesis is important because previous studies show that sociodemographic characteristics of people influence risk perceptions and exposure. For example, the work of [15] shows that the level of education attained by the research participants could influence perceptions and the adoption of appropriate fire safety behaviours as they can read educational materials on fire disaster risks and preparedness, while [20] reveals that older people have a higher fire risk because of fatigue, confusion, and hearing impairment.

This research is necessary because the findings can provide information for reforms and enforcement of the policies on the siting of fuel stations to reduce fire disaster risk in Ghana and similar contexts. The findings will also help city authorities to appreciate the fears, concerns, and strategies of residents so that they can fashion out local actions to reduce the risk. The article discusses the theoretical framework in the second section. The third section presents conceptual issues and some empirical studies relevant to the study. In the fourth section, the methodology is presented, while the results are presented in the fifth section. After that, we discuss the results in the sixth section, while the theoretical and practical applications of the findings constitute the seventh section. The article ends with a discussion of the conclusions and policy implications of the findings.

2. Theoretical framing

Theories explaining disaster risk are often framed around risk perception and responses as expressed by the disaster risk perception theory (RPT) and protection motivation theory (PMT). Risk perception measures people's subjective judgment, interpretations, and feelings as well as the sociocultural dispositions toward the likelihood of death, injury, illness, and disease because of an event such as fire [24]. Theorising risk from the RPT point of view, we argue that individuals perform actions based on certain clues, then interpret the situation; and based on the signals, they decide what to do to insulate themselves from the potential consequences of disasters [25]. Our view is that decisions and actions taken in any situation are influenced by interpreting the situation and activities [26]. In such instances, the perceptions of residents or occupants of buildings near fuel stations may be influenced by hearing discussions, watching television news, and seeing others' actions during such situations [26]. Therefore, the perceptions may find their way into their decisions and actions in the event of a fire disaster [25]. One weakness of the RPT is that it does not show how perceptions may translate into people's behaviour toward risk. It is also argued that public risk perception can be wrong sometimes [27]. However, public perceptions can be explored and used to encourage appropriate behaviours in response to risk, and this necessitated the use of the PMT to complement the RPT to address the research objectives.

For the PMT, severity appraisal and coping appraisal constitute the critical factors that influence people's decision to protect themselves against the risk of a disaster [28–30]. The threat severity appraisal focuses on finding the source of the threat and issues that increase or decrease the likelihood of maladaptive behaviours; while assessing the adaptive responses to the potential or real threat and one's ability to engage in activities that protect them or avert the danger constitutes the coping appraisal [28,31]. Based on the appraisals, it is argued that people will take personal safety measures that protect them and their properties to the extent that the consequences will be severe if the threat continues. In other words, people's perception of the severity of the impact of an event and their ability to cope usually motivate them. The propositions of the theory make it a flexible framework for risk analysis, and as such, it has been applied in several studies, including the pro-environmental behaviour of farmers [32,33], sustainable waste management behaviours [34], climate change adaptation and mitigation [35], and health and safety behaviours [36]. The theory has critics. [37], for example, points out that the theory needs to incorporate the skills and means people required to take action to shield them from the consequences of disasters. However, combining the two theories provides a valuable framework for us to explain residents' perceptions of fire disaster risk regarding the siting of fuel stations in dense residential areas and associated behaviours that could reduce their vulnerability.

3. Understanding disasters: fuel station fires in perspective

Disaster occurs when a hazard strikes a community or vulnerable people who cannot handle the impacts and therefore require external support to cope with the situation [38]. It is generally an unforeseen and sudden event that disrupts the social functioning of the community and exacts not only incredible human suffering but also economic and environmental damages, which often exceed the capacity of the society to handle based on its current resource level [38,39]. The extent to which an event can occur and its actual or anticipated adverse effects constitute disaster risk [5]. Disaster risk is an outcome of a hazard's severity and frequency, the number of people and assets exposed and the potential damage [6]. Disasters could be natural (flood, rainstorm, tsunami, earthquake, and drought) or artificial (fire). It is, however, worth noting that the heterogeneity of individuals and communities in their exposures reflects the varying degrees of effects they might suffer during a disaster [38]. For instance, the location of people exposes them and their properties to the likelihood of suffering the consequences of a disaster. Therefore, we conceive disaster risk reduction as the instituted (formal or informal) mechanisms to lessen the vulnerabilities of people and places through the design and implementation of policies, strategies, rules, regulations, guidelines, and practices [5,40]. Effective disaster risk reduction, however, requires resources and investment in the relevant infrastructure and skills at the individual, community, and national levels.

Although there is no agreement on the number of people injured in an event to qualify as a disaster [41], posit that any incident that

leads to the death of 25 people or more qualifies as a disaster. Fire disasters could occur because of natural forces/processes or human actions such as negligence or errors [41]. It can also occur in an environment where igniters such as lighting or dropping cigarettes on flammable surfaces or materials are commonplace [41]. As some studies [42] show, fire is often a rapid, self-sustaining oxidation process alongside the evolution of varying intensities of heat and light. Generally, four elements - flammable materials/substances, ignition source, oxygen, and a reaction mechanism - cause a fire event. The flammable gases used for cooking, kerosene, gasoline, and combustible material constitute a potential source of fire disasters [42]. As such, fire spread is fuelled by wood, thatched roofs, high wind, congestion, poor access to a fire hydrant, and inadequate water distribution system [42,43]. Also, the lack of exposure protection, inadequate public protection, hot or dry weather conditions, delay in the discovery of fire, inadequate personal fire protection, and absence of fire alarm led to fire spread [42,43]. Fire disasters often lead to injuries, deaths, and property damage [12,13,41].

Studies on the siting of fuel stations in residential areas and the related disaster risk are often viewed from the viewpoint of the health and safety of fuel attendants, spatial distribution and vulnerability of residents, land use planning responses, and the degree of compliance with planning and safety standards and regulations [12,14,21,44,45] with little attention on residents' perceptions. For example [44], examined fuel station attendants' awareness of hazards, safety measures, and practices. The study found that they had little knowledge of the safety procedures and that fuel stations did not comply with the safety standards, while also ignoring the views of neighbourhood residents on the disaster risk. The work of [21], centred on attendants' health and safety standards, occupational hazards, and health problems associated with fuel stations in Ghana. The study, however, did not address residents' perceptions and the measures put into place to reduce the fire disaster risk at fuel stations.

On their part [45], showed that the fuel stations were sited in high population density areas, and most of them did not meet the siting standards and regulations in Kaduna in Nigeria. However, the perceived risks posed by the facilities and the measures to reduce vulnerability among residents were not covered. More recently [12], investigated how land use planning and zoning practices reduce fire disaster risk from gas and petrol stations in Kumasi, Ghana [14]. focused on the residents' perceptions of policy compliance to safety standards and reported that most stations failed the criteria and that residents were unaware of their vulnerability to fire disaster risks. However, it is essential to examine the safety behaviours and measures to reduce vulnerabilities to disaster risk associated with living near fuel stations. This is because fire safety behaviours could be more effective if property owners and residents invest in fire equipment, such as fire extinguishers, smoke detectors, and fire alarms, and acquire knowledge of fire service contact numbers to take urgent actions in the event of an emergency [20].

4. Methodology

4.1. Study setting

The study was conducted in urban Wa. Wa is the capital town of the Upper West Region and the administrative capital of Wa Municipality (Fig. 1). It is considered one of the fastest growing cities in Ghana (see 23). There are 143,358 residents in the city, with 73,351 of them being females and 70,007 males [46]. The residents undertake agriculture, services, sales, crafts, and other professions to earn a living [47]. The city is also the hub of commerce in the region; a link to the rest of the country and a major transit route to

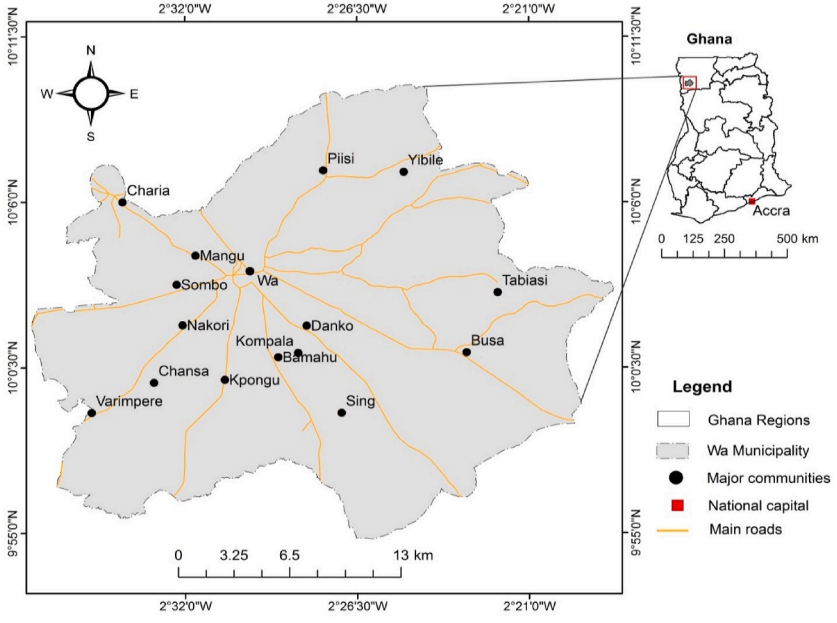

Fig. 1. Study area in the regional and national contexts adopted from [48].

Burkina Faso and Mali, creating a high demand for fuel to power the vehicles in transit to neighbouring countries as well as the socio-economic activities within the region. These have led to the proliferation of fuel stations in the city. Studies also show that the city is experiencing rapid urban population growth and physical expansion [23,48]. The growth of the city is accompanied by urban population growth, booming business activities, and increased vehicular numbers that together also lead to a high demand for fuel for numerous purposes. As a result of the developments, fuel stations are put up in any available space, including dense residential areas in the city. In all, there are 36 fuel stations located in the city, but 12 are in densely populated areas. Preliminary visits to the 12 fuel stations show that they have inadequate safeguards for residents. They can be a source of fire disaster risk to the residents. Therefore, the highly urbanised area within the city is chosen for the study to examine residents' disaster risk reduction strategies through their perceptions and safety measures.

4.2. Study approach

The study used the mixed methods research design to collect, analyse and make inferences from data [49]. Data were collected from residents living near fuel stations using questionnaires. Interview guides were used to collect qualitative data from officials of the Ghana National Fire Service (GNFS), Environmental Protection Agency (EPA), National Petroleum Authority (NPA), and Land Use and Spatial Planning Authority (LUSPA). The study applied the concurrent mixed research method, which entails collecting both quantitative and qualitative data simultaneously.

4.3. Sampling and sampling procedures

Before sampling residents to participate in the study, a preliminary visit to 12 fuel stations within dense residential areas was undertaken. Through the preliminary visit, 128 residential houses and 64 business establishments were identified as situated within 30.8 m away from the boundary of the 12 fuel stations in the city. The 30.8-m threshold for identifying residential and business establishments was used because it is the approved standard recommended by the National Petroleum Authority (NPA) regarding the siting of gas and fuel stations in residential areas. From the 128 residential buildings and business establishments, we identified 340 as the sampling frame. The sample size was computed using the relation: $n = \frac{N}{1+N\ (e)^2}$ where n = sample size, N = sampling frame, and e = alpha level [50]. The computation yielded a sample size of 184. In terms of sampling, the houses and business establishments were assigned, and after that, the simple random sampling technique was deployed to select the respondents using the fishbowl method without replacement until arriving at the sample size. Also, one official each was purposively sampled from the Ghana National Fire Service (GNFS), Environmental Protection Agency (EPA), National Petroleum Authority (NPA), and Land Use and Spatial Planning Authority (LUSPA) to participate in the study because we presumed that they have in-depth knowledge concerning the issue under investigation. Before the commencement of the data collection, we sought approval for the data collection instruments from the Research Ethics Review Board of SD Dombo University of Business and Integrated Development Studies, which was granted. Approval was given for the data collection after the instruments were reviewed, and suggestions provided to improve the content were incorporated.

4.4. Data collection and analytical methods

A structured questionnaire was used to elicit data from the residents and operators of business establishments. The questionnaire comprised open-ended and close-ended items relating to respondents' sociodemographic characteristics; perceptions about the location of fuel stations, hazards; knowledge of the severity of fire risk; and fire safety and emergency fire procedures. Some items also covered the measures to reduce their vulnerability to fire disaster risk. An observation checklist supported with a camera was used to validate research respondents' claims. The interview guide used to collect data from the staff of the relevant state agencies revolved around their role in reducing fire disaster risk and their experiences and engagement with residents and fuel station operators regarding human and asset safety. We also use pictures from Google Earth Maps to show the location of fuel stations in some residential areas in the city. The survey data were first cleaned after they had been entered into Statistical Package for Social Sciences (SPSS) software version 28 for analysis. After that, descriptive statistics, and the Likert scale were applied to the quantitative data. Further, a Chi-square test was used to test the significant association between residents' sociodemographic characteristics and the perception of the probability of fire disasters occurring at the fuel stations and their severity. Before the data analysis, we checked for internal consistency of the items on the questionnaire using a one-dimensionality test. The Cronbach alpha test was conducted to check for the internal consistency of the items on the questionnaire. The test yielded 0.839, within the acceptable 0.70 and above Cronbach alpha [51]. Out of the 184 questionnaires sent out, 182 were returned with valid data. The interview responses were also analysed using the five-phase thematic analyses procedure [52].

5. Results

5.1. Sociodemographic and housing profile of respondents

Table 1 shows the sociodemographic breakdown of the sample. As shown in Table 1, most (67.6 %) of the research participants were men, while the [46] revealed in the Population and Housing Census that there are more women in Ghana than men in 10 out of

the 16 regions in the country. A large proportion of the sample attained secondary education (36.9 %) followed by those who attained tertiary education (29.7 %). Interestingly, only 15.4 % of them have never been to school which is lower than the national average of 20.8 % [46]. For occupation, the findings show that 42.9 % are engaged in trading as a livelihood activity, while only 4.4 % of them are involved in farming showing that more urban economic activities are emerging in the city [23]. Also, most of the sampled respondents live in cement block houses. On aggregate, the maximum age was 61 years, while the minimum was 20 years, with a mean age of 37.1, confirming the [46] report that Ghana's population is transitioning from a children-dominated to a youth-dominated age structure. The age of people may also influence people's perception of fire disaster risk analysis because studies show that younger people are more likely to suffer more injuries. The maximum number of years residents lived in a house close to a fuel station was 28 years with a standard deviation of 6.4, while the oldest fuel station was 23 years at its current location with a standard deviation of 4.2.

5.2. Reasons for siting fuel stations in residential areas: residents' perspectives

The research participants' perspectives were sought concerning the reasons for siting fuel stations in residential areas (profit maximisation, easy accessibility, enhanced competition, job creation, nature of the land, location preference, EPA approval, business potential, and heavily travelled street). A 6-point Likert scale (strongly disagree [SD], disagree [D], neither agree nor disagree [NAD], agree [A], strongly agree [SA], and do not know [DK]) was used to elicit the perspectives of the research participants regarding the reasons for siting fuel stations in residential areas. As shown in Fig. 2, many respondents strongly disagreed with the assertion that fuel stations are sited in residential areas after approval was granted. A resident also intimated that:

> *I do not believe that the EPA granted the people (fuel station operators) a permit to site it here. Look at how close the fuel station is to the shop. The shop had been here for several years before the people came to construct the fuel station, but I was still waiting for someone to consult me* (Interview with a resident, 10th September 2022).

This finding is curious, given that some institutions are mandated by law to approve and grant permits before the siting of fuel stations in Ghana. However, the EPA, LUSPA, and GNFS officials reveal that due diligence was followed in granting permits for the construction of these facilities in residential areas.

As regards the reasons, 57.1 % of the research respondents strongly agreed with the claim that fuel stations are sited in residential areas because of easy access (Fig. 2). Also, 53.3 % of them strongly agreed that enhanced competition accounted for the siting of fuel stations in residential areas. A similar trend of high scores could be observed for job creation (55.5 %), nature of the land (56.0 %), and location preference (57.7 %) as the reasons for siting fuel stations in residential areas in the city. A large percentage of the research participants (49.5 %) agreed with the claim of profit maximisation, while half of the research participants strongly agreed with the notion of business potential. Finally, 52.2 % of the research participants strongly agreed that heavily travelled streets influenced the siting of fuel stations in residential areas. Although small proportions of the research participants disagreed with notions that socioeconomic factors influenced the siting of fuel stations in residential areas, the scores varied. For instance, 13.2 % of them disagreed with the claim that fuel stations are sited in residential areas because of business potential. In comparison, 6 % disagreed with the claim that fuel stations are sited in residential areas to maximise profit.

Since the research participants were aware of the reasons accounting for the siting of fuel stations in residential areas, it was essential to ascertain their involvement in the processes. The results showed that most research participants (92.9 %) needed to be informed and consulted before establishing fuel stations close to their buildings or structures. However, only a small proportion of them (18.7 %) attempted to find out or engage the facility owners and the relevant state authorities concerning establishing a fuel station close to their building or structure. Those who did not try to inquire said they did not expect to obtain sufficient responses from either the relevant state authorities or the owners of the fuel stations. A resident stated.

> *I did not attempt to find out because I did not know whom to contact or complain about the issue. Nevertheless, I know it is the government's responsibility to ensure that things are done correctly in the country. So, it isn't my duty to ask people why they are*

Table 1
Participants' sociodemographic profile.

Characteristics	Category	N	%
Gender	Male	123	67.6
	Female	59	32.4
Education	Basic	32	17.6
	Secondary	68	37.4
	No formal education	28	15.4
	Tertiary	54	29.7
Occupation	Trading	78	42.9
	Artisan	50	27.5
	Salary worker	33	18.1
	Unemployed	13	7.1
	Farming	8	4.4
Housing Type	Cement block	118	65.4
	Mud bricks	28	15.6
	Wooden	36	19.0

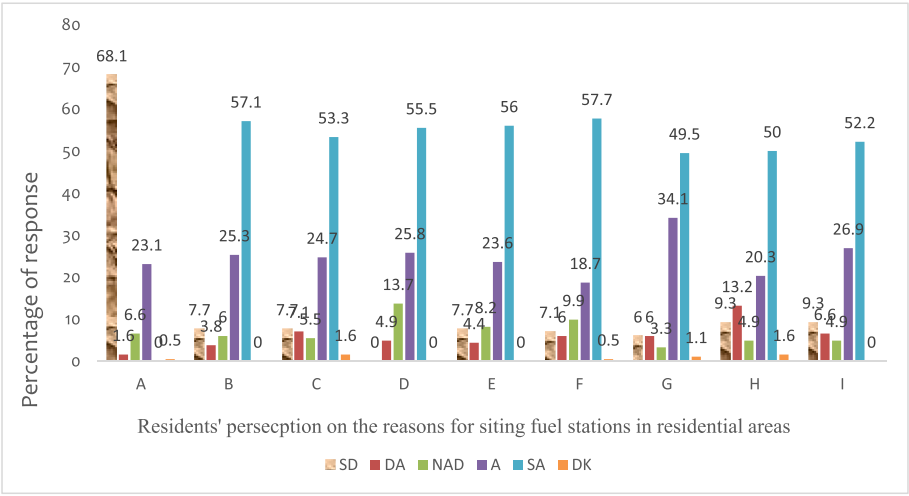

Fig. 2. Reasons for Siting Fuel Stations in Residential Areas. **Note:** A **(**Fuel stations are sited in residential areas after EPA reports have been approved). B (Fuel stations are sited in residential areas because of easy accessibility). C (Fuel stations are sited in residential areas to enhance competition). D (Fuel stations are sited in residential areas to create jobs). E (Fuel stations are sited in residential areas because of the nature of the land). F (Fuel stations are sited in residential areas because of location preference). G (Fuel stations are sited in residential areas due to profit maximisation). H (Fuel stations are sited in residential areas because of business potentials). I (Fuel stations are sited in residential areas because of the heavily travelled street(s)).

> *constructing a fuel station in a residential area. If the people (state agencies) have the power to make sure that filling stations are sited at the appropriate places and allow them to put them where people live, then who am I to question the contractor or the owner?* (Interview with a resident, 8th September 2022).

Those participants who tried to inquire indicated they contacted the Municipal Assembly, landowners, and owners of the fuel stations during the initial stages of the construction. However, the responses from these individuals and the Assembly yielded little positive results. A resident intimated that; "I and some other people from this area went to the Assembly Member to complain about it and he said he would investigate the matter and get back to us, but we did not hear from him again" (Interview with a tenant, September 9, 2022). Supporting the claim, another resident said.

> *When I noticed that a fuel station was being constructed close to my house, I went to the Assembly to report the matter, but I did not get a positive response from them. So, I stopped wasting my time going there to complain* (Interview with a resident, 9th September 2022)

Although efforts were made to engage the relevant state agencies regarding the siting of fuel stations close to some residential and

Fig. 3. Some fuel stations in residential areas.

commercial buildings, responses were not forthcoming, compelling the residents to live with the fire hazard (see Fig. 3).

5.3. Residents' perceptions on fuel stations' fire disaster risks

The analysis in this section focuses on the residents' perspectives on the probability of fire disasters occurring and their severity since the research participants rated the probability of fire disaster risk associated with living and working near fuel stations as catastrophic. Almost all of them (98.9 %) were aware of the fire disaster risk they were exposed to because of their nearness to fuel stations. Because of this, we ascertained their perception of the likelihood of a fire disaster occurring at the fuel stations. A large proportion (45.6 %) of them rated the probability of fire disaster risk occurring as occasional, while 9.3 % each rated the likelihood of a fire occurring as probable and frequent respectively. More females indicated that fire disaster occurrence was a remote probability than males. However, more males indicated it as an occasional probability than females. A chi-square test revealed that there is no significant association between gender and the perception of the likelihood of fire disasters occurring at fuel stations. However, more of those who have attained tertiary education indicated the frequent likelihood of fire disasters occurring at fuel stations (18.5 %). In comparison, more living/working in wooden structures indicated the likelihood as probable (11.1 %). A statistically significant association exists between education level, housing type of resident, age, duration of stay, and residents' perception of the likelihood of fire disasters occurring at the fuel stations (see Table 2). The finding does not fully support the null hypothesis that no statistically significant association exists between residents' sociodemographic characteristics and perception of the likelihood of fuel stations' fire disasters.

In terms of perception of the severity of the disaster in the event of a fire at the fuel stations, most of the respondents (50.5 %) rated the severity of the disaster risk of staying and/or living near fuel stations as catastrophic. In comparison, only a small proportion (4.4 %) indicated no risk. Others also rated the severity of the risk as critical, marginal, and negligible. A similar trend of rating the severity of the disaster risk could be observed based on the sociodemographic variables, although the proportion varies across the ratings.

Table 2
Perceptions of the likelihood of fire occurrence.

Gender	Probability of fire disaster occurring					Total
	Improbable	Remote	Occasional	Probable	Frequent	
Male	15 (12.2 %)	27 (22.0 %)	59 (48.0 %)	13 (10.6 %)	9 (7.3 %)	123 (100 %)
Female	18 (13.6 %)	15 (25.4 %)	24 (40.7 %)	4 (6.8 %)	8 (13.6 %)	59 (100 %)
Total	23 (12.6 %)	42 (23.1 %)	83 (45.6 %)	17 (9.3 %)	17 (9.3 %)	182 (100 %)
$\chi^2 = 3.008$, df = 4, p-value = 0.556						
Education						
Basic	4 (12.5 %)	8 (25.0 %)	12 (37.5 %)	5 (15.6 %)	3 (9.4 %)	32 (100 %)
No formal education	3 (10.7 %)	6 (21.4 %)	18 (64.3 %)	1 (3.6 %)	0 (0.0 %)	28 (100 %)
Secondary/Technical	12 (17.6 %)	14 (20.6 %)	35 (51.5 %)	3 (4.4 %)	4 (5.9 %)	68 (100 %)
Tertiary	4 (7.4 %)	14 (25.9 %)	18 (33.3 %)	8 (14.8 %)	10 (18.5 %)	54 (100 %)
Total	23 (12.6 %)	42 (23.1 %)	83 (45.6 %)	17 (9.3 %)	17 (9.3 %)	182 (100 %)
$\chi^2 = 22.166$, df = 12, p-value = 0.036						
Housing type						
Cement block house	16 (13.6 %)	31 (26.3 %)	51 (43.2 %)	11 (9.3 %)	9 (7.6 %)	118 (100 %)
Mud house	3 (10.7 %)	4 (14.3 %)	15 (53.6 %)	2 (7.1 %)	4 (14.3 %)	28 (100 %)
Wood/metal structure	4 (11.1 %)	7 (19.4 %)	17 (47.2 %)	4 (11.1 %)	4 (11.1 %)	36 (100 %)
Total	23 (12.6 %)	42 (23.1 %)	83 (45.6 %)	17 (9.3 %)	17 (9.3 %)	182 (100 %)
$\chi^2 = 364.0$, df = 23, p-value = 0.000						
Age (in years)						
20–30	8 (15.4 %)	12 (23.1 %)	23 (44.2 %)	5 (9.6 %)	4 (7.7 %)	52 (100 %)
31–40	5 (7.6 %)	15 (22.7 %)	21 (31.8 %)	12 (18.2 %)	13 (19.7 %)	66 (100 %)
41–50	8 (17.4 %)	15 (32.6 %)	23 (50.0 %)	0 (0.0 %)	0 (0.0 %)	46 (100 %)
50–60	2 (11.8 %)	0 (0.0 %)	15 (88.2 %)	0 (0.0 %)	0 (0.0 %)	17 (100 %)
60+	0 (0.0 %)	0 (0.0 %)	1 (100 %)	0 (0.0 %)	0 (0.0 %)	1 (100 %)
Total	23 (12.6 %)	42 (23.1 %)	83 (45.6 %)	17 (19.3 %)	17 (9.3 %)	182 (100 %)
$\chi^2 = 44.182$, df = 16, p-value = 0.000						
Resident stay duration (years)						
1–5	14 (16.1 %)	23 (16.4 %)	36 (41.4 %)	11 (12.6 %)	3 (3.4 %)	87 (100 %)
6–10	5 (9.1 %)	13 (23.6 %)	22 (40.0 %)	4 (7.3 %)	11 (20.0)	55 (100 %)
11–15	3 (21.4 %)	2 (14.3 %)	6 (42.9 %)	1 (7.1 %)	2 (14.3 %)	14 (100 %)
16+	1 (3.8 %)	4 (15.4 %)	19 (73.1 %)	1 (3.8 %)	1 (3.8 %)	26 (100 %)
Total	23 (12.6 %)	42 (23.1 %)	83 (45.6 %)	17 (9.3)	17 (9.3 %)	182 (100 %)
$\chi^2 = 23.741$, df = 12, p-value = 0.022						

Note: Frequent (likely to occur often), probable (likely to occur several times), occasional (likely to occur sometimes), remote (unlikely but possible), and improbable (so unlikely, it can be assumed).

However, more females indicated that it could be catastrophic (50.8 %) than males, while more of those living in cement block houses (53.4 %) rated the severity of a fire disaster as catastrophic.

A chi-square test revealed there is no statistically significant association between the perception of the severity of fuel station fire disaster and the sociodemographic characteristics of residents (See Table 3). The findings support the null hypothesis that there is no statistically significant association between residents' sociodemographic characteristics and perception of the severity of a fire disaster.

5.4. Residents' perceptions of safety behaviours near fuel stations

Residents' perception of fire safety behaviours was also examined. Most respondents (64.8 %) did not receive any education on safety practices and behaviours to reduce their vulnerability to the fire disaster risk linked to fuel stations—those who had knowledge acquired it through personal experiences, television, and friends. The knowledge could help the residents reduce their vulnerability to fire and explosion disaster risks associated with living or working near fuel stations. However, the findings showed that the knowledge was not translated into investment in acquiring fire safety equipment and measures. As shown in Table 4, most of them (71.9 %) had no fire extinguishers at homes or their business centres. Similar results were observed for smoke detectors, fire emergency escape plans, and emergency exit routes.

However, a small proportion of households and business establishments indicated they have these equipment and measures on their premises. As regards fire extinguishers, for example, only 28 % of the respondents indicated that they have them at their premises as part of fire safety measures (Fig. 4). In comparison, 16.5 % had smoke detectors at their premises.

However, a large proportion (45.7 %) of them knew the fire emergency contact number that they could use to alert the GNFS in case of a fire outbreak. The finding was corroborated by a resident who underscored the importance of knowing fire emergency contact

Table 3
Participants' perceptions of fire disaster severity.

Gender	Severity of fire disaster risk					Total
	Catastrophic	Critical	Marginal	Negligible	No risk	
Male	62(50.4 %)	24 (19.5 %)	19 (15.4 %)	10 (8.1 %)	8 (6.5 %)	123 (100.0 %)
Female	30 (50.8 %)	14 (23.7 %)	14 (23.7 %)	1 (1.7 %)	0 (0.0 %)	59 (100.0 %)
Total	92 (50.5 %)	38 (20.9 %)	33 (18.1 %)	11 (6.0 %)	8 (4.4 %)	182 (100.0 %)
$\chi^2 = 8.419$, df = 4, p-value = 0.077						
Education						
Basic	15 (46.9 %)	10 (31.3 %)	3 (9.4 %)	0 (0.0 %)	4 (12.5 %)	32 (100 %)
No formal education	12 (42.9 %)	6 (21.4 %)	7 (25.0 %)	3 (10.7 %)	0 (0.0 %)	28 (100 %)
Secondary/technical	38 (55.9 %)	11 (16.2 %)	10 (14.7 %)	6 (8.8 %)	3 (4.4 %)	68 (100 %)
Tertiary	27 (50.0 %)	11 (20.4 %)	13 (24.1 %)	2 (3.7 %)	1 (1.9 %)	54 (100 %)
Total	92 (50.5 %)	38 (20.9 %)	33 (18.1 %)	11 (6.0 %)	8 (4.4 %)	182 (100 %)
$\chi^2 = 17.862$, df = 12, p-value = 0.120						
Housing type						
Cement block house	63 (53.4 %)	21 (17.8 %)	23 (19.5 %)	6 (5.1 %)	5 (4.2 %)	118 (100 %)
Mud house	13 (46.4 %)	7 (25.0 %)	5 (17.9 %)	2 (7.1 %)	1 (3.6 %)	28 (100 %)
Wood/metal structure	16 (44.4 %)	10 (27.8 %)	5 (13.9 %)	3 (8.3 %)	2 (5.6 %)	36 (100 %)
Total	92 (50.5 %)	38 (20.9 %)	33 (18.1 %)	11 (6.0 %)	8 (4.4 %)	182 (100 %)
$\chi^2 = 3.320$, df = 8, p-value = 0.913						
Age (in years)						
20–30	29 (55.8 %)	11 (21.2 %)	7 (13.5 %)	3 (5.8 %)	2 (3.8 %)	52 (100 %)
31–40	31 (47.0 %)	16 (24.2 %)	12 (18.2 %)	4 (6.1 %)	3 (4.5 %)	66 (100 %)
41–50	22 (47.8 %)	7 (15.2 %)	11 (23.9 %)	3 (6.5 %)	3 (6.5 %)	46 (100 %)
50–60	10 (58.8 %)	3 (17.6 %)	3 (17.6 %)	1 (5.9 %)	0 (0.0 %)	17 (100 %)
60+	0 (0.0 %)	1 (100 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	1 (100 %)
Total	92 (50.0 %)	38 (20.9 %_	33 (18.1 %)	11 (6.0 %)	8 (4.4 %)	182 (100 %)
$\chi^2 = 8.445$, df = 6, p-value = 0.934						
Resident stay duration (years)						
1–5	45 (51.7 %)	19 (21.8 %)	12 (13.8 %)	5 (5.7 %)	6 (6.9 %)	87 (100 %)
6–10	24 (43.6 %)	14 (25.5 %)	14 (25.5 %)	2 (3.6 %)	1 (1.8 %)	55 (100 %)
11–15	10 (71.4 %)	1 (7.1 %)	1 (7.1 %)	2 (14.3 %)	0 (0.0 %)	14 (100 %)
16+	13 (50.0 %)	4 (15.4 %)	6 (23.1 %)	2 (7.7 %)	1 (3.8 %)	26 (100 %)
Total	92 (50.5 %)	38 (20.9 %)	33 (18.1 %)	11 (6.0 %)	8 (4.4 %)	182 (100 %)
$\chi^2 = 12.729$, df = 12, p-value = 0.389						

Note: The figures inside parentheses are the proportions while those outside the parentheses represent the absolute responses. Also, note that. Catastrophic (operating fuel stations near residential houses may cause major harm),Critical (operating fuel stations near residential houses may cause severe harm/injury) Marginal (operating fuel stations near residential houses may not lead to severe harm/injury) Negligible (operating fuel stations near residential houses may cause minor harm/injury) No risk (operating fuel stations near residential houses may result in no harm/injury).

Table 4
Availability of fire safety equipment and measures.

Variable	Category	N	%
Fire extinguisher	Available	51	28.0
	Not available	131	71.9
Smoke detector	Available	30	16.5
	Not available	152	83.5
Fire escape plan	Available	58	31.9
	Not available	124	68.1
Emergency exit	Available	45	24.7
	Not available	137	75.3
Fire safety training	Available	36	18.7
	Not available	148	81.3
Windows open easily	Available	67	14.8
	Not available	115	85.2
Emergency phone contact number	Available	83	45.6
	Not available	99	54.4
Fire prevention investment	Available	43	23.6
	Not available	139	76.4

when he stated:

> *Everyone or property owners should know the fire emergency telephone number to easily call the fire service in the event of an outbreak. I have saved it on my phone and have written it on the walls of my room and at the entrance of my house so that if there is a fire emergency, anyone can contact the GNFS for assistance* (Interview with a resident, 20th September 2022).

Fire emergency contact information is essential for everyone, homes, and institutions, so that the GNFS can be contacted about the situation when a fire breaks out. Therefore, the point-of-contact information about the GNFS should be placed at vantage points so that anybody can easily contact the GNFS for help when the need arises.

The respondents' perspectives were sought concerning fire safety behaviours near fuel stations (fireworks, gas equipment, lighting matches, burning trash, protecting fireplaces, keeping fire escape routes clear, and adhering to planning and building guidelines). This was done using a five-point Likert scale. From the results (see Table 5), a significant proportion of the research participants (54.9 %) strongly agreed that avoiding fireworks near fuel stations reduces fire disaster risk. Most of the respondents (53.8 %) also strongly agreed with the claim that being careful with the use of gas equipment near fuel stations could reduce fire disaster risk. The 58.8 % each were recorded for not lighting matches near a fuel station, protecting fireplaces with screens, and adhering to and complying with planning and building guidelines, respectively, as safety behaviours that could reduce the occurrence of fire at fuel stations.

On the other hand, 65.4 % of the research respondents strongly agreed that not burning trash or other items near fuel stations reduces fire disaster risk. Furthermore, 54.9 % of the research participants agreed that keeping all escape routes and fire exits clear and making regular checks reduces fire disaster risk near fuel stations.

The perception of and adoption of appropriate fire safety behaviours by the people living and/or working close to fuel stations could prevent future occurrences of fire and explosion. In support of this assertion, a resident intimated.

> *I was here before the fuel station was put up. Because I could not stop the construction, I don't light matches when I am close to the fuel station. I also ensure people don't burn trash and other items outside or near the fuel station. This way, I am assured that if other people*

Fig. 4. A fire extinguisher at business premises near a fuel station.

Table 5
Residents' perceptions of fire safety behaviours.

Perspectives on fire safety behaviour	Strongly disagree	Disagreed	Neither agree nor disagree	Agreed	Strongly agreed	Don't know
A	16(8.8 %)	14 (7.7 %)	12 (6.6 %)	40 (22.0 %)	100 (54.9 %)	0 (0.0 %)
B	11 (6.0 %)	15 (8.2 %)	10 (5.5 %)	48 (26.4 %)	98 (53.8 %)	0 (0.0 %)
C	10 (5.5 %)	7 (3.8 %)	13 (7.1 %)	45 (24.7 %)	107 (58.8)	0 (0.0 %)
D	8 (4.4 %)	6 (3.3 %)	6 (3.3 %)	43 (23.6 %)	119 (65.4 %)	0 (0.0 %)
E	5 (2.7 %)	9 (4.9 %)	10 (5.5 %)	49 (26.9 %)	107 (58.8 %)	0 (0.0 %)
F	6 (3.3 %)	12 (6.6 %)	17 (9.3 %)	46 (25.3 %)	100 (54.9 %)	1 (0.5 %)
G	6 (3.3 %)	12 (6.6 %)	9 (4.9 %)	48 (26.4 %)	107 (58.8 %)	0 (0.5 %)

Note: A (Avoiding fireworks near fuel stations reduces disaster risk) B (Being careful with the use of gas equipment near fuel stations) C (Not lighting a match near fuel stations reduces the risk of disaster) D (Not burning trash or other items near the fuel station reduces the disaster risk) E (Protecting fireplaces with screens reduces the disaster risk) F (Keeping all escape routes and fire exits clear and making regular checks reduces disaster risk) G (Adhering to and complying with planning and building guidelines to reduce fire disaster risk).

> *living and/ or working near the fuel stations adopt similar measures, we can reduce fire and explosion risk as well as reduce our vulnerability* (Interview with a resident, 12th September 2022)

Therefore, people's awareness of their responsibilities regarding fire safety is of the utmost importance in reducing their susceptibility to fire emergencies, especially those associated with fuel stations in dense residential areas.

6. Discussion

Discussions around fire disaster risk associated with fuel stations often revolve around the frequency and severity of hazards, the number of people and properties exposed, and vulnerability to potential damage. A starting point of our research was to answer the question concerning the reasons for siting fuel stations in residential areas, followed by the risk perceptions, and ended with the safety behaviours of residents residing or working close to them. Addressing these issues from the residents' point of view is vital because they are the potential victims of fire disasters at fuel stations. Their perceptions of fire disaster risks in fuel stations are relevant in fashioning national and local actions to reduce their vulnerability. Most residents believed that the appropriate approvals were not obtained before the construction of fuel stations in residential areas. The finding demonstrates that some residents were not involved in the processes leading to the establishment of fuel stations in residential areas as required by NPA and EPA. Therefore, the residents and their properties were exposed to fire disaster risks linked to fuel stations [12,13]. The results highlighted the need to involve residents and educate them on fire disaster risks linked to fuel stations. This could help residents to appraise and take appropriate actions to lessen their vulnerability to fire disasters that may occur at fuel stations [5,28,31,40].

Being aware of the fire disaster risks linked to residing or working close to fuel stations could be because fuel stations store large quantities of petrol and diesel that emit flammable vapours into the air that can detonate when in contact with fire, heat, or light [13]. Although the officials from EPA, NPA, and LUSPA indicated that residents were consulted before permits were granted for the siting of fuel stations in residential areas, there appears to be no broader consultation in the processes. Meanwhile, more residents' involvement could have aided an adequate evaluation of the dangers of residing close to fuel stations with remedial measures that could reduce fire disasters [16]. Also, the people's perception of the likelihood of fire and explosion risk demonstrates their awareness of the dangers of fuel stations which contrasts with the results reported by Ref. [14]. People's awareness of fire disaster risks may encourage them to take appropriate measures to reduce their vulnerability [29,30]. According to the respondents, the probability of fire disaster risk occurring was occasional, while the likelihood of fire disaster striking was ranked as probable. This perception could make them apathetic to taking precautionary measures to reduce their vulnerability to fire disasters at fuel stations [25,26,53]. However, residents' sociodemographic characteristics were significantly associated with their perception of the likelihood of fire disasters occurring at fuel stations.

Most of the research participants perceived the severity of fire disaster risks as catastrophic. This notion is perhaps influenced by the 2015 flood and fire disaster that killed several people and destroyed properties in Accra, Ghana. This supports the propositions of the PMT that events elsewhere could influence people's perceptions about an issue that confronts them [25]. We found that residents did not have the requisite equipment or had not put in place the precautionary measures to shield them from the consequences of fire disasters. However, the work of [20] shows that investment in equipment, such as fire extinguishers, smoke detectors, fire alarms, and sand could help people take urgent actions during a fire emergency. The absence of equipment and measures put in place at homes and business centres suggests that residents may not respond adequately to fire disasters at the fuel stations. However, a large proportion of the residents know the contact numbers of the fire service department which they can call in case of an emergency. The finding is in line with the observation of [20].

7. Theoretical implications and practical applications of the findings

From the findings, two implications can be drawn concerning the RPT and PMT theories. Firstly, the (RPT) proposition that individuals perform an action based on clues, the interpretation of the situation, and the signals [25] and then decide what to do to insulate themselves from the consequences of an event such as fire was not upheld by the findings. This is because the views held by the

residents regarding fire disaster risk linked to fuel stations were separate from those regarding the probability of fire disasters occurring at fuel stations. However, the axiom that people's perceptions about a phenomenon may be influenced by events elsewhere [26] holds with our findings. The agreement with the theory is reflected in their judgment of the severity of the fire disaster at fuel stations as catastrophic, signalling that in the event of a fire, they foresee colossal human and economic losses.

Secondly, the findings disconfirmed the proposition of PMT that people's appraisal of the severity of an event and the coping measures available to them influence their responses to a perceived threat [28,29]. This is because the perceived severity of the fire disaster as catastrophic did not translate into measures and investments to reduce their vulnerability. This may challenge state agencies in their quest to encourage residents to undertake protective measures and invest in appropriate equipment to reduce their vulnerability to fire disaster risks at fuel stations. This attitude puts their safety and that of their properties in jeopardy.

The practical applications are closely related to the theoretical implications of the findings. Firstly, the siting of fuel stations in residential areas requires broader consultation and rigorous evaluation of the unique fire risks they pose to residents. Secondly, avoiding fire-related activities near fuel stations can reduce fire disaster risks. It is, therefore, imperative for the EPA, LUSPA, GNFS, and NPA to carry out a rigorous evaluation of sites and conduct proper environmental impact assessments as well as provide adequate training and education on fire safety behaviours for residents near fuel stations as part of the measures to reduce fire disasters linked to fuel stations, especially in dense residential areas in cities.

8. Conclusion and policy implications

The proliferation of fuel stations in residential areas poses significant fire disaster risks. The research recognises that fuel stations are established within the context of poor planning, non-regulation enforcement, and weak evaluation of fuel station projects in residential areas. The research also reorganises that fuel stations, especially those in residential areas, need to comply with the regulatory standards provided by the relevant state agencies. The focus of this research, therefore, was to elicit the perception of residents on fire disaster risks and safety behaviours so that appropriate recommendations gleaned could find their way into policies, regulations, guidelines, and local-level actions to avert fire outbreaks that could cause widespread social, economic, and environmental losses. Although most of the residents were at the various locations before the establishment of the fuel stations, they appear not to have been involved or consulted, which further worsens their plight as potential victims of fire disasters. This informed the view that permits were granted after the establishment of fuel stations in the residential areas. Residents believed that there were severe fire disaster risks at the fuel stations. This viewpoint demonstrates that fire disasters at fuel stations could lead to huge human, economic, and environmental losses that could exceed the capacity of the residents to handle. Because of this, one would have thought that residents would invest in equipment and take precautionary measures to reduce their vulnerability to fire disasters. However, only a small proportion of them invested and took measures to reduce their vulnerability to fire disasters linked to their nearness to fuel stations.

To reduce fire disasters occurring at fuel stations, we recommend that the relevant state agencies, NPA, EPA, National Disaster Management Organisation, and the GNFS must inform residents and/or consult with residents before setting up fuel stations, especially those in dense residential areas. Broadening the consulting would allow more residents to express their concerns while the authorities design appropriate local actions to address the concerns. We also recommend that residents be encouraged to invest in fire extinguishing equipment and adhere to fire safety behaviours at both household and immediate environment levels. Investing in fire equipment and measures will help them reduce the risk of fire disasters linked to fuel stations in residential areas. Furthermore, policies, regulations, and guidelines must be strictly enforced so that fuel stations comply with them in their establishment and operations. Finally, we recommend policy and regulatory reforms to make it mandatory for the owners of such fuel stations to sponsor the education of residents on the appropriate safety behaviours to help avert fire disasters at fuel stations, especially those located in residential areas.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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