

MARKET ACCESSIBILITY, REGULATORY GOVERNANCE, AND PUBLIC-SAFETY RISKS AROUND PETROL FILLING STATIONS IN KEFFI, NIGERIA

KEYWORDS

Petrol Filling Stations, Location Choice, Risk Perception, Environmental Pollution, Regulatory Governance.

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ABSTRACT

Petrol filling stations contribute to urban transportation but generate land-use conflicts when commercial locations are poorly linked to safety and pollution controls. This research investigated location factors, hazard perceptions, and preferred risk-control measures among stakeholders in Keffi Local Government Area, Nigeria. It used a cross-sectional mixed method involving interviews with petroleum marketers and town planners and structured interviews with 382 respondents, with field observation, and informal interviews of marketers with respondents (in their vehicles). Structured interviews asked a series of open-ended questions with multiple responses. Interview respondents included station attendants, passengers or drivers, station managers, regulators, medical or teaching personnel, and residents or other community members. Descriptive frequencies and percentages, with multiple responses permitted, were used, and location factors with multiple responses were identified by cross-tabulation. Locations were associated with traffic flow, exit-road access, adjacency to motor parks and junctions, and vehicle entry and departure ease. Out of 43 inventoried stations, 26 sat along three major exit routes, 19 near motor parks, and 27 in convenient locations for station users. Environmental pollution (51.8%) was most often cited, followed by atmospheric pollution (45.0%), accidents (32.5%), and fire or explosion (25.1%) effects. Appropriate measures included fire-fighting equipment (64.4%), prevention of leakage (55.5%), improved enforcement of planning regulations (51.8%), and routine safety inspections (46.1%). The study highlighted underlying tensions between market-centered accessibility goals and precautionary city planning objectives, as well as a preference for both local control measures and an emphasis on the role of institutions. The author recommends integrated authorization, routine risk-based safety inspections, accident and risk management planning, community notification mechanisms, and station relocation or modification. Because the Master thesis does not report the results of a completed inferential test, the study should be viewed as an exploration of perceptions and observed associations rather than a causal analysis.

I. INTRODUCTION

The siting of petrol filling stations balances a continual trade-off between potential accessibility and safety. Operators wish to locate in high levels of passing traffic, visibility, easy access and near to flow of transport while countervailing aspirations of regulators and urban planners are to safeguard people's safety and protect from passing traffic, local properties, schools and healthcare facilities, capacity of the road network, the quality of the environment and ease of access to emergency services. Where the commercial incentives to site change are poorly balanced the competitive attributes of sales growth that they provide can simultaneously exacerbate land-use conflicts and public exposure.

This tension especially manifests in Nigerian secondary cities that are in intensive corridor development, as major road alignments are "littered with residences, commercial buildings, institutions, motor parks, and petrol stations, often before infrastructure and effective planning capacity have developed" (Nigerian Secondary Cities Programme, 2016: 33). During fuel shortages, vehicle queues can snake into carriageways, and tanker trucks queuing to deliver can disrupt otherwise normal transportation flows; fuel handling can emit toxic compounds, and spillage can contaminate ground or groundwater. According to World Health Organization (2019), the inhalation of benzene (a constituent of petrol) is a path of exposure to suspected or confirmed carcinogenic activity [which] had been identified as a major health concern. These hazardous effects, none of which claim to be universal, necessitate some degree of caution in siting, upkeep, monitoring, and response planning.

As a result of new regulations introduced by the Petroleum Industry Act 2021, Nigeria created the NMDPRA as the regulator of midstream and downstream oil and gas activities; however, planning permission and land use control are still local issues. According to Ambituuni et al. (2014, p.22), downstream petroleum safety is influenced by institutional fragmentation and implementation gaps; thus, comprehension of the operators and affected stakeholders perception on location choice, risks and mitigation priorities can enhance compliance on such technical audits.

The parent thesis focused on fuel-station location and public safety in Keffi Local Government Area. In order not to repeat its companion geospatial paper, this article considers three social-institutional issues: what social factors shape station-location decisions; which of these safety and environmental consequences were most frequently expressed by the stakeholders? And which risk reduction and governance efforts received the strongest backing? This article does not aspire to design the exposure to the toxics or health outcomes. It analyses stakeholder experience as data for risk governance and planning intervention.

II. LITERATURE REVIEW

Access to the Market and Location Choice

Classical location theories focus on market range, transport cost, accessibility and demand threshold. Central Place Theory, for example, addresses the spatial distribution of services in relation to the demand for that service and its range (Christaller, 1966). Land-use theory, on the other hand, concentrates on competition for easily accessible sites within the city (Alonso, 1964). Petrol stations are highly road-dependent services: the market for a petrol station is –or at least should be– influenced by the volume of traffic using the road in question, and in which direction the traffic flows, by the visibility enjoyed by the site, by the geometry of access to the site, by the continuity of the route, and by how easily a driver can leave and then re-join the road.

These market pressures can induce linear agglomeration. Spared the trouble of analysis, individual operators will independently choose the same lines drawing upon the identical traffic and business signals. But individually rational selection can still lead to collectively inefficient spatial patterns with over-dense combinations of driveways, redundant service areas, congested facilities, and heightened caution within proximity of sensitive areas. In contemporary facility-location analysis, suitability is therefore approached as a multi-criteria issue, not just a market-access issue (Farahani, et al., 2010). Safety, conformity with environmental constraints, emergency access, and cumulative corridor capacity must now join profitability.

Public-Safety and Environmental Pathways

Risks related to fuel-station activities can be organized into acute and chronic pathways. Acute pathways include fire, equipment failure, collisions, tanker incidents, and obstruction of emergency access. Chronic pathways include fumes or vapour hazards, traffic-related air pollution,

noise, contaminated soil and groundwater, and on-going congestion. Benzene is especially worrying because it has directly been linked to haematological effects and cancer (WHO, 2019). Petroleum hydrocarbons may additionally leach through the soil profile and affect ground waters, depending on tank condition, geology, fate and transport, drainage and remediation measures.

Risks perceived are not the same as the measured risks. Odour, visible spillage, duration of queuing, and previous experience may lead residents to see some hazards, while the operator may concentrate on monitoring - compliance with equipment, and the use of operational controls. Risk-perception work reveals that judgements are reduced to experience, perceived control, institutional strength, familiarity and damage potential. A good study should take responses to the questionnaire as reflecting stakeholder perception, unless linked to monitoring results, administrative data on incidents, or epidemiology.

Regulations, Enforcement and Safety Culture

Formal regulation is one aspect of safety. Institutional capacity determines whether approvals are timely coordinated, whether inspections are frequent, whether sanctions are credible, whether records are up-to-date. (North, 1990). Ambituuni et al. (2014) found that Nigeria's downstream petroleum safety & environmental regulation has long-established shortcomings. Overlapping mandates may promote reactive rather than preventive enforcement, especially after incidents, rather than screening of proposed sites and cumulative corridor impacts.

At the site level, the components of safety culture are leak prevention, equipment standards, employee training, readily available fire-fighting equipment, emergency shut-down equipment, escape procedures, accident recording, and interface with fire and health services. The concept of the "hierarchy of controls" suggests that safest siting and engineering is normally more reliable than behaviour-only or emergency response only. Consumers' education and training, for all its usefulness, should be used to supplement not replace safe design, inspection and enforcement.

Evidence Gap and Analytical Suggestion

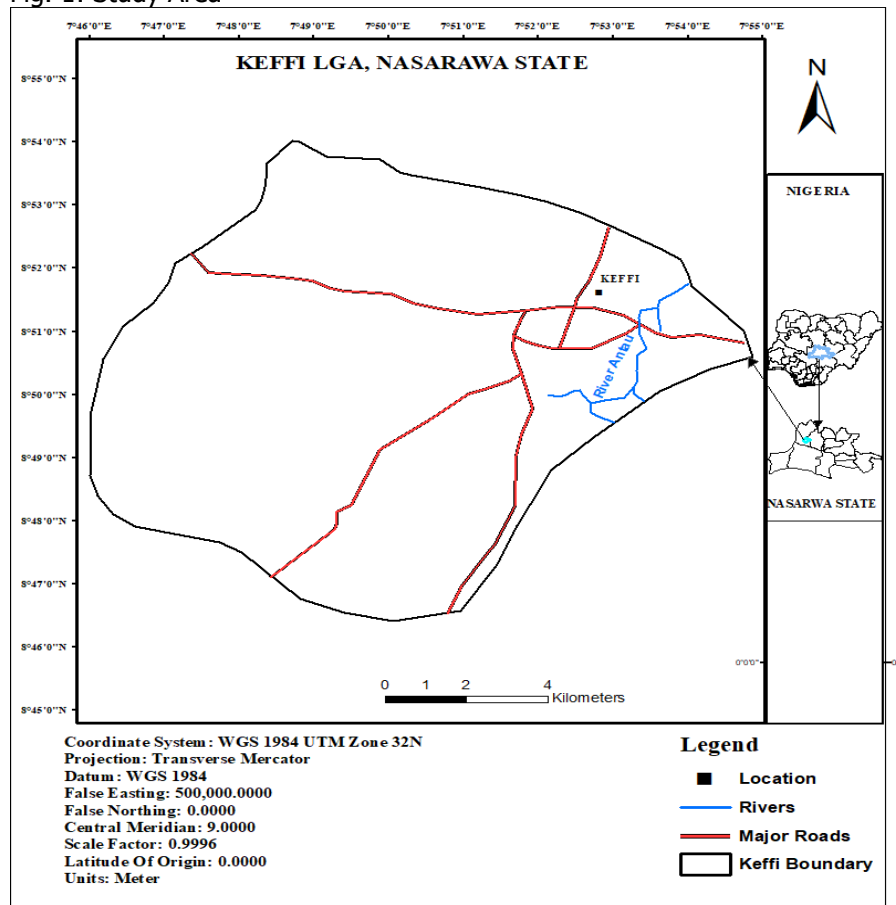
Most station studies focus on the GIS buffers or the technical standards. Even fewer establish a link between the rationality of commercial site selection and the subjective risks perceived by workers, road users, residents and regulators. Knowing the link matters, because mitigation will have failed if it does not accommodate operators' 'horizontal' accessibility aspirations or community 'virtual' exposure. This study's analytical hypothesis is that market-led corridor choice will generate 'externalised' traffic, environmental and emergency risks if institutional controls do not 'internalise' those costs through planning conditions, infrastructure standards, rigorous inspection and, if necessary, displacement.

III. MATERIALS AND METHODS

Study Setting and Design

Keffi is a small secondary town in Nasarawa State, Northern central Nigeria, 57 km from the capital, Abuja (see figure1). Because of its position at the border to the Federal capital territory and the neighboring North-central settlements, Keffi attracts through traffic between the urban and the rural areas and also intensive intra-urban movements. This research used a cross sectional, mixed method2design consisting of a structured household questionnaire survey, field observation and key-informant interviews.

Fig. 1: Study Area



Source: Authors Analysis, (2025)

Population, Sample, and Respondent Groups

Calculations forecasted Keffi population of about 140,000 and 382 respondents were chosen based on stratified samples according to the Krejcie and Morgan method. Samples reflecting variability of burden or regulation were pump attendants, station drivers, station managers, Petroleum regulatory authority officers, Urban-development officials, teacher/Nursing and Medical personnel, residents close to stations and other respondents. Unstructured interviews were held with representatives of the Independent Petroleum Marketers Association of Nigeria and the Nasarawa Urban Development Board.

No indication of the response rate obtained, strata-specific sampling frames, reliability coefficient of the questionnaire, ethics-approval number or item level non-response was given. These should be sought from field records prior to submission.

Measures and Analysis

Respondents' occupation, causes of negative impacts, fire-protection measures preferred and protection measures suggested to reduce future hazards were documented with the questionnaire. During interviews and field observations, location selection factors, which were noted as the most common, were traffic movement, exit roads, location near motor parks, convenience, nodal or junction location.

Analysis was descriptive (counts and percentages). Questions on hazards and mitigation permitted multiple responses and their percentages are therefore not mutually exclusive and sum to more than 100%. The parent thesis states a hypothesis that stations close to residences cause more accidents or injuries but provides no statistical testing, effect estimate, confidence interval or model. The article does not claim the hypothesis was supported. Causal inference would require a defined measure of exposure, geocoded incident data, temporality, and traffic and population at risk adjustments.

IV. RESULTS

Characteristics of respondents/ respondents profile.

The occupation categories were dominated by who working at the petrol pumps (24.1%) residents (20.4%) and the drivers (14.1%). Regulatory and planning respondents (8.0%) were included to bring an institutional perspective to data from workers and exposed community members.

Table 1. Occupational distribution of respondents

Occupational group	Frequency	Percentage (%)
Pump attendants	92	24.1
Drivers	54	14.1
Fuel-station managers	38	9.9
Petroleum regulatory officials	16	4.2
Regulatory agency/urban-development officials	22	5.8
Teachers/medical personnel	44	11.5
Residents	78	20.4
Others	38	9.9
Total	382	100.0

Source: Field Survey (2026)

Factors Influencing Station Location

Both stakeholder interviews and the station inventory highlighted five common locational drivers (see Table 2). Traffic flow was frequently cited as an important factor as it increases the possible customer pool when there is continuous movement of vehicles. Exit roads also attracted attention as many interurban drivers refueled prior to departing Keffi. 26 of 43 stations inventoried were along these corridors: Abuja-Keffi, Keffi-Akwanga and the Nasarawa Bypass.

Motor-park nearness was also a market element; 19 stations were located near motor-park axes. Ease of access in and out was another market element, categorized for the thesis as "convenient" location, at 27 stations. Junctions and peri-urban nodes attracted stations because they collect movements from different, dispersed origins. This source does not indicate a scored ranking nor regression model for these, so they are rolled up as observed qualitative recurring factors and inventory.

Table 2. Reported station-location drivers and supporting evidence

Location driver	Commercial rationale	Evidence reported in thesis
High traffic flow	Larger and more continuous customer base	Recurrent stakeholder explanation; no separate count
Exit-road location	Captures interurban vehicles before departure	26 stations on three principal exit corridors
Proximity to motor parks	Access to commercial and intercity vehicles	19 stations reported near motor parks
Convenient access	Easier entry, refuelling, and return to traffic	27 stations in locations described as convenient
Junction or nodal location	Aggregates demand from several routes	Qualitative finding; no separate count

Source: Field Inventory and Stakeholder Interviews (2026).

Perceived Negative Impacts

Environmental pollution was the most common negative effect reported by 51.8% of respondents. It was followed by atmospheric pollution (45.0%) and accidents (32.5%) and fires or explosions (25.1%) (Table 3). Respondents were concerned about both chronic environmental conditions and events with a lower frequency of occurrence.

Table 3. Reported causes or forms of negative impact

Impact	Frequency	Respondents selecting (%)
Environmental pollution	198	51.8
Atmospheric pollution	172	45.0
Accidents	124	32.5
Fire or explosion	96	25.1
Other impacts	38	9.9

Source: Field Survey (2026)

The questionnaire evidence does not produces pollutant levels, medically diagnosed end points or number of incidents. It can however provide an indication of the impacts that stakeholders experience or are concerned about, and direct the priorities for technical enquiry.

Place Priorities in Fire-Prevention and Hazard-Reduction

The third prevention measure most endorsed was the use of the fire-fighting devices (64.4%), the leakage prevention (55.5%) and the real-time warning devices (42.9%). Leaving the work place in the event of emergency was rated by 36.1% (Table 4).

Table 4. Preferred measures for preventing or limiting fire emergencies

Preventive measure	Frequency	Respondents selecting (%)
Use of fire-fighting devices	246	64.4
Leakage prevention	212	55.5
Real-time warning/alert systems	164	42.9
Evacuation of premises	138	36.1

Source: Field Survey (2026).

At the governance level, the most representative measures were the implementation of planning regulations (51.8%) and the regular safety inspection (46.1%). Improving public-awareness programmes (38.7%) and relocation of sub-optimally sited stations or emergency-response facilities etc. obtained a relatively high level of endorsement (Table 5).

Table 5. Suggested actions for reducing future filling-station hazards

Suggested action	Frequency	Respondents selecting (%)
Strict enforcement of planning regulations	198	51.8
Regular safety inspection	176	46.1
Public-safety awareness programmes	148	38.7
Relocation of poorly sited stations	124	32.5
Provision of emergency-response facilities	112	29.3

Source: Field Survey (2026)

V. DISCUSSION

Results indicate apparent market-accessibility logic. The magnitude of the taxi market may be greater by attracting high traffic flows, exits, motor parks, junctions and proximity accesses. This access logic explains the competing convergence among operators on those major corridors. It further reveals planning dilemma: a site may be both commercially efficient and a source of congestion, pollution or emergency hazards to other land-uses and road-users.

The dominance of the environment and atmospheric pollution in their responses indicates that routine circumstances are of comparable importance to communities to spectacular emergencies. Odours, emissions, spills, noise and congestion are seen occur on multiple occasions, possibly influencing views of managerial failure. Responses should prompt routine air-quality and soil or groundwater monitoring, at older stations and sites close to homes and sensitive institutions. But they should not be expressed as the measured clinical or environmental impacts. The WHO's evidence on benzene warrants caution; but local exposure should be proved through appropriate sampling and study design.

Accidents and fire/explosion were not chosen as often as pollution but are still significant because of their potential severity. Access points to stations along congested roads can create conflicts between entering vehicles, exiting vehicles, through traffic, bikes, pedestrians and roadside activity. This potential conflict might escalate in times of shortage when queues dominate the roads.

Therefore, need a strong response with traffic-impact assessment, access-management guidelines, queue-storage provision, tanker delivery standards and roadside obstruction enforcement.

Two of the mitigation measures that respondents plan to use are technical, (fire-fighting devices), and administrative, (leakage prevention). The others are administrative, (enforcement) and institutional, (inspection). Respondents seem to be using the right balance of measures, but the hierarchy of controls indicates that fire-fighting devices by themselves will not be enough. Leakage prevention, safe tank and dispenser systems, ignition source control, separation and incompatible sites are all preferable to controlling fires after they are started.

The rather limited choice of evacuation and emergency-response measures in use could suggest a somewhat reactive approach to safety or a lack of concern for safety issues; or it could imply a preoccupation with the provision of equipment. All stations need to have a emergency plan specific to the site, trained staff, clear display of the congregation scheme, clear of the exits; procedures for calling for help and coordinated fire drills. The petitioners and the community institutions need to be assured about how warnings will be sent not expected to respond to a technical failure.

High enforcement needs is an indicator of a trust/ accountability problem. Regulations can be relied on only if the approval conditions are known and clear, inspections are formally documented, penalties are predictable, and agency information is accessible to others. A permit platform based on coordinates would let regulators see where clusters, sensitive receptors, final inspection reports, and licensing status. Channels for broad public reporting could contribute local knowledge if complaints were corroborated and shielded from revenge or closing decisions from the regulator.

VI. PLANNING AND POLICY RECOMMENDATIONS

This study recommends six connected interventions. 1. Planning and petroleum regulators should develop an integrated pre-approval screening tool, addressing market access, streets and road safety, land use compatibility, interstation distance and emergency access. 2. Inspection programs should employ risk-based scheduling, focusing on old stations, dense station clusters, high traffic access points, complaint "hotspots" and areas proximate to sensitive land uses.

Station owners should carry out recordable integrity and servicing programmes of tanks, pipework, dispensers, electrical installation, drainage, spill controls, warning devices, fire-fighting equipment. 4. Roads authorities and planning agencies should mandate access-management plans for well-provisioned forecourts with sufficient queue-storage space, allowing safe tanker parking/manoeuvring, good pedestrian access.

Emergency response must not only ensure staff are trained and regularly drilled, emergency equipment is available, evacuation protocols are in place, communication is maintained and arrangements made with fire and health authorities. 6. Displacement should only be considered for sites at which issues cannot be satisfactorily mitigated by redesign, operational control or land use management, and such considerations be subject to well defined legal procedures.

VII. CONCLUSION

Fuel-station location in Keffi is determined primarily by market factors such as accessibility, notably traffic flow, exit roads, motor parks, ease of access and junctions. Stakeholders also indicate safety problems associated with pollution, accidents and fires, and support stronger engineering controls, enforcement and inspection. The fundamental policy dilemma is not to oppose accessibility, but to control it, allowing business activities to benefit from reliable access conditioned on safe access, land use compatibility, safety of facilities, environment quality and institutional accountability.

All evidence is perceptual and descriptive. Prior to submission, the questionnaire tool, ethics documentation, response rate, reliability test, and item-level data file should be scrutinized. All untested residential-proximity hypotheses should be eliminated or tested with geocoded incident and exposure data. Time-sensitive future studies should include CT-patient surveys and air-quality monitor readings, tank- and vehicle-occupancy integrity records, traffic-conflict studies, and spatially indexed fire- and collision-related data.

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