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Assessing the Spatial Distribution and Locational Impact of Fuel Service Stations: A Case Study of Kathmandu Metropolitan City

Rachita Subedi [a], Jagadish Chandra Pokharel [b]

[a, b] *Department of Architecture, Pulchowk Campus, IOE, Tribhuvan University, Nepal*
[a] rachitasubedi@gmail.com

Abstract
This study assesses the spatial distribution and impact of fuel service stations in Kathmandu. Using spatial analysis, GIS, and qualitative data analysis, it examines clustering patterns and the influence of these stations on traffic, air quality, land use, and socio-economic factors. The research aims to inform urban planning and policymaking by optimizing station placement for efficiency, minimizing environmental consequences, and promoting urban sustainability, considering both environmental and social aspects.

Keywords
Fuel service stations, Spatial distribution, Locational impact, Urban planning, Transportation management, Environmental sustainability, Traffic congestion

1. Introduction

1.1 Background

Spatial distribution and locational impact of fuel service stations have gained increasing importance in urban planning and environmental management, particularly in Kathmandu, Nepal. Rapid Urbanization and Motorization in Kathmandu underscore the necessity of comprehending fuel station distribution to improve accessibility and mitigate environmental and social effects. The city's rising vehicle numbers have led to traffic congestion and inefficiencies, issues that can be alleviated Through strategic fuel station placement. Additionally, concerns air quality and health risks arising from the emissions of these stations, especially when they are situated near sensitive areas such as Residential neighborhoods and educational institutions [1]. Understanding the impact of fuel station locations in Kathmandu is crucial for implementing effective measures to address environmental and safety risks.

Urban planning and sustainable development necessitate optimizing the spatial distribution of fuel service stations in Kathmandu. This entails considering factors like accessibility, land use planning, and social equity specific to the city's unique context. Efficiently placed fuel stations can enhance accessibility for vehicle owners and public transportation users, thereby contributing to a more sustainable and efficient urban transportation system [2].

1.2 Statement of the Problem

More than half of the rapidly growing global population resides in urban areas, a trend projected to intensify in the forthcoming decades [3]. Urban centers worldwide grapple with a myriad of hazards, encompassing traffic congestion, pollution, and uncoordinated development challenges. Alongside these perils, cities contend with accidents, explosions, and fires. In Kathmandu, a variety of fuel service stations proliferate, ranging from simple, unregulated pump operations lacking proper infrastructure and location considerations to a handful of well-planned, capital-intensive complexes with trained staff and ancillary services like restaurants. Nonetheless, some fuel stations disrupt local traffic flow or encroach upon roads, causing significant disruptions. Additionally, they obstruct access to residences and public spaces. The current spatial distribution of these stations in Kathmandu remains poorly documented and analyzed, making it uncertain whether they are strategically situated to facilitate convenient access for vehicle owners and public transportation users. Furthermore, the absence of information regarding clustering or spatial variations hampers targeted interventions for improved placement and utilization. Moreover, the comprehensive impact of these stations on surrounding areas, including effects on traffic congestion, air quality, land use, and socio-economic factors, remains largely unexamined. Without a thorough evaluation of these impacts, devising effective strategies to mitigate adverse effects and promote sustainable development in Kathmandu becomes a formidable challenge.

1.3 Objective

The major objective is to comprehensively analyze the spatial distribution patterns of fuel service stations in Kathmandu, evaluate their locational impact on traffic congestion, air quality, land use, and provide evidence based recommendations for optimizing their placement and impact to support sustainable urban development and transportation management in Kathmandu Metropolitan city.

1.4 Scope of the Study

This study is centered on Kathmandu Metropolitan City, Nepal, taking into account its distinct urban characteristics, topography, road network, and socio-economic dynamics, with the intent of providing findings and recommendations that are specifically applicable to fuel service stations within the city limits. The research's primary focus lies in examining

the spatial distribution patterns of these stations within Kathmandu Metropolitan City, considering clustering, density, and proximity to different land uses, while also identifying any spatial variations across the city. Additionally, it evaluates the locational impact of these stations on various aspects such as traffic congestion, air quality, land use, and socio-economic factors, shedding light on associated challenges and benefits. Furthermore, the study scrutinizes the environmental implications of fuel service stations, particularly their contribution to air pollution and health risks related to their proximity to sensitive areas, all with the aim of assessing the overall environmental sustainability of their locations. Lastly, the research offers insights and recommendations for urban planning strategies, transportation management, and policy interventions related to fuel service station placement in Kathmandu, ultimately striving to contribute to the development of a sustainable and efficient urban transportation system. It's important to note that the study's scope is delimited to the spatial distribution and locational impact of fuel service stations within Kathmandu Metropolitan City and does not encompass other facets of the fuel supply chain or broader energy-related concerns within the city. This study delves into the unique urban landscape of Kathmandu Metropolitan City, scrutinizing the spatial and locational dynamics of fuel service stations and their far-reaching impacts on various urban facets. By providing tailored recommendations, it aims to bolster urban planning and transportation management practices, fostering a more sustainable and accessible urban environment for Kathmandu's residents.

2. Literature Review

2.1 Concept of Location of Fuel Service Stations

Public perception regarding the location of fuel service stations often hinges on their awareness of standards and guidelines. Traditionally, these stations were situated in sparsely populated areas [4]. However, the contemporary reality contrasts with this practice, as many fuel service stations now arise within urban settings, surrounded by residential and public structures, disregarding the associated risks. These stations tend to appear in newly developed areas once their business potential is recognized, often leading to permits for locations detrimental to overall urban development. A preference for highly frequented streets to maximize patronage results in significant traffic hazards and congestion [5].

2.2 Factors which Determine Location of Fuel Service Stations

It is argued that firms, driven by the goal of profit maximization, choose their locations strategically to gain a competitive edge in the market. This choice depends on factors such as the elasticity of product demand, the presence of competitors, proximity to customers, direct customer interactions, the scope of the market area (regional, national, international), and the overall competitiveness of the industry. In more competitive markets, firms are inclined to seek and adapt to locations that offer maximum profitability[6].

It is emphasized that the location of petrol service stations is closely linked to factors like traffic volume and type, proximity to major travel routes, visibility from the road, ease of access, and the site's ability to attract customers. Physical attributes of a site play a pivotal role in determining whether a service station succeeds or fails. Additionally, the distance of catchment areas from residential neighborhoods significantly influences a petrol station's business prospects, highlighting the importance of site proximity to surrounding residential areas. This aligns with the preference of fuel service station owners, driven by the objective of profit maximization[7].

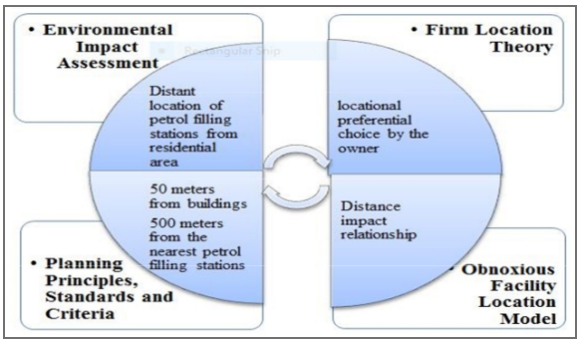

Figure 1: Determinants for the Location of Petrol Filling Stations

2.3 Theoretical Framework

2.3.1 Location Theory

Traditionally, economic theory overlooked spatial considerations, with classical economists assuming economic activities occurred in a static, dimensionless world. This spatial neglect, termed a "wonderland of no dimensions" by Isaard, contrasted with their recognition of the importance of time in economic analysis. However, their acknowledgment of space and distance factors remained implicit, relegating spatial phenomena to secondary importance relative to time in evaluating the economy's workings and performance [8].

However, Nyabuti warned that firms adopting a short-term perspective and disregarding potential future competitors might face locational instability in their business. Equilibrium outcomes, in such cases, may prove unsatisfactory. For businesses like service stations, involving substantial capital investment, relocation can pose a significant financial burden. This caution underscores the need for investors to make location choices with clear and well-calculated foresight, considering the potential entry of competitors in the future [8].

2.3.2 Theory of Location of Fuel Service Stations

The location of fuel service stations, privately owned by entrepreneurs, can be influenced by various factors. A study in Zambia identified four main determinants that contribute to these location choices: owner preferences, environmental criteria from the Environmental Protection Agency Zambia, guidelines from the Energy Regulation Board of Zambia (2015), and planning principles and standards outlined in the Town and Country Planning Act (now Urban and Regional Planning Act 2015). Additionally, theoretical considerations regarding obnoxious facility locations and Central Place Theory play a role in shaping these decisions [9].

Obnoxious facility location models categorize facilities into desired and undesired ones, with petrol service stations often falling into the latter category due to environmental risks, particularly fire and explosion hazards. The proximity of these stations to residential areas can negatively impact property values and pose health risks to both residents and workers . Therefore, it is crucial to place obnoxious facilities like petrol service stations away from populated areas to mitigate adverse effects[10].

In practice, fuel service station operators often prioritize central locations to maximize sales and profits, emphasizing factors such as traffic flow, visibility, ease of access, and proximity to major travel routes. Central Place Theory underpins this preference for centrality, focusing on places that offer convenient access to consumers for goods and services. Operators seek central locations to minimize consumer travel costs and exposure to a broad customer base [11].

While fuel service station operators have location preferences driven by the desire for centrality, it's essential to recognize that the location of these stations, despite its significance, often sees a gap between established laws and principles and actual compliance with regulations [7].

2.4 Effects of Fuel Service Stations on Adjacent Properties

Songotola identified several factors contributing to the positive or negative effects of locating petroleum filling stations near residential neighborhoods. These factors encompass fire outbreaks due to fuel spillage, road accidents resulting from increased vehicle movement during fuel scarcity, traffic congestion around petrol stations, the presence of hazardous substances that can harm employees and nearby residents, and pollution caused by volatile organic compounds in petroleum motor spirit affecting air quality, aesthetics of nearby buildings, and even aquatic life in areas close to rivers. To mitigate these negative impacts, Sangotola recommended a series of control measures, including enforcing safety regulations, halting the indiscriminate placement of fuel stations in residential areas, conducting educational campaigns for station staff about health risks, providing proper training and protective gear, maintaining storage tanks and pumps, ensuring designated parking areas away from tanks and pumps, establishing safe traffic flow systems, implementing security measures, and adhering to various safety protocols to safeguard both individuals and the environment [12].

2.5 Design Standards of a Fuel Service Station

2.5.1 National Standard

Petroleum Product Seller Regulation-2075

This regulation signifies a significant milestone in regulating the petroleum industry, with a focus on promoting efficiency, transparency, and environmental responsibility. It responds to the evolving global energy landscape and emphasizes equitable trade, consumer protection, and ecological preservation. Chapter 3 of this regulation outlines specific guidelines and standards for the location of fuel stations.

For general fuel stations, there should be a minimum distance of 300 meters between two stations. Packed retailers (selling petroleum in drums) should be at least 5 kilometers away from the nearest fuel station, while model fuel service stations should maintain a minimum distance of 10 kilometers between them.

General petrol pump standards differ for highways (such as Tribhuvan and Araniko) and roads within Kathmandu Metropolitan City. For highways, the requirements include a minimum area of 2500 sq. m (8 katthas or 5 ropanees) with specific infrastructure like a permanent selling area structure, compound wall, canopy, fire safety measures, public toilets, safe drinking water provision, coffee shop, and adequate parking.

Kathmandu Metropolitan City, the minimum area is 750 sq. m (4 katthas or 2 ropanees 6 aanas) with similar infrastructure specifications tailored to the urban setting.

Before the regulation, general petrol pumps had minimum area requirements and infrastructure elements like a permanent selling area structure, compound wall, canopy, fire safety measures, public toilets, safe drinking water provision, and greenery in the buffer strip.

Model petrol pump standards vary based on the region. For hilly and Himalayan areas, a land area of 5 ropanees with a street face of 40 meters (1 bigha in the Terai region) is required. Specific facilities include a canopy, public toilets, separate selling area, office, drinking water provision, fire safety systems, hoarding boards, 24-hour operation, vending machines, convenience stores, card swapping facilities, restaurants, and ample parking with emergency pump shut-off provisions during sensitive conditions.

Figure 2: 3D of model petrol pump

2.6 Urban Planning and Planning for Service Stations

The location of motor vehicle fuel service stations is a matter that necessitates clear planning policies. Planning authorities should carefully assess several factors: firstly, the impact on traffic flow and road safety; secondly, the compatibility of the proposed station with neighboring land uses and overall development plans; thirdly, its effect on the local amenity; and finally, the suitability of its location, layout, and design.

In practice, planning primarily concerns road safety and the preservation of amenity, rather than an immediate need for service stations, which can vary. While service stations are essential in town centers and near neighborhood shopping areas, their integration into existing environments is crucial. They should be easily accessible, clearly visible, and not pose a traffic hazard. Ideally, new service stations should be situated

on main roads entering a town, at the outskirts of built-up areas, and in large towns near major road junctions, particularly radial and ring roads. However, planning consent is generally not granted on fast open stretches of road, by-passes less than 19 kilometers long, or locations too close to side roads, junctions, or roundabouts. While service stations should typically not be directly opposite each other on the same road, exceptions may be considered where traffic flow slows down [13].

2.6.1 Traffic Flow and Road Safety

The primary function of a road is to carry traffic wishing to use it at maximum speed consistent with safety. The capacity of road varies with its width and the average speed of traffic using it. The speed of traffic depends largely on the road alignment and the amount of interference from cross traffic junctions, turning and maneuvering at junctions and accesses and traffic signals. Service stations should be visible to drawers from both directions for not less than 100 meters within 40mph speed and 65 meters where the legal speed is 30mph, this being the accepted minimum stopping distances for respective speeds [14].

2.6.2 Provision of Amenities

If a site is pleasant, it should be the object of planning authorities to cause it to remain so, and thereby ensure that only appropriate development(s) take place. If at all a service station development would be incongruous in a given site it should not be allowed to take place It is a question of whether a given development is appropriate and harmonious. It should be noted that in zoning of urban land use no land is demarcated purposely for fuel service station use and as such service station rely on change of use from other land uses especially residential and commercial. However, in some special cases a planner may demarcate a site for a service station. Service stations are development in area of mixed development with other land uses hence they should be carefully designed and sited to accord with their surroundings [15].

3. Methodology

3.1 Research Approach

The research follows a mixed-methods approach. This approach combines both qualitative and quantitative research methods to comprehensively explore the spatial distribution and locational impact of fuel service stations. Quantitative methods involve spatial analysis using GIS to map fuel service station locations.and traffic data counting to assess their impact on traffic flow and congestion. Additionally, environmental data would be quantitatively analyzed to evaluate the stations' environmental implications. On the other hand, qualitative methods include surveys and interviews with key stakeholders to capture their perceptions and experiences regarding the topic. Thematic analysis would be applied to the qualitative data to identify common themes. By integrating these diverse research methods, the paper aims to offer a well-rounded and evidence-based understanding of fuel service station distribution and its impact in Kathmandu, providing valuable insights for urban planning, transportation management, and environmental policies.

3.2 Study Area

Kathmandu, the capital and eldest metropolitan city of Nepal, lies in the Kathmandu Valley in the Himalayas, with its sister cities Patan (Lalitpur) to the southeast and Bhaktapur to the east. It is situated in Kathmandu district, Province No. 3, and encompasses 32 wards across 49 square kilometers, located between latitudes 27°10'N and 27°32'N and longitudes 85°27'E to 85°49'E, at an altitude of 1,400 meters (4,600 feet). Administratively, Kathmandu is divided into these 32 wards.

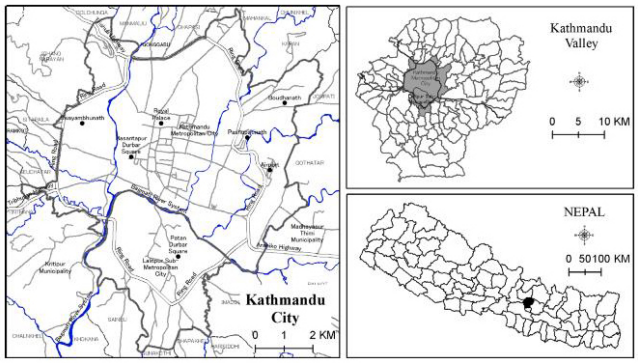

Figure 3: Study area – Kathmandu in its spatial context

The city shares boundaries with Lalitpur Metropolitan City (Patan) to the south, forming one urban area encircled by a ring road, Kirtipur to the southwest, and Madhyapur Thimi to the east. To the north, the urban area extends into several municipalities, including Nagarjun, Tarakeshwor, Tokha, Budhanilkantha, Gokarneshwor, and Kageshwori Manohara.

Kathmandu experiences a climate characterized by warm days followed by cool nights and mornings, with unpredictable weather that can result in temperatures dropping to 1° C (34° F) or lower during winter. Monsoon-based rainfall, concentrated from June to September, contributes to an annual precipitation of around 1,400 millimeters (55.1 inches) in the Kathmandu Valley, with an average humidity of 75%.

In terms of demographics, Kathmandu is the most populous city in Nepal, with a total population of 975,543 in 2011. This marked a significant increase from the population of 427,045 in 1991 and 671,805 in 2001. The population is projected to reach 1,319,597 by 2021, leading to an expansion of the city's area. This rapid population growth and urbanization have spurred increased competition for land use, particularly in areas like Sinamangal, Nayabazaar, and along Kalanki National Highway, where the demand for fuel products has attracted entrepreneurs to establish fuel stations.

3.3 Study Population, Sample Selection and Sample Size

The study population for this paper comprises various relevant groups, aligning with the research objectives. It includes:

1. **Fuel Service Stations:** Encompassing all fuel service stations within Kathmandu City's geographical boundaries in Nepal.

2. **Policymakers and Urban Planners:** Encompassing individuals holding policymaking and urban planning roles within governmental and municipal organizations responsible for the city's development.
3. **Fuel Station Operators:** Involving owners and operators of fuel service stations located in Kathmandu.
4. **Community Members:** Comprising residents and commuters from various areas within Kathmandu directly impacted by the presence and distribution of fuel service stations.

3.4 Sample Selection

The sample selection process aims to efficiently gather data from a representative subset of each study population. To achieve this, a purposive sampling technique is suitable for policymakers, urban planners, fuel station operators, and community members, ensuring individuals with pertinent expertise and experiences are included. The sample size is contingent on research objectives, available resources, and statistical considerations. For fuel service stations, it should be sizable enough to encompass location and distribution diversity. For stakeholders like policymakers and urban planners, a sufficient sample size ensures a representative grasp of their perspectives. Striking a balance between adequacy and practicality is pivotal in determining the sample size.

3.5 Method of Data Collection

The study employed both primary and secondary data collection methods to assess fuel service station spatial distribution and its impact.

a. Primary Data Collection:
Various techniques were utilized, including structured surveys to gather quantitative and qualitative input from key stakeholders like policymakers, urban planners, fuel station operators, and community members. Random sample survey of 67 household survey was carried out.selection of households was based on specific criteria related to road hierarchy and proximity to three designated fuel stations. Interviews were also conducted with select participants to delve deeper into qualitative insights. Field observations allowed direct examination of station distribution, traffic patterns, and local conditions.

b. Secondary Data Collection:
Geographic Information Systems (GIS) data from municipal databases and other sources were employed to map station locations and analyze their spatial patterns. Environmental data on air quality, sourced from monitoring stations and meteorological departments, helped evaluate the environmental consequences of station placement. Furthermore, a comprehensive review of academic papers, research articles, and journals provided insights into fuel service station spatial distribution and its impact in urban settings.

3.6 Data Analysis

The data should be analyzed so as to build up a sort of intellectual model where relationship involved between various variables are carefully brought out so that meaningful inferences can be drawn where facts and figures are to be seen in perceptive of objectivity. In order to harmonize data collected from the field, coding of close-ended questionnaires was necessary . Qualitative data, which could not be coded, was summarized and presented in descriptive form in tables, pie-charts and plates. It is from SPSS package that frequencies and percentages were gotten from. Mean, smallest and highest values of various variables were also drawn from thepackage.

3.7 Limitation of the research

The research primarily focuses on fuel service station spatial distribution and its city-level locational impact. However, it may not capture fine-scale variations within neighborhoods or specific areas, potentially missing local nuances and micro-level impacts. The study concentrates on factors like traffic congestion, air quality, land use, and socioeconomic aspects but does not delve into other significant variables beyond its scope, such as noise pollution, groundwater contamination, and cultural heritage considerations, which could provide a more comprehensive view.

The findings and recommendations, while valuable, may be context-specific to Kathmandu City and might not be directly transferable to other regions due to the unique urban characteristics, topography, and socio-economic dynamics of Kathmandu. Additionally, resource and time constraints could limit the depth and scope of the study, potentially leaving certain aspects unexplored or providing more of a snapshot than a longitudinal assessment.

Acknowledging these limitations is essential to provide a realistic perspective on the research's scope and potential implications. Despite these constraints, the study can still offer valuable insights and recommendations for addressing fuel service station spatial distribution and its locational impact in Kathmandu City.

4. Results and Discussions

4.1 Spatial Analysis

4.1.1 Mapping of the Fuel Service Station

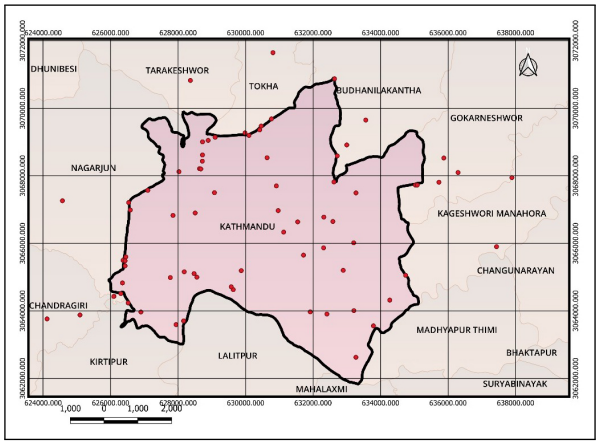

Figure 4: Mapping of fuel station

Fuel Service station were mapped in QGIS. The list of existing fuel service station was provided by the Nepal Oil Corporation.

a. Administrative Division

To see the distribution, it was again mapped according to the administrative division of Metropolitan city i.e., wards

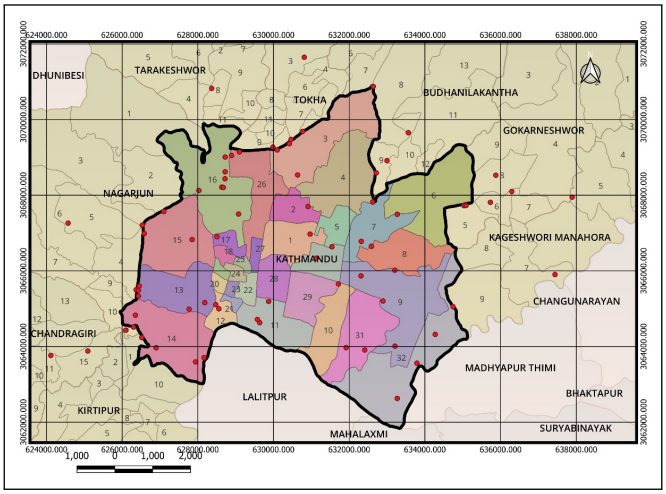

Figure 5: Distribution of fuel station according to wards

b. Road

To see the distribution, it was again mapped according to the road hierarchy of Metropolitan city.

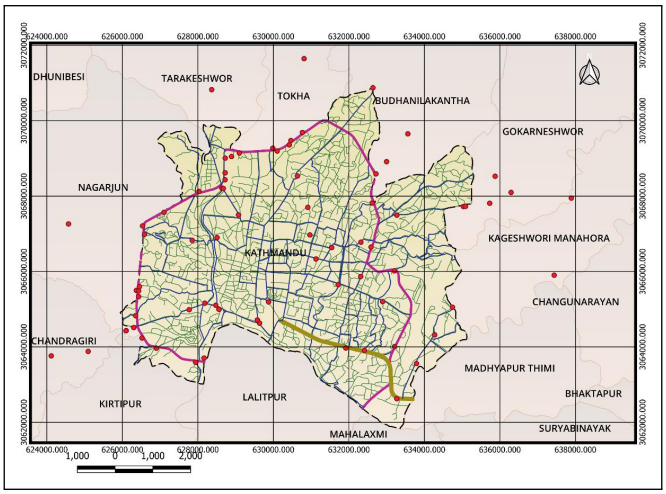

Figure 6: Distribution of fuel station according to roads

From the spatial analysis of Fuel Service Station according to roads; we see maximum clustering of fuel station in ring roads followed by Strategic roads. However, local roads and Araniko highway has the least amount of fuel stations.

4.2 Locational Analysis

4.2.1 Analysis on Surveyed Fuel Station operator

Among 79 fuel station of the Kathmandu metropolitan City, 3 of them were choosen for assessing the locational impact.

1. Shree Shyama Oil., Kalanki, ward-14 (2044-03-17)
2. Shree Valley Rikesh Suppliers, Girigaun, Ward-32 (2050-01-08)
3. Shree Jay Kumari Enterprises, Nayabazar, Ward-16(2049-08-19)

The selection of three sites is done on the basis of hierarchy of roads as the fuel service station are sited along these roads. The Shyama oil Stores lies on the national highway; Shree Valley Rikesh Suppliers lies on the ringroad, whereas Shree Jay Kumari Enterprises lies on the feeder road.

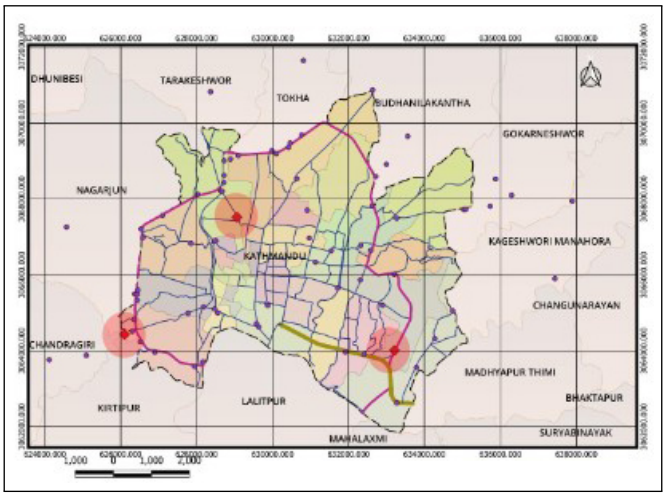

Figure 7: Site for locational analysis

4.2.2 Location decision

The primary factors influencing the choice of location for all three fuel service stations were easy access to major roads. Shyama Oil Store emphasized access to highways, ensuring convenience for both local residents and passing motorists. Shree Jay Kumari Enterprises in Nayabazar also considered the area's potential for future growth, anticipating increased business in an expanding population.

Interestingly, all fuel station operators responded with a "no," indicating a lack of challenges during the location selection process. They found the installation to be straightforward, possibly due to the absence of regulations at the time, simplifying both location selection and installation procedures. This suggests a relatively smooth and unobstructed experience in choosing the station's location.

4.2.3 Impact on Business

Fuel service station operators unanimously reported that the location of their stations had a substantial influence on their business performance and customer traffic. The strategic positioning of their stations in high-traffic areas with easy access to major roads and commercial centers played a pivotal role in driving their success. Jay Kumari Enterprises, situated in a densely populated area, has benefited from a steady customer base, with the station being a convenient choice for local residents, further enhancing their customer traffic.

4.2.4 Traffic Flow and accessibility

Fuel service station operators mentioned that their station's location contributes to traffic congestion during office hours and festivals. Proximity to commercial zones intensifies vehicular activity as people travel to and from work. The station's accessibility and convenience may lead to increased

traffic in the vicinity, causing congestion as vehicles line up for refueling.

This observation highlights the trade-off between the benefits of a well-placed fuel station and the traffic management challenges it can pose. The station's role as a convenience provider must be balanced with its impact on traffic flow.

4.2.5 Environmental Measures

None of the respondents mentioned specific measures to mitigate environmental impacts, such as air pollution, although the oil corporation suggested tree planting, at the very least potted plants. However, all station operators have implemented fire safety protocols, including the use of 30kg, 50kg, and 400kg fire extinguishers, as required by the oil corporation.

Shyama Oil Stores, in particular, suggested additional steps to enhance environmental performance by installing measures to mitigate air pollution, such as vapor recovery systems.

4.2.6 Land use Compatibility

All operators responded that their fuel service station's operations do not negatively impact the quality of life for nearby residents or the functionality of neighboring businesses. This suggests that the operators do not perceive compatibility issues. However, it's important to note that potential compatibility challenges, such as traffic congestion, safety concerns, and environmental impacts, may still exist in areas with sensitive land uses.

4.2.7 Community Relations

All the operators responded no engagement with the local community or residents around the fuel service station. This absence of engagement could mean that there is limited dialogue regarding the station's operations, potential impacts, and the community's perspectives. This could potentially lead to misunderstandings or unaddressed concerns.

4.2.8 Future Development

All of them responded indicating no intention to relocate or expand the fuel service station in the future. This suggests a contentment with the current operational setup. This response could stem from various factors such as the station's successful performance in its current location, the absence of regulatory constraints that might necessitate relocation, or a well-established customer base that is already being served effectively.

For the improvement Jay Kumari Enterprises Nayabazar showed interest on investing in the latest technologies that enhance customer convenience and streamline operations. This could involve introducing contactless payment options, improving their fuel dispensing systems, and optimizing traffic flow within their station to reduce wait times.

4.3 Respondent Analysis

4.3.1 Socio-Demographic Characteristics of Respondents

Type of Residential facilities	Frequency	Percent
Home	20	37
School	2	4
Business	30	56
Health facility	1	3
Total	53	100

Figure 8: Surveyed Residential facilities Close to Fuel Stations

4.3.2 Age Distribution of Respondents

Survey shows that majority of residents above 50 years(42%); age 40 to 50 years constituted 41% and followed by those within the 20 to 30 years (19%) which is also followed by age 15 to 20 years (11%).

4.3.3 Sex of Respondents

Generally, females have been identified as the main gender group plying their trade around fuel stations. Out of the 53 respondents, male constituted 32 percent while 68 percent were females (figure 9).

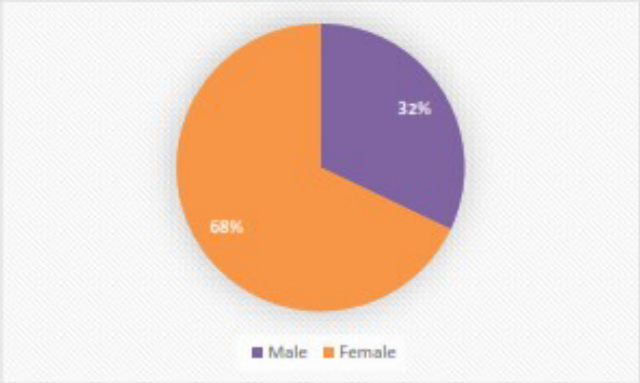

Figure 9: Representation of surveyed gender

4.3.4 Health and safety consideration

The notable 62 percent affirmative response to the inquiry about perceived health risks related to the proximity of fuel service stations. From their perspective, living in proximity to existing fuel stations raises legitimate health and safety concerns. The air quality, often compromised by emissions and volatile organic compounds from fuel-related activities, poses a potential risk to respiratory health. Increased traffic around these stations raises safety concerns, with the potential for accidents and exposure to hazardous materials. Noise pollution from vehicular movements and station operations can impact the overall well-being of residents. Additionally, the inherent fire hazards associated with fuel stations are a source of anxiety for households. Ensuring proper emergency response plans and heightened awareness among residents becomes crucial. Groundwater contamination due to fuel storage adds another layer of concern.

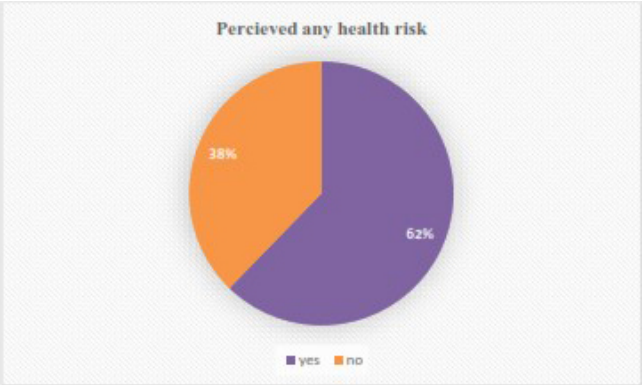

Figure 10: Representation of surveyed gender

5. Conclusion

In Kathmandu, fuel service stations show non-uniform distribution, clustering in specific areas due to factors like commercial zones and historical development patterns.Recognizing and understanding these spatial variations are vital, providing insights into how fuel stations impact their immediate surroundings in localized ways. The locational analysis of all three fuel stations have impact their surroundings with heightened traffic congestion, compromised air quality in densely populated areas, and notable effects on land use, especially near residential or commercial zones.Fuel service stations has also posed dual challenges of air pollution and fire hazards due to fossil fuel combustion. Addressing these issues requires safety measures, technological innovations, and regulatory interventions for community and ecosystem well-being.

6. Recommendation

Urban planning in Kathmandu necessitates implementing zoning regulations to guide fuel service station locations, preventing clustering and ensuring a balanced distribution. Managing station impact involves traffic strategies, environmental assessments, and integration into land-use planning to avoid conflicts with residential or environmentally sensitive zones. Mitigating environmental implications requires enforcing advanced emission control technologies and safety protocols to minimize air pollution and fire hazards. Achieving harmonious coexistence demands comprehensive planning, including community engagement and integration into broader urban strategies for compatibility and social equity. Incentive programs for strategic station locations play a key role in fostering positive symbiosis between fuel services and community well-being.

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