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

by

Rachita Subedi

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ABSTRACT

The spatial distribution and locational impact of fuel service stations play a crucial role in urban planning, transportation, and environmental management. This thesis aims to assess and analyze the spatial distribution patterns of petrol service stations, as well as their locational impact on surrounding areas. By understanding the current distribution patterns, policymakers and urban planners can make informed decisions to optimize the placement of petrol service stations for efficient access, minimize adverse environmental effects, and enhance urban sustainability.

The study will employ a mixed-methods approach, combining spatial analysis techniques, GIS, and qualitative data analysis. It will examine the spatial distribution patterns of fuel service stations in Kathmandu, identifying any clustering or spatial variations. Additionally, the research investigates the locational impact of these stations on surrounding areas, including traffic congestion, air quality, land use, and socio-economic factors.

The findings of this research will contribute to enhancing urban sustainability in Kathmandu. By understanding the spatial distribution of fuel service stations, policymakers and urban planners can make informed decisions to optimize their placement for efficient access and minimize adverse environmental effects. The research also addresses the potential environmental implications of fuel service stations, providing insights into air pollution and carbon emissions. Furthermore, by considering socio-economic aspects, such as accessibility and social equity, the study aims to ensure that the placement of fuel service stations caters to the diverse needs and preferences of the community.

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

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1.1 Background

The spatial distribution and locational impact of fuel service stations have become increasingly significant in urban planning and environmental management, including in the context of Kathmandu, Nepal. As Kathmandu experiences rapid urbanization and motorization, understanding the distribution patterns of fuel service stations is crucial for optimizing accessibility and minimizing environmental and social impacts in the city.

In Kathmandu, the proliferation of fuel service stations is influenced by several factors specific to the city. Firstly, the growing number of vehicles in Kathmandu has led to an increased demand for fuel and convenient access to fuel service stations. This rise in vehicle ownership has resulted in challenges related to traffic congestion and inefficient travel patterns within the city. Proper placement of fuel service stations can help alleviate these issues and improve traffic flow. Furthermore, the environmental impact of fuel service stations in Kathmandu is a growing concern. The city already faces challenges related to air pollution, and the emissions from fuel service stations contribute to this issue. The proximity of fuel service stations to sensitive land uses, such as residential areas and educational institutions, raises additional concerns about air quality and potential health risks for the population(Alesheikh A. and Golestani H., 2011). Understanding the locational impact of fuel service stations in Kathmandu is crucial for implementing effective measures to mitigate these environmental and hazard risks.

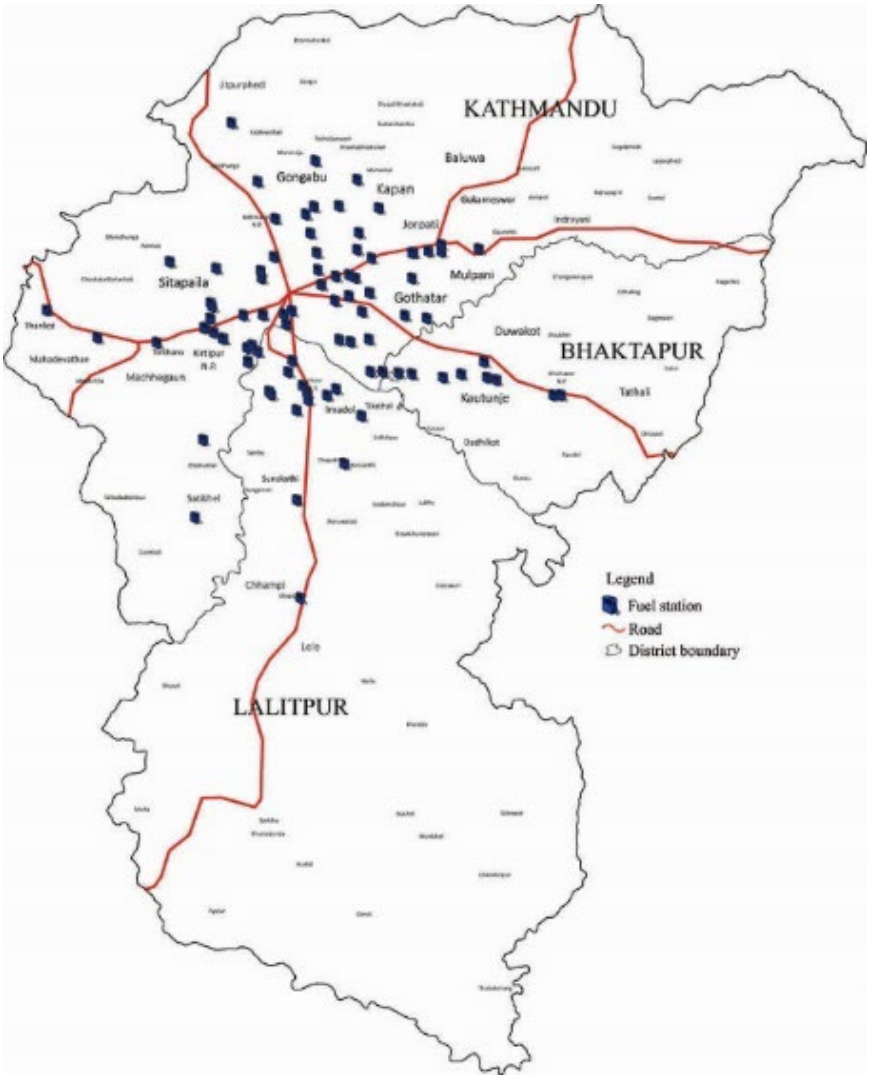

Figure 1- 1 Mapping of fuel station in Kathmandu Valley

According to NOC, there are 123 petrol stations in Kathmandu, 29 in Lalitpur and 20 in Bhaktapur. NOC officials say pumps operators do not bother about possible disasters. “Some pumps were established even before the government introduced the criteria for operating them. So, we are unable to make them relocate,” said NOC Managing Director Surendra Paudel.

A typical refill station holds at least 20 kiloliters (20,000 liters) of diesel and 12 kiloliters (12,000 a) of gasoline. According to NOC standards, this indicates that at any one time, 3,440 kiloliters (3.4 million liters) of diesel and 2,064 kiloliters (2 million

liters) of petrol are in underground storage in the Valley. Aside from that, NOC's Thankot depot, which supplies the fuel pumps, holds 5310 kiloliters of petrol, 8400 kiloliters of diesel, and 710 kiloliters of kerosene. According to NOC, the fuel depot at Sinamangal, near Tribhuvan International Airport, holds 7,000 kiloliters of aviation fuel. Given the vast amounts of fuel in storage, a fire could result in massive casualties in the surrounding districts. It is past time to review safety procedures, and NOC has pledged to do so for its Sinamangal and Thankot departments. has developed safety guidelines for operating petrol stations. Station operators in the Valley, however, do not adhere to them. According to firefighters, the resources mentioned in the directives are likewise insufficient.(Dhungana Nabin, 2023).

According to the 2016 guidelines, a petrol station in the terai and inner terai shall have at least one bigha (13 ropani) of land (except in Udayapur, Chitwan, Makwanpur, Dang, and Surkhet's hill areas). There should be five ropani in the hill and mountain locations. Similarly, a three- to five-foot concrete compound wall or cemented pillars with barbed wire on three sides should be present. The directives also mention a canopy of around 18 meters and up to 30 meters of roof to cover the refilling area, five toilets, including one for the disabled, a fire-retardant system inside the compound, underground containers, mapping of its capacity and quantity, and the ability to serve eight vehicles at a time.(*Govt Tells 18 Fuel Stations to Relocate to Safer Spots - MyRepublica* -, 2020).

From an urban planning and sustainable development perspective, optimizing the spatial distribution of fuel service stations in Kathmandu is essential. It involves considering factors such as accessibility, land use planning, and social equity within the unique context of the city. Efficient placement of fuel service stations can enhance accessibility for both vehicle owners and users of public transportation, contributing to a more sustainable and efficient urban transportation system(Ayodele S. J, 2011).

In conclusion, assessing the spatial distribution and locational impact of fuel service stations is vital for effective urban planning, transportation management, and environmental sustainability in Kathmandu. By understanding the specific factors influencing the distribution and evaluating the locational impacts within the city, policymakers and urban planners can make informed decisions to optimize

accessibility, minimize environmental risks, and promote social equity in the context of Kathmandu.

1.2 Problem Statement

More than half of the worlds rapidly rising population lives in cities, and this figure is only anticipated to rise in the coming decades. (United Nation, 2014). Most metropolitan areas around the world are vulnerable to hazards such as traffic congestion, pollution, and a variety of other issues caused by uncoordinated development. Aside from these dangers, cities face other issues such as accidents, explosions, and fires.

It is clear that numerous types of fuel service stations are currently common in Kathmandu. The majority of them range from a simple pump run as a one-man business without any specialized construction, space regulations, or site considerations. On the other hand, complicated capital-intensive service stations are few. Infrastructure is peculiar to these stations; land areas, site, and locational factors are considered. Before deployment, the workforce is thoroughly trained, and supplementary services such as restaurants are considered when deciding on the site, location, and layout plan.

Nonetheless, some motor vehicle gasoline service stations are positioned in areas where they interfere with neighborhood traffic flow. While other station locations are such that the adjacent road is used as the fueling bay, bringing traffic to a halt. Access to residences and other public services and areas is also hampered by fuel service stations.

The current distribution patterns of fuel service stations in Kathmandu are not well documented or analyzed. As a result, it is unclear whether these stations are strategically located to ensure optimal accessibility for both vehicle owners and public transportation users. Additionally, the lack of information regarding the spatial distribution of fuel service stations makes it difficult to identify any clustering or spatial variations, which could help inform targeted interventions for better placement and utilization of these stations.

Moreover, the locational impact of fuel service stations on surrounding areas, including traffic congestion, air quality, land use, and socio-economic factors, has not been comprehensively evaluated. Without a detailed assessment of these impacts, it is challenging to develop effective strategies to mitigate adverse effects and promote sustainable development in Kathmandu.

1.3 Research Objectives

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 socio-economic factors, and provide evidence-based recommendations for optimizing their placement and impact to support sustainable urban development and transportation management in Kathmandu.

So that, the specific objectives of this study are:

1. To analyze the current spatial distribution patterns of fuel service stations in Kathmandu, identifying any clustering or spatial variations.

2. To evaluate the locational impact of fuel service stations on surrounding areas, including traffic congestion, air quality, land use, and socio-economic factors.

3. To investigate the environmental implications of fuel service stations, particularly in terms of air pollution and fire hazards.

4. To recommend planning approaches that can be used to harmonize the location and siting of fuel service stations.

1.4 Scope of the Study

1.4.1 Geographic Scope:

The study focuses specifically on Kathmandu Metropolitan city, Nepal, considering its unique urban context, topography, road network, and socio-economic dynamics. The findings and recommendations are intended to be applicable to fuel service stations within the city limits.

1.4.2 Spatial Distribution:

The study aims to analyze the spatial distribution patterns of fuel service stations within Kathmandu Metropolitan city, considering factors such as clustering, density, and proximity to different land uses. It examines the overall distribution trends and identifies any spatial variations within the city.

1.4.3 Locational Impact:

The study evaluates the locational impact of fuel service stations on various aspects, including traffic congestion, air quality, land use, and socio-economic factors. It assesses how the placement of these stations influences the surrounding areas and identifies any associated challenges or benefits.

1.4.4 Environmental Impact:

The study examines the environmental implications of fuel service stations, particularly their contribution to air pollution. It considers the potential health risks associated with their proximity to sensitive land uses and evaluates the overall environmental sustainability of their locations.

1.4.5 Urban Planning and Transportation Management:

The study provides insights and recommendations for urban planning strategies, transportation management, and policy interventions related to the spatial distribution and locational impact of fuel service stations in Kathmandu. It aims to contribute to the development of sustainable and efficient urban transportation systems. It is important to note that the study's scope is limited to the spatial distribution and locational impact of fuel service stations in Kathmandu Metropolitan city. It does not encompass other aspects of fuel supply chains or broader energy-related issues within the city

1.5 Justification of the Study

Understanding the spatial distribution and locational impact of fuel service stations is crucial for effective urban planning and sustainable development in Kathmandu. By

evaluating the existing patterns and impacts, policymakers and urban planners can make informed decisions regarding the placement and management of these stations, leading to more efficient land use, improved transportation systems, and reduced environmental impacts. Fuel service stations play a significant role in urban transportation, and their strategic placement can help mitigate traffic congestion and improve travel efficiency. By assessing their distribution patterns and their impact on traffic flow, the study can provide insights into potential measures for optimizing the locations of fuel service stations, thereby enhancing the overall transportation system in Kathmandu Metropolitan city. Kathmandu faces significant environmental challenges, including air pollution. Fuel service stations contribute to these environmental issues, and understanding their locational impact is crucial for implementing targeted measures to mitigate pollution and promote environmental sustainability. The study can provide evidence-based recommendations to minimize the adverse environmental effects associated with the placement of fuel service stations. Proximity to fuel service stations may have implications for the health and well-being of the population, especially when located near sensitive land uses such as residential areas and educational institutions. Assessing the locational impact of fuel service stations can help identify potential hazard risks and guide policies and regulations to protect the community's well-being. Additionally, the findings and recommendations of the study can serve as a valuable resource for policymakers, urban planners, and relevant stakeholders involved in fuel station management and urban development in Kathmandu Metropolitan City. The study can contribute to evidence-based decision-making, enabling the formulation of effective policies, guidelines, and regulations for the optimal placement and management of fuel service stations in the city.

1.6 Expected Outcomes

The research aims to achieve several outcomes. Firstly, it seeks to understand the spatial distribution patterns of fuel stations across Kathmandu, identifying areas of clustering, and dispersion. Additionally, the research intends to assess the impact of fuel station locations on various factors, including traffic congestion, air quality, and land use. By establishing relationships between fuel station locations and these impact factors, the

study aims to provide insights into the locational implications. It will also examine the environmental and hazard implications of fuel service stations, focusing on air quality and potential health risks. Ultimately, the expected outcome of the research is to provide evidence-based recommendations for policy and planning purposes, supporting sustainable urban development, optimizing traffic flow, improving air quality, and promoting equitable access to fuel services in Kathmandu Metropolitan City.

1.7 Conceptual Framework of the Research and Methodology

Research paradigms are fundamental philosophical frameworks based on ontological, epistemological, and methodological assumptions(Guba & Lincoln, Y.S, 1994).

The ontological perspective refers to the researcher's beliefs about the nature of reality and the entities or phenomena under investigation. In this research, the ontological stance can be based on a realist perspective, assuming that there is an objective reality that exists independently of human perception. It acknowledges that fuel service stations, spatial distribution patterns, traffic congestion, air quality, and socio-economic factors are tangible entities and phenomena that can be observed and measured(Alele & Malau-Aduli, 2023).

The epistemological perspective pertains to the researcher's understanding of how knowledge is acquired, validated, and interpreted. In this research, the epistemological stance can be aligned with an empiricist or positivist perspective. It emphasizes the use of empirical evidence, quantitative data, and systematic observation to understand and explain the relationships between variables. The research aims to generate knowledge through objective and systematic analysis of data collected from reliable sources, employing statistical methods and spatial analysis techniques(Alele & Malau-Aduli, 2023).

The term ‘paradigm’ may be defined as “a loose collection of logically related assumptions, concepts, or propositions that orient thinking and research” or the philosophical intent or motivation for undertaking a study(Mackenzie, 2006). Alternatively, a paradigm, which includes three elements: a belief about the nature of knowledge, a methodology and criteria for validity. The paradigm gives the basis for

the choice of methodology, methods and sources.

The wide term "methodology" is used to describe the study design, methodologies, approaches, and processes employed in a planned investigation(Khatri, 2020). This suggests that participants, data collection tools, and data analysis indicators are the only methodological aspects in a paradigm that contribute to understanding the study problem. In order to learn more about a research problem, the methodology describes the logic and flow of the systematic procedures used to carry out a research project.

In this research, qualitative and quantitative methods is used. Qualitative research with human beings involves three kinds of data collection are in-depth, open-ended, interviews, direct observation and written documents (Patton, 2005). Qualitative research is done to learn about people's reasons, opinions, and motivations. Quantitative research is also utilized to quantify the issue. Quantitative data includes surveys and close ended questionnaires. This research adopts the qualitative research methodologies which emphasizes on the natural settings. This concentrates on the meaning and interpretation of the text, as well as how others view it. This is accomplished by the use of a questionnaire survey.

CHAPTER-2: LITERATURE REVIEW

2.1 Introduction

This chapter is a review of the literature. It investigates the current literature on the issue in a larger sense, with the goal of providing a theoretical framework for the study. It also addresses the placement of retail activity and the criteria that are taken into account while locating various economic activities in metropolitan settings. It takes into account the position and siting of fuel service stations.

2.2. Concept of Location of Fuel Service Stations

The public's perception of the location of gasoline service stations can be regarded in relation to the public's understanding of standards and criteria for the location of fuel service stations. Historically, fuel service facilities were mostly found in rural locations.(Isabel, M. et al., 2010). On the ground, the situation is rather different, since many fuel service stations are being established in metropolitan areas surrounded by residential and public buildings. Regardless of the dangers involved with fuel service stations, this trend has been seen. Fuel service stations appear in newly built areas only when development has progressed to the point that the areas' business viability can be judged. A delayed need for Service Site is then formed, which will result in a request for permissions to utilize sites that are damaging to the area's sound development. Preference for placements on regularly traveled routes in order to maximize patronage from the local area as well as passing traffic results in major traffic risks and traffic congestion. (R. Gopalaswamy, 1977).

According to the Australian Transport Safety Bureau (ATSB, 2005), between 1993 and 2004, there were 243 reported incidents of fires breaking out at petrol stations. Spain's continuing urban growth in recent years has resulted in many fuel stations being established within urban areas surrounded by buildings. This issue has sparked a debate between residents whose homes are close to gas stations and the land management authority.(Isabel, M. et al., 2010)

Studies have been conducted to determine the dangers related with the locations of fuel service stations and the public's perceptions. The case of the City of Singapore is an intriguing issue in the literature. Chan et al. (2004) suggested a structural model to explain both the geographic placements of Singapore's gasoline retailers and the pattern of pricing rivalry between retailers and other property types within their geographic areas. Surprisingly, the model's premise was that the Singapore government decides where gasoline stations should be located in the city. This was discovered to be quite unusual in comparison to most capitalist market driven economies. The writers highlighted that the Singapore government is a social welfare planner (Chan et al., 2004).

Another study, Hamid et al. (2009), explored the potential of a petrol station site based on traffic volume counts, utilizing a regression and Geographic Information approach (GIS)-based spatial approach. The writers emphasized the importance of site potentiality in influencing the business viability of a gas station that relies on client visits. On this note, Kearny (1998) indicated that it was empirically discovered in the United States of America that site location was the most important factor for drivers when selecting a petrol station.(Hamid et al., 2009).

The subject of entrepreneur site preferences is also addressed in the literature (Njoku & Alabge, 2015; Mohammed et al, 2014; Afolabi et al, 2011). According to Njoku and Alagbe (2015), while petrol Fuel Service Stations should be positioned in easily accessible areas, there has been concern that there has been over-provision within one geographical region as well as indiscriminate placements within Oyo town and Nigeria at large. (Afolabi O.T et al., 2011).

2.3 Factors which Determine Location of Fuel Service Stations

According to Lösch (1954), a firm trying to maximize profit (a basic premise of all economic theory) may choose a specific location to obtain a competitive edge over other enterprises and locate in a market region that delivers the maximum profit. The location of the most profitable market area was based on the assumption of equal transportation and population distribution costs. He

contended that the more competitive the market, the more enterprises will seek and adjust to the highest profit position. The site chosen will be influenced by demand considerations such as:

1. Elasticity of product demand
2. Location of competitors.
3. Importance of proximity to customers.
4. Importance of direct contact with customers.
5. Extent of market area (regional, national, international)
6. Relative competitiveness of the industry.

According to Iman et al. (2009), the location of petrol Fuel Service stations is usually associated with the type and volume of traffic flows passing through the site, proximity to a major travel route, visibility from the road, time it takes drivers to slow down to enter the petrol station, general ability to attract customers, road direction or movement, artery types, and distance of catchment areas from residential neighborhoods. These physical elements of a site location might mean the difference between success, mediocrity, and failure in service station use.(Iman et al., 2009). In terms of the distance between catchment regions and residential neighborhoods, site proximity to residential districts can be expected to have a substantial impact on a petrol station's business.(Iman et al., 2009). This explains the locational preference of fuel service stations owners which is based on profit maximization.

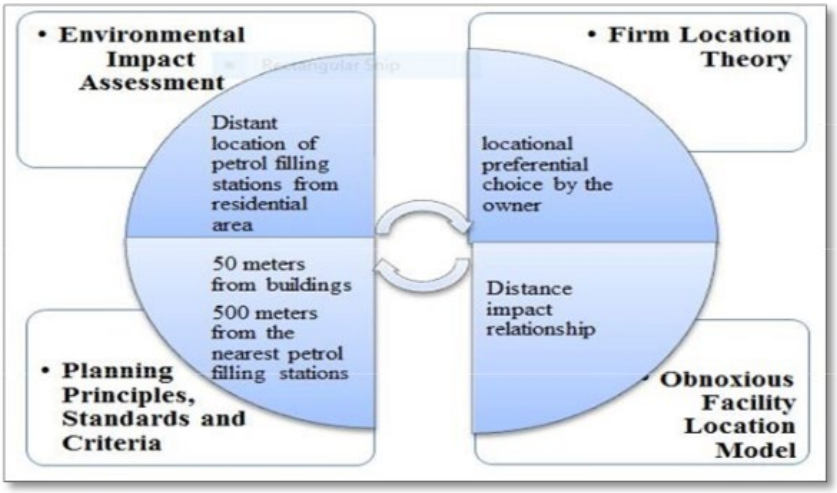

Figure 2- 1 Determinants for the Location of Petrol Filling Stations (source: Public perceptions on location of filling stations in the city of Kitwe in Zambia)

2.4 Theoretical Framework

2.4.1 Location Theory

Traditionally economic theory ignored spatial aspects. Classical economists assumed that economic activity occurred in a static, spaceless world. Isaard has referred to it as a Economic theory has traditionally overlooked geographical aspects. Classical economists assumed that economic activity occurred in a static, spaceless world. It has been described as a "wonderland of no dimensions" by lsaard in his book "Location and Space Economy." Classical economists expressly recognized the importance of time in economic analysis, but their recognition of space and distance considerations was implicit. For decades, spatial phenomena were ignored, and the role of space appeared secondary to time in assessing how the economy (Mbau, 1997).

Nourse (1968) contribution to agglomeration shows that firms can profit by locating adjacent to each other. Agglomeration economies are divided into three classifications. These are transfer econ0omics, internal economics of scale to the firm and external economics of scale to the firm that are internal to the industry(Nourse, 1968). Figure 2.2 shows agglomeration of service stations. When firms adopt a short-term view and ignore the entry of competitors in future there is locational instability of business

(Nyabuti, 1991). In many cases the form of equilibrium arrived at is usually unsatisfactory. Given the case of a service station, which involves huge capital investment relocating could be a financial burden. This makes the investor more cautious, requiring that the investment decision on locational choice be arrived at with a clear and well-calculated foresight The choice of a site should therefore take into consideration the future anticipation of the competitor(s)(Mbau, 1997)

2.4.2 Theory of Location of Fuel Service Stations

Based on the literature review of this study and considering the fact that Fuel Service stations are service activities that are privately owned by entrepreneurs, they could be regarded as firms whose location could also be influenced by the preferential choices of the owners (entrepreneurs). In this respect, a study in Zambia identified four main determinants that could be embedded in the conceptual postulations, i.e., location choices made by the owner of the Fuel Service station; the locational criteria specified by the Environmental Protection Agency Zambia; Guidelines for siting of Fuel Service stations by the Energy Regulation Board of Zambia (2015), and the Planning Principles and Standard of the Town and Country Planning Act (now Urban and Regional Planning Act 2015);and some theoretical formulation regarding obnoxious and inflammatory facilities locations, and the Central Place Theory(Taylor et al., 2016).

The discussion on the theoretical expositions begins with the obnoxious facility location model; Obnoxious facilities location model categorized facilities into two, i.e., desired facilities and undesired facilities. Desired facilities are those which are desired by inhabitants to be placed in closer areas i.e. areas of relatively high population density. Undesired facilities are those which are never desired to be placed in nearby areas by the inhabitants and they are termed under what is known as obnoxious facilities(Rana & Garg, 2014). In a study by Muzenda (2015), it was discovered that petrol Fuel Service stations pose a risk to the environment and are a source of concern in case of fire explosion. Hence, they can be categorized under obnoxious facilities. The location of petrol Fuel Service stations is a very significant issue and the need to consider it's impact under various relevant parameters such as distance, population and access time on a location is of grave importance (Rana and Garg, 2014). Muzenda (2015) also

discovered that these undesired facilities pose a threat to the immediate economic structure of a community. This can be fairly interpreted as having a negative impact on the residential value of property within the area, but having an adverse effect on the value of commercial property within the same neighborhood.

Obnoxious facility location problem deals with the proper placement of such materials which are preferred to be placed far from the populated area to prevent the inhabitants from health-related issues as caused by such facilities (Thomas et al, 2015). If petrol Fuel Service stations are located closer to populated areas, it may be dangerous to the lives of mankind and keeping in view all adverse effects of the petrol Fuel Service stations over the environment, it's population and also its economy, it is thereby crucial to locate obnoxious facilities away from the populate area (Rana and Garg, 2014). This exposition by Rana and Garg (2014) was affirmed by the studies of Mshelia et al (2015) and Afolabi et al (2011), who highlighted on respiratory and other health problems affecting both workers and residents living within close proximity of the Fuel Service stations.

As stated earlier based on a study carried out in Zambia, the location of a Fuel Service station is supposed to be in consonance with the Energy Regulation Board planning principles, and standards and guidelines for sitting of petrol Fuel Service stations. Unfortunately, most petrol Fuel Service station operators fail to adhere to these laws and principles, and instead usually assume that quality of site location is associated with the type and volume of traffic flows passing the site, proximity to a major travel route, visibility from the road, time taken by drivers to slow down to enter the petrol station, general ability to attract customers, road direction or movement, artery types, and distance of catchment areas from residential neighborhoods (Iman, et al., 2009). This means that Fuel Service station operators always have a location preference with the hope of maximizing sales and profits. Hence, they will choose to locate their business at a central place where they feel it will attract a lot of motorists for refueling and as a result, maximize their income (Iman, et al., 2009).

Central place theory essentially concerns places that provide a convenient point of focus for consumers for the purchase of goods and services, and centrality is the essence of

the point of focus(Gbakeji, 2014). Centrality refers to a state of high accessibility, the quality of being at the center of the transportation system (Morrill, 2010; Ayeni, 2011). Thus, it follows that the term: central place is a relative one. It describes the relationship between a point and other points in the surrounding region, and the central place is that point which can be most 'easily' reached from other locations in the region. Hence, this is the desire of Fuel Service station operators; to locate their businesses at a central place where they can attract motorists. The primary concern of Fuel Service station's operators is a central place which would minimize the travel cost of the consumers in gaining access to the services they require and at the same time, give them a great exposure to consumers. Centrality implies that consumers generally use service centres that will enable them satisfy their wants with the minimum effort (Gbakeji, 2014).

Even though a Fuel Service station's operators have locational preferences, it should be understood that, the location of Fuel Service stations generally despite its importance to the economy, is expected to be guided by a defined standard (Kadili et al., 2021). Bolen (1988) stated that, every location on the earth has its analyzable advantages and disadvantages, before the planning permission is granted to construct a petrol Fuel Service station, it is a requirement to conduct an Environmental Impact Assessment (EIA). Lawrence (2007) defined EIA as an aid to decision-making; providing a systematic examination of the environmental implications of a proposed action and alternatives before a decision is taken. Lösch (2014) argued that, a firm seeking to maximize profit (a basic assumption of all economic theory) may choose a certain location to gain a competitive advantage over other firms and locate in a marked area that provides the greatest profit. Locating the market area of greatest profit depends on assumptions of equal costs of transportation and population distribution. He argued that, the more competitive the market, the more firms will be inclined to seek and adjust to the maximum profit location. The location selected will depend in part upon such demand factors such as: Elasticity of product demand, Location of competitors, Importance of proximity to customers, Importance of direct contact with customers, Extent of market area (regional, national, and International) relative competitiveness of the industry(Mbau, 1997).

Iman, et al (2009) stated that, location of petrol Fuel Service stations is usually associated with the type and volume of traffic flows passing the site, proximity to a major travel route, visibility from the road, time taken by drivers to slow down to enter the petrol station, general ability to attract customers, road direction or movement, artery types, and distance of catchment areas from residential neighborhoods. Such physical factors in a site location can make the difference between excellence, mediocrity, or failure in use for service station purposes. With respect to the distance of catchment areas from residential neighborhoods, site proximity to the surrounding residential neighborhoods can be expected to exert significant influence on a petrol station business and also on the value of property located within such neighborhood. This explains the locational preference of petrol Fuel Service stations owners which is based on profit maximization, and it also explains the deterrent towards siting of residential properties close to petroleum Fuel Service stations and other classes of commercial real estate (O'Sullivan, 2005).

In carrying out an environmental site assessment on petrol Fuel Service stations, Mulroy (2012) in his presentation at an Environmental Petroleum Seminar in Mitchelstown County Cork disclosed that, petrol Fuel Service stations are an environmental liability as they are a potential hazard to the environment hence, site investigation and generic risk assessment need to be undertaken in order to institute a remedial plan for mitigating the significant negative impact that petrol Fuel Service station pose to the environment. Hence, due considerations will be made in relation to a petrol Fuel Service station's locational standards and principles as established a country's environmental standard requirements.

2.5 Effects of Fuel Service Stations on Adjacent Properties

Songotola et al (2015) considers the following as some factors responsible for the negative/positive effect, associated with citing petroleum filling stations in close proximity to any residential neighborhood:

i. **Fire outbreak**: The storage of petrol may lead to fuel spillage which can cause fire outbreak if not properly handled. During the inferno, a lot of

lives could be lost and valuable properties destroyed.

ii. **Road accident**: Usually, there is considerable movement of vehicles during fuel scarcity which could lead to accidental collision with structures, people and other vehicles.

iii. **Traffic congestion**: Traffic congestion is a common feature at petrol stations situated very close to each other, near a market place or next to road intersection and junction. Also, traffic congestion occurs during loading and unloading of passengers and goods around the premises of petrol stations. This may be detrimental to residential properties, but beneficial to commercial properties who will likely experience a boost in their product sales or service deliveries as the case may be.

iv. **Hazardous substances**: Some items of stock and chemicals used in general cleaning in service stations can be harmful. Chronic exposure to them through use, accidental spillage or leakage can cause respiratory problems, dermatitis or chemical burns to both employees within the filling station premises and nearby residents.

v. **Pollution:** The volatile organic compounds in petroleum motor spirit pollutes the air with attendant health effects on the inhabitants of the area and the environment in general. Also, such hazardous chemicals tend to react with the paint of buildings, thus damaging the aesthetics of any nearby residential building. In areas where fuel stations are situated very close to rivers, these vapours are potential threats to aquatic life.

Sangotola (2015) furtherly states that in reducing the negative impacts discussed above, he recommended the following control measures in mitigating such negative impacts:

1. Enforcement of required safety regulation and standards for safety in Fuel Service stations;

2. Indiscriminate siting of fuel stations within residential areas should be stopped

to avoid fire outbreaks and accidents during fuel scarcity;

3. Enlightenment campaign to educate petrol station attendants and other staff on the negative health implications of exposure to petrol fumes;

4. Petrol staff should be adequately trained on operational procedures at Fuel Service stations and should be provided with appropriate protective clothing;

5. Storage tanks and dispense pumps should be well maintained and monitored;

6. Provision of sufficient designated parking areas away from tanks and pump;

7. Devise a safe system of traffic movement at Fuel Service stations;

8. Provide mechanical protection to vulnerable structures such as fuel tanks and liquefied natural gas storage areas;

9. Identify hazardous (dangerous) area and control all sources of ignition;

10. All electrical equipment should be suitably insulated and supplied through a circuit protected by a residual current device;

11. Appropriate wet stock management procedures should be used;

12. Use of closed-circuit television, panic alarms and other security measures, store all hazardous substances in their original containers; and

13. Keeping all escape routes and fire exits clear and make regular checks.

2.6 Design Standards of a Fuel Service Station

2.6.1 National Standard

Petroleum Product Seller Regulation-2075

The Petroleum Product Seller Regulation-2075 represents a pivotal step in the regulatory framework governing the petroleum industry, aimed at ensuring efficient, transparent, and environmentally responsible practices within the realm of petroleum

product sales. Enacted in response to the evolving dynamics of the global energy landscape and the increasing significance of sustainable resource management, this regulation stands as a cornerstone for promoting equitable trade, consumer protection, and ecological preservation within the petroleum sector.

Chapter 3 of the regulation includes the guidelines and standards for siting any fuel station. Some of them are:

i. Distance between the fuel Service Station:

- For general Fuel station, distance between two fuel station should be at least 300m radius.
- For packed retailer (selling petroleum in drum) distance from them to any of the nearest fuel station should be at least 5 km
- For model fuel service station, distance between two fuel station or any new fuel station should be at least 10km distance.

For **general petrol pump** the standards are:

i. For **highways** (Tribhuvan, Araniko)

- Area at least 2500 sq. m /8 katthas or 5 ropanees with frontage of 35m;
- Permanent structure of selling area with plinth of at least 95sq. m;
- 1.20 m height of compound wall with 0.90 m chaneling fence at three side of the land;
- 10x20x6.5m canopy with fire resistant material;
- For fire safety, Fire retardant system;

Stored Pressure Trolley Type 50-70 KG DCP-2 nos., stored Pressure 10 KG DCP ABC Type- 8 nos., 2000l capacity pvc water storage tank;

- Emergency shut off system;
- Public toilet with 2 male, 2 female and 1 universal;
- Provision of Safe drinking water; coffee shop
- Parking with both heavy and light vehicles.
- Provision of greenery in Buffer strip along with the small height tree, plant plantation.

ii. For roads of **Kathmandu Metropolitan City**

- Minimum area of 750 sq.m or 4 katthas or, 2 ropanees 6 aanas with frontage 25m;
- Permanent structure of selling area with plinth of at least 47 sq. m;
- 1.20 m height of compound wall with 0.90 m channeling fence at three side of the land;
- 6x12.5x5m canopy with fire resistant material;
- 2nos 12K.L of storage tank;
- For fire safety, Fire retardant system;

stored Pressure Trolley Type 50-70 KG DCP- 1nos., Stored Pressure 10 KG DCP ABC Type-6nos.

- 1000l capacity pvc water storage tank
- Provision of public toilet with 1 male, 1 female and 1 universal.
- Provision of Safe drinking water;
- Parking with both heavy and light vehicles.
- Provision of greenery in Buffer strip along with the small height tree, plant plantation.

iii. For general petrol pump **before regulation**

- Minimum area of 750 sq.m or 2 katthas or, 1 ropanees 8 aanas with frontage 20m;
- Permanent structure of selling area with plinth of at least 47 sq. m;
- 3' to 5' height of compound wall
- 6x6 canopy with fire resistant material;;
- For fire safety,10kg extinguisher- 4nos; 1000l capacity pvc water storage tank
- Provision of public toilet with 1 male, 1 female and 1 universal.
- Provision of Safe drinking water;
- Provision of greenery in Buffer strip along with the small height tree, plant plantation.

For **model petrol pump** the standards are:

- For hilly and Himalayan region area required is 5 ropanees of land and street face of 40 m land. (For terai -1 bigha of land)
- 12mx12m canopy covering the refilling area is required.
- Public toilet should be provided with 2 male, 2 female and 1 universal.
- Separate selling area, office and drinking water should be provided.
- For fire safety fire retardant system should be provided.
- Hoarding board with 20 feet height with proper signage should be provided.
- Should be open for 24 hour.
- Vending Machine, Convenient Store, card swapping facilities should be provided.
- Restaurant serving at least 20 people should be provided.
- Parking facility for at least 20 vehicles with 500 sq. m area should be provided.
- Provision of Emergency pump shut off during sensitive condition
- Underground storage tank should be provided in the open area. (no structures are allowed to be built on its surface)

Figure 2- 2 3D of model petrol pump (source: Petroleum Product Seller Regulation-2075)

Figure 2- 3 Masterplan of model petrol pump (source: Petroleum Product Seller Regulation-2075)

2.7 Urban Planning and Planning for Service Stations

Motor vehicle fuel service station owners and dealers express a preference for having a station on nearly any busy road, emphasizing the continual necessity for a clear planning policy regarding their placement. Planning authorities should address several key questions: Firstly, what impact would a service station have on traffic flow and road safety? Secondly, does the proposal align with the overall development plan, especially in terms of compatibility with neighboring land uses? Thirdly, what would be the effect on amenity? Lastly, are the location, layout, and design of the station satisfactory? This comprehensive evaluation ensures a well-informed and balanced approach to fuel service station planning.

Therefore, planning primarily prioritizes road safety and minimizing harm to amenity rather than the actual necessity of a service station, which is challenging to gauge. Given that most vehicles cover significant distances without an immediate need for fuel, planning for service stations becomes necessary only in exceptional cases. In practical

terms, obtaining planning consent for service stations proves challenging. While service stations are essential in town centers and near local shopping areas, their integration should align with existing surroundings, ensuring accessibility, visibility, and the prevention of traffic hazards.

The ideal location for a new service station is on the main roads entering a town at the periphery of the built-up area. In large towns, proximity to major road junctions, especially radial and ring roads, is preferred for service station placement. Planning consent is typically not granted for fast open stretches of road, bypasses shorter than 19km, or locations like opposite breaks in central reservations in dual carriageways or "too close" to side road connections or roundabouts. While having service stations opposite each other on the same road is generally discouraged, exceptions may be considered where traffic slows down, provided other criteria are met. Adhering to planning standards, the design and layout of service stations significantly impact the overall appearance of the built-up environment.

2.7.1 Traffic Flow and Road Safety

The fundamental purpose of a road is to facilitate the movement of traffic at the highest safe speed possible. The road's capacity is influenced by its width and the average speed of the traffic it accommodates. Traffic speed, in turn, is primarily determined by the road's alignment and the degree of interference from factors such as cross traffic, turning at junctions, access points, and traffic signals. For service stations, visibility is crucial, and they should be perceptible to approaching drivers from both directions, with a minimum visibility requirement of 100 meters for a 40mph speed limit and 65 meters for a 30mph speed limit. These distances align with the recognized minimum stopping distances for the respective speeds.(Sedgwick & Westbrook, 1969)

2.7.2 Provision of Amenities

If a site possesses aesthetic qualities, planning authorities should aim to preserve its pleasant character, ensuring that only suitable developments occur. The key consideration is whether a proposed development aligns with appropriateness and harmony. Notably, in the zoning of urban land use, no specific land is designated for

fuel service station use. Consequently, service stations often depend on a change of use from other land categories, particularly residential and commercial. However, in certain instances, planners may designate a site explicitly for a service station. Given that service stations are part of areas with mixed development and various land uses, careful design and placement are essential to ensure they seamlessly integrate with their surroundings (Oyesile et al., 2018)

CHAPTER-3: CASE STUDY

A case study of only existing model fuel station in Kathmandu Metropolitan City was done. Shree Satya Narayan Pvt. Ltd is Situated in Balaju, Kathmandu-16. It was established in the year 2079 B.S and has been recently operated as a model petrol pump. The fuel station is about 800 m far from the nearest fuel station i.e Shree Chakrapath Fuel Centre, Balaju. Here the standard distance set for the model fuel station has not been followed and also possess higher vulnerability to the adjacently situated Siddhartha Vanasthali Institute.

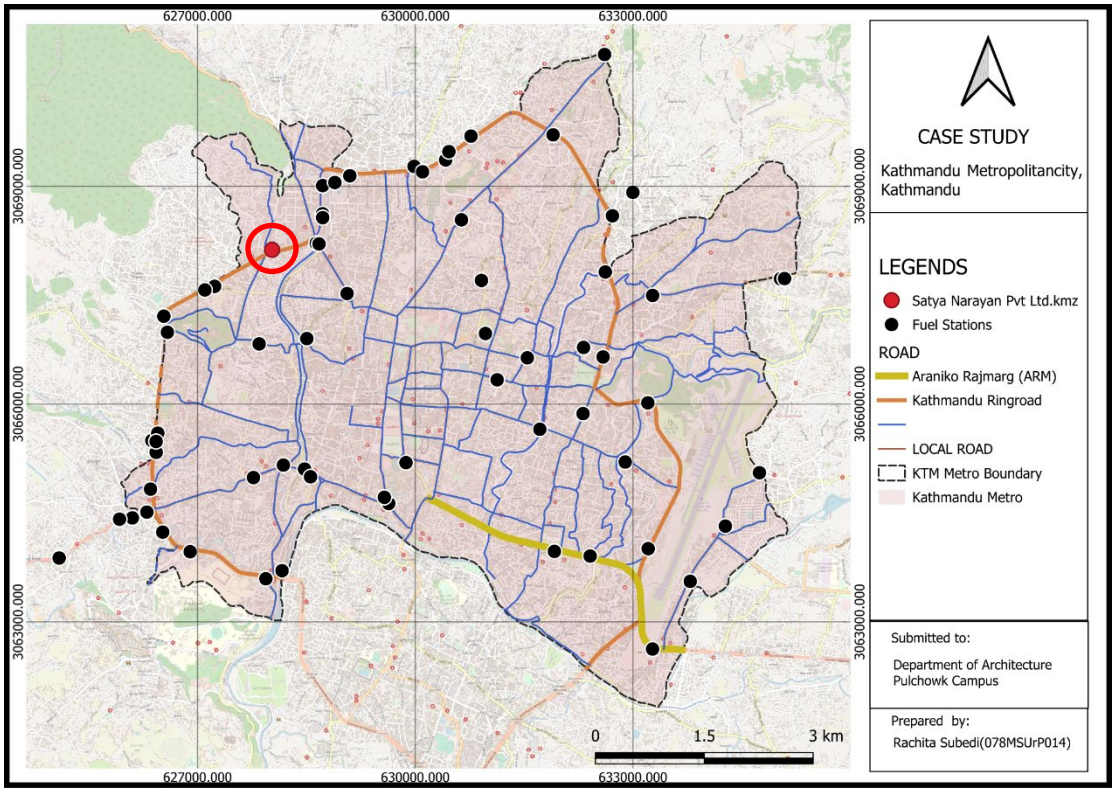

Figure 3- 1 Mapping of model fuel station

However other infrastructural standards like fire safety, setbacks, buffer area, ticket counter, restaurants, toilets and parking has been strictly implemented in this fuel station.

Figure 3- 3 Setback followed

Figure 3- 2 Separate entry and exit

Figure 3- 5 Taxi parking facilty

Figure 3- 4 Bike parking facility

Figure 3- 7 Buffer area provided with greeneries

Figure 3- 6 Site plan mentioned

Figure 3- 9 Restaurant provided

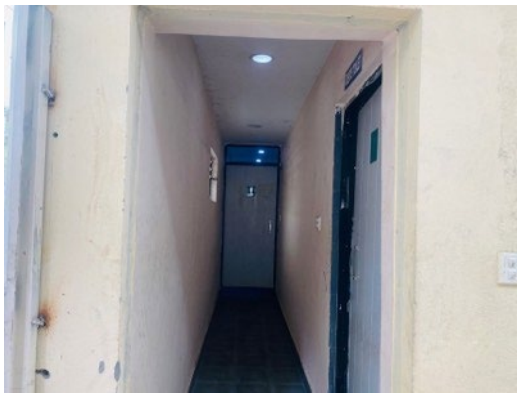

Figure 3- 10 Separate restrooms

Figure 3- 8 Ticket counter

Figure 3- 11 Fire Extinguishers

Figure 3- 12 Proper Signage

CHAPTER-4: METHODOLOGY

This chapter includes the overview of overall research work. The research has been performed with a review of literature on the spatial distribution and locational impact of fuel service stations. Collection of primary data was done by conducting questionnaire survey from the household nearby. The obtained data was analyzed by using SPSS v 26 statistical tool and MS Excel to draw conclusions. The natures of the studies that were collected through literature review were location specific and the outcomes were not globally transferable to each other. Hence literature review as well as key informants' interview were performed in order to develop the questionnaires for this research. The flow chart of overall research design is presented in the Fig. 3.1.

4.1 Research design

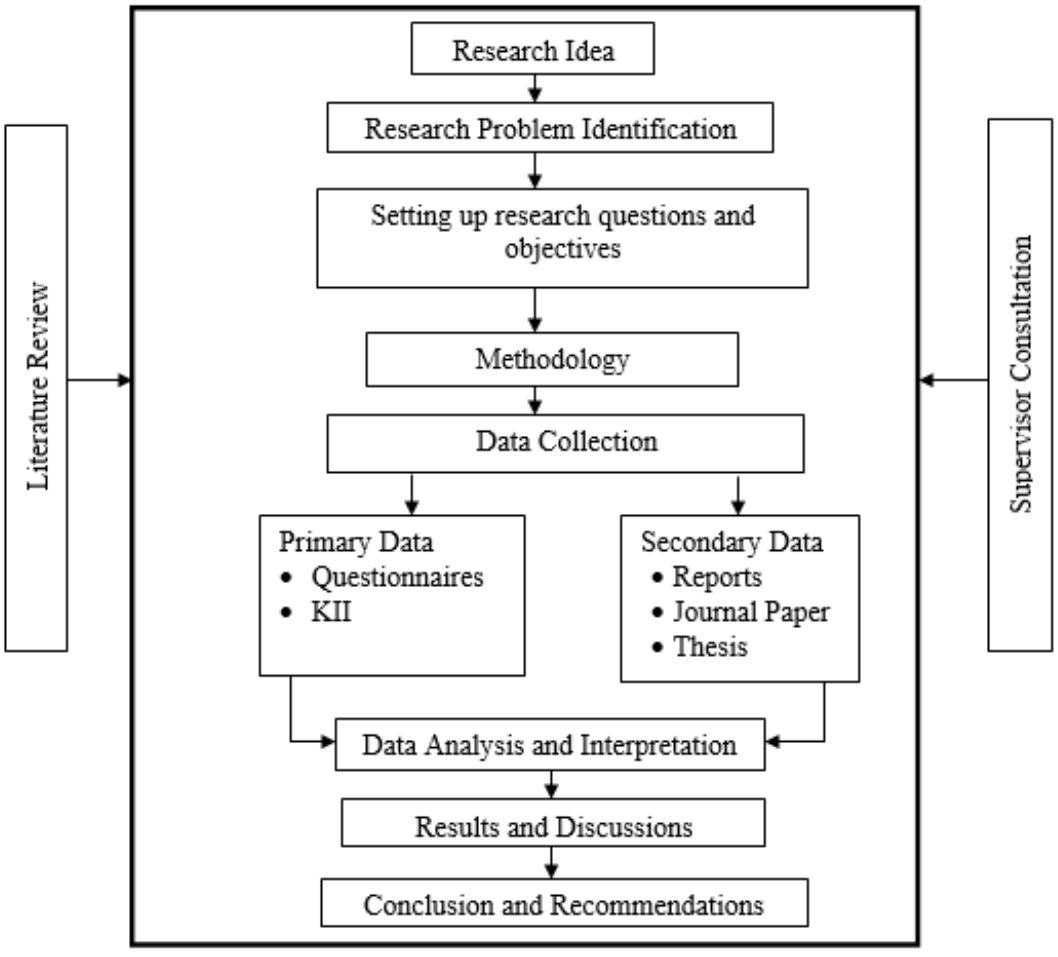

Figure 4- 1 Research Process Flow Chart

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4.2 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 thesis 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.

4.3 Study Area

Kathmandu is the capital and eldest metropolitan city of Nepal. The city is the urban core of the Kathmandu Valley in the Himalayas, which also contains two sister cities namely Patan or Lalitpur, 5 kilometers (3.1 mi) to its southeast and Bhaktapur, 14 kilometers (8.7 mi) to its east. It is also acronymic as ‘KTM’.

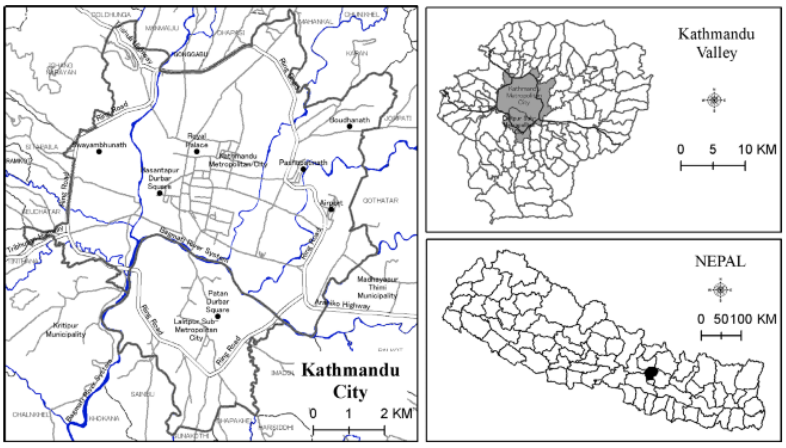


Figure 4- 2 Study area – Kathmandu in its spatial context.

4.3.1 Size and Location

Kathmandu is a Metropolitan City, which is located in Kathmandu district, Province No. 3 of Nepal. Kathmandu has total 32 wards, which are scattered across 49 square kilometers of geographical area. It is located 85.333336. 27°27′E to 27°49′E longitude and 85°10′N to 85°32′N latitude. It is located in the Kathmandu Valley, a large valley in the high plateaus in central Nepal, at an altitude of 1,400 metres (4,600 feet).

Kathmandu and adjacent cities are composed of neighbourhoods, which are utilized quite extensively and more familiar among locals. However, administratively the city is divided into 32 wards, numbered from 1 to 32.

The city is bounded by several other municipalities of the Kathmandu valley: south of the Bagmati by Lalitpur Metropolitan City (Patan), with which it forms one urban area surrounded by a ring road, to the southwest by Kirtipur and to the east by Madhyapur Thimi. To the north the urban area extends into several municipalities; Nagarjun, Tarakeshwor, Tokha, Budhanilkantha, Gokarneshwor and Kageshwori Manohara.

4.3.2 Climate

The city generally has a climate with warm days followed by cool nights and mornings. Unpredictable weather is expected, given that temperatures can drop to 1 °C (34 °F) or less during the winter. During a 2013 cold front, the winter temperatures of Kathmandu dropped to −4 °C (25 °F), and the lowest temperature was recorded on 10 January 2013, at −9.2 °C (15.4 °F). Rainfall is mostly monsoon-based (about 65% of the total concentrated during the monsoon months of June to September), and decreases substantially (100 to 200 cm (39 to 79 in)) from eastern Nepal to western Nepal. Rainfall has been recorded at about 1,400 millimetres (55.1 in) for the Kathmandu valley, and averages 1,407 millimetres (55.4 in) for the city of Kathmandu. On average humidity is 75% The chart below is based on data from the Nepal Bureau of Standards & Meteorology, Weather Meteorology for 2005. The chart provides minimum and maximum temperatures during each month. The annual amount of precipitation was 1,124 millimetres (44.3 in) for 2005, as per monthly data included in the table above.[31] The decade of 2000–2010 saw highly variable and unprecedented precipitation anomalies in Kathmandu. This was mostly due to the annual variation of the southwest monsoon(*DHM*, 2023.).

4.2.3 Air quality

Air pollution is a major issue in the Kathmandu Valley. According to the 2016 World Health Organization's Ambient Air Pollution Database, the annual average PM2.5 (particulate matter) concentration in 2013 was 49 µg/m3, which is 4.9 times higher than recommended by the World Health Organization.

4.2.4 Demographics

Kathmandu's urban cosmopolitan character has made it the most populous city in Nepal. According to the National Population Census of 2011, the total population of Kathmandu city was 975,543 in 254,292 households with an annual growth rate of 6.12% with respect to the population figure of 2001.

In one decade, the population increased from 427,045 in 1991 to 671,805 in 2001. The

population was projected to reach 915,071 in 2011 and 1,319,597 by 2021. To keep up this population growth, the KMC-controlled area of 5,076.6 hectares (12,545 acres) expanded to 8,214 hectares (20,300 acres) in 2001.

Also, due to high population growth, more residential facilities are springing up thereby creating competition for the use of the land spaces, as the Kathmandu Metropolitan City happens to be the regional capital and administrative centre, more commercial activities are linked to it and the entrepreneurs would want to catch on this opportunity of high demand for fuel products by way establishing stations to meet these demands. The subject areas assessed include Sinamangal, Nayabazaar and along Kalanki National Highway.

4.4 Study Population, Sample Selection and Sample Size

3.4.1 Study Population:

The study population for this thesis would include various groups of interest that are relevant to the research objectives. In this case, the study population consist of the following:

Fuel Service Stations: The population would encompass all fuel service stations within the geographical boundary of Kathmandu City, Nepal.

Policymakers and Urban Planners: This group includes individuals holding policymaking and urban planning roles within governmental and municipal organizations responsible for the city's development.

Fuel Station Operators: The population would involve owners and operators of fuel service stations in Kathmandu.

Community Members: The population would comprise residents and commuters in different areas of Kathmandu who are directly affected by the presence and distribution of fuel service stations.

4.4.2 Sample Selection:

The sample selection process involves identifying a representative subset of each study population to gather data efficiently and effectively.

For policymakers, urban planners, fuel station operators, and community members, a purposive sampling technique is appropriate to ensure that individuals with relevant expertise and experiences are included in the study.

The sample size depends on the research objectives, available resources, and statistical considerations. For fuel service stations, the sample size should be large enough to capture the diversity of locations and distribution patterns. For stakeholders like policymakers and urban planners, a sufficient sample size should be needed to ensure a representative understanding of their perspectives. A balance between adequacy and practicality is essential in determining the sample size.

4.5 Method of Data Collection

The study was based on primary as well as secondary data to assess the spatial distribution and locational impact of fuel service stations.

4.5.1 Primary Data Collection:

For the collection of primary data, following methods was used:

a. **Surveys**:

Structured surveys were designed and conducted to gather quantitative and qualitative data from key stakeholders, including policymakers, urban planners, fuel station operators, and community members. The survey questions should focus on their perceptions, preferences, and experiences related to fuel service station locations and their impact.

b. **Interviews**:

Semi-structured interviews were conducted with selected stakeholders to gain more

in-depth qualitative insights on the spatial distribution and locational impact of fuel service stations. Interviews can allow for open-ended responses and follow-up questions to understand stakeholders' perspectives better.

c. **Field Observations**:

Field observations to directly observe the spatial distribution of fuel service stations, traffic patterns, and environmental conditions in specific locations of Kathmandu. Field observations can complement other data collection methods by providing real-time information.

d. Traffic Data Collection:

Quantitative data will be collected on traffic flow and congestion around selected fuel service stations using various techniques, such as manual traffic counts, and video recordings.

4.5.2 Secondary Data Collection:

For the collection of primary data, following methods was used:

a. Geographic Information Systems (GIS) Data:

Obtain GIS data from relevant sources to map the locations of fuel service stations and analyze their spatial distribution patterns. These data can be acquired from municipal databases, transportation authorities, or other spatial data repositories.

b. Environmental Data:

Secondary data on air quality from air monitoring stations, meteorological departments, or environmental agencies to assess the environmental implications of fuel service station locations will be collected.

c. **Academic Papers and Journals:**

Conduct a comprehensive literature review to gather information from academic papers, research articles, and journals that offer insights into the spatial distribution and

locational impact of fuel service stations in urban areas.

4.6 Data Analysis

Mugenda (1999) highlights the challenge of interpreting raw data obtained from the field, emphasizing the need for analysis to construct an intellectual model. This model aims to elucidate relationships between variables, enabling the derivation of meaningful inferences that go beyond the raw facts and figures, contributing to objectivity. To streamline the collected data, coding of close-ended questionnaires was essential. After coding, all questionnaires were processed using the Statistical Package for Social Scientists (SPSS). For qualitative data that couldn't be coded, a descriptive summary was presented through tables, pie charts, and plates. The SPSS package facilitated the extraction of frequencies and percentages, as well as the determination of means, smallest, and highest values for various variables.

4.7 Limitations of the Research

The research focuses on the spatial distribution and locational impact of fuel service stations at the city level. While this provides a valuable overview, it may not capture fine-scale variations within different neighborhoods or specific areas. Local variations and micro-level impacts may be missed, limiting the ability to provide detailed insights for specific localized interventions.

Among 79 fuel station of the Kathmandu metropolitan City, only three of them were chosen for assessing the locational impact. 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 study primarily focuses on the locational impact of fuel service stations on traffic congestion, air quality, land use, and socio-economic factors. However, there may be other significant impacts and variables that are beyond the scope of this research, such as noise pollution, groundwater contamination, and cultural heritage considerations. These additional factors could provide a more comprehensive understanding of the overall impact of fuel service stations. The findings and recommendations of this research may be specific to the context of Kathmandu City and may not be directly

applicable to other cities or regions. The unique urban characteristics, topography, and socio-economic dynamics of Kathmandu may limit the generalizability of the study's results to different geographical settings. Conducting a comprehensive analysis of the spatial distribution and locational impact of fuel service stations requires sufficient time and resources. Time constraints may limit the scope and depth of the study, potentially leaving certain aspects unexplored or providing a snapshot rather than a longitudinal assessment.

It is important to acknowledge these limitations to provide a realistic understanding of the research's scope and potential implications. Despite these limitations, the research can still provide valuable insights and recommendations for addressing the spatial distribution and locational impact of fuel service stations in Kathmandu City.

4.8 Research Matrix

To achieve the desired objective of research, various surveys and analysis were performed. The detail of research activity is mentioned on Table 4.1.

Table 4- 1 Research Matrix

Objective	Data Required	Data Source	Tools/Analysis	Outcomes
To assess the spatial distribution patterns of fuel service stations in Kathmandu Metropolitancity..	GIS data on fuel service station locations	Literature review, KII, Responses from the respondents	Spatial analysis using GIS, nearest neighbor analysis,	GIS-based mapping of fuel service stations in Kathmandu. Spatial analysis to identify clustering or dispersion patterns.
To analyze the locational impact of fuel service stations on traffic flow and congestion..	Traffic data collected around fuel service stations.	KII and Secondary Data	Quantitative traffic flow analysis, traffic simulation models.	Traffic data collection around selected fuel service stations.

To evaluate the environmental implications of fuel service station locations on air pollution levels.	Air quality data from monitoring stations.	Survey questionnaire	Quantitative air quality analysis, statistical analysis.	Collection of air quality data from monitoring stations near fuel service stations. Quantitative analysis of air pollution levels in proximity to fuel stations. Assessment of the contribution of fuel stations to air quality degradation.
To examine the compatibility of fuel service station locations with surrounding land uses.	Surveys and interviews with community members and stakeholders.		Thematic analysis of qualitative data, content analysis of documents and reports.	

CHAPTER-5: RESULTS AND DISCUSSIONS

The study aimed at assessing the locational of fuel stations in Kathmandu Metropolitan City. This chapter specifically delves into fuel stations within Kathmandu, examining residents' perceptions regarding the stations' locations concerning factors like congestion, pollution, and safety.

5.1 Spatial Analysis

5.1.1 Mapping of the Fuel Service Station

Fuel Service station are listed according to its chronological establishment. The list of existing fuel service station is provided by the Nepal Oil Corporation. The distance between each fuel station with their nearest fuel station is also measured to see the compliance with standard.

Table 5- 1 List of fuel stations

S.N	List of Fuel Station	Address	Date of Establishment (B.S.)	Distance From the nearest fuel Station
1	Shree Mayaram Volaram	Tripureshwor	2030	95
2	Shree Mali Oil Store	Kalimati	2030	300
3	Shree Jayanti Oil Store	Tripureshwor	2036	95
4	Shree Ripumardani Petrol Station	Bhadrakali	2037	1000
5	Shree Prahari Kalyan Kosh Petrol Pump	Nakshal	2039	100

6	Shree Kanak Trade Centre	Teku	2040	120
7	Shree Kumari Oil Store	Battisputali	2042	840
8	Shree Kota Dhuku Oil Store	Balaju	2043	30
9	Shree Shyama Oil	Kalanki	2044	200
10	Shree Bandana Oil Stores	Jadibuti	2045	900
11	Shree Dakhsinkali Oil Stores	Balkhu	2045	280
12	Shree D. M Oil Store	Kalanki	2046	300
13	Shree Chakrapath Fuel Centre	Balaju	2047	370
14	Shree Bagmati Petrol Centre	Tinkune	2048	200
15	Shree Baba Oil Stores Pvt. Ltd	Kalanki	2048	170
16	Shree Aakash Jogini Enterprises	Gongabu	2049	220
17	Shree Matadevi Oil Stores	Sitapaila	2049	50
18	Shree Baral Oil Stores	Jorpati	2049	50
19	Shree Jay Kumari Enterprises	Nayabazar	2049	780
20	Shree Ambe Petroleum	Niakap	2049	500
21	Shree Shrestha Oil Distributers	Tilganga	2049	1161

22	Shree Trilochan Enterprises	Lazimpat	2049	485
23	Shree Harisiddhi Oil Stores	New Baneshwor	2050	1000
24	Shree Valley Fuel Centre	Ganeshwor	2050	870
25	Shree Hama Oil Pvt. Ltd	Swayambhu	2051	620
26	Shree Khadka Oil Suppliers	Golfutar	2051	200
27	Shree Puja Kothi Petrol Pump	Gonagabu	2052	315
28	Shree Three Brothers Oil Stores	New Baneshwor	2052	480
29	Shree Trshul Oil	Kalanki	2052	300
30	Shree Sita Trade Centre	Kalanki	2054	475
31	Shree MaitiDevi Petroleum Suppliers	Jadibuti	2054	1260
32	Shree Kamakhya Oil Stores	Koteshwor	2054	660
33	Shree Sano gaucharan Oil Stores	Gyaneshwor	2054	600
34	Shree Ganapati Oil Trading	Bafal	2054	100
35	Shree Aradhana Traders	Sifal	2055	320
36	Shree Chuchhepati Fuel Centre	Boudhha	2055	1100

37	Sita Care Pvt. Ltd.	Siyuchatar	2056	1200
38	Shree Rajdhani Oil Store	Dhumbarahi	2057	780
39	Shree Jay Goma Ganeh Oil Stores	Gairidhara	2057	825
40	Shree Newa Trade Concern	Indreni	2058	770
41	Shree New Pushpanjali Fuel Concern	Jaybageshwori	2058	320
42	Shree City Trading Pvt. Ltd.	Balaju	2058	770
43	Shree Taleju Bhawani Trade Centre	Gongabu	2058	150
44	Shree Alite Fuel Concern	Dhumbarahi	2058	800
45	Shree Tapasya Traders	Sinamangal	2058	1000
46	Shree Narayani Petrol Centre	Bafal	2058	150
47	Shree Sai Enterprises	Balaju	2059	40
49	Shree New Banglamukhi Oil Store	Sano Vryang	2059	135
50	Shree Makalu Oil Stores	Kalanki	2059	340
51	Shree Krystal Fuel Suppliers	Balaju	2059	360
52	Shree National Trading Ltd.	Teku	2061	110
53	Shree Halchowk Fuel Station	Halchowk	2064	200

54	Shree New Baba Oil Stores	Kalanki	2065	470
55	Shree Sajha Pasal Sewa Sahakari	Balkhu	2065	280
56	Shree H.R Housing and Oil Stores	Kapan	2066	450
57	Shree Sherpa Oil Stores Pvt. Ltd.	Tokha	2066	300
58	Shree Bhadra Fuel Concern	Kapan	2066	300
59	Shree Prahari Kalyan Kosh Petrol Pump	Gongabu	2067	90
60	Shree Samriddhi Oil Stores	Gothatar	2067	950
61	Shree OM Shiva Sai Oil Pvt Ltd	Pepsicola	2068	917
62	Shree Satya Narayan Pvt Ltd.	Balaju	2073	800

The listed fuel stations are then mapped in QGIS to see the spatial distribution.

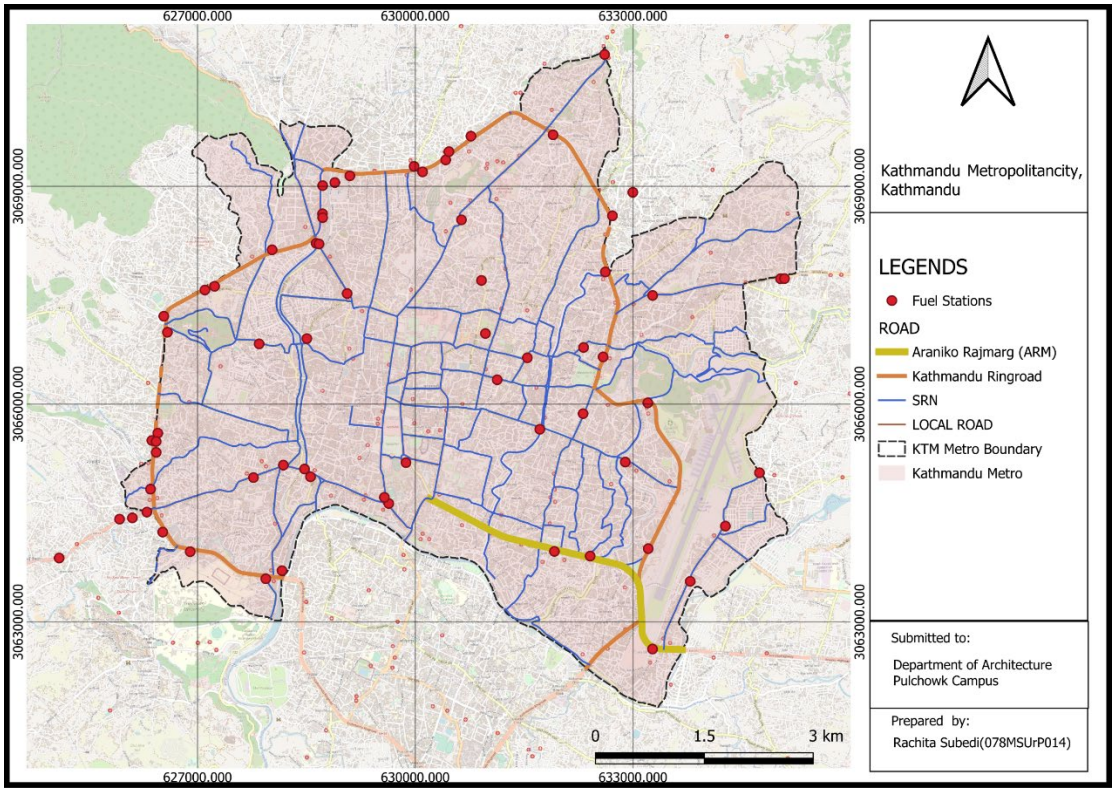


Figure 5- 1 Mapping of fuel station

5.1.2 Nearest Neighbor Analysis

In achieving the first objective, which is to determine the distributional pattern of the fuel stations, nearest neighbor analysis was brought to bear. This attempts to measure the distributions according to whether they are clustered, random or regular. Nearest neighbor analysis was used to determine the distribution pattern of facilities, and has a distribution spectrum that ranges from random, regular to cluster. The nearest petrol stations neighbors to each of the fuel stations were determined with the nearest neighbor distance for each of the fuel station documented using the software ArcGIS. Having determined the area the study area and ascertained the total number of petrol filling stations, the formulae below was thus applied in determining the distribution pattern;

$$Rn = \frac{\bar{D}(Obs)}{0{\cdot}5\sqrt{\frac{a}{n}}}$$

Rn is the nearest neighbor value; D (Obs) is the mean observed nearest neighbor distance; a is the area under study; and n is the total number of petrol filling stations. The nearest neighbour formula will produce a result between 0 and 2.15, where the following distribution patterns form a continuum:

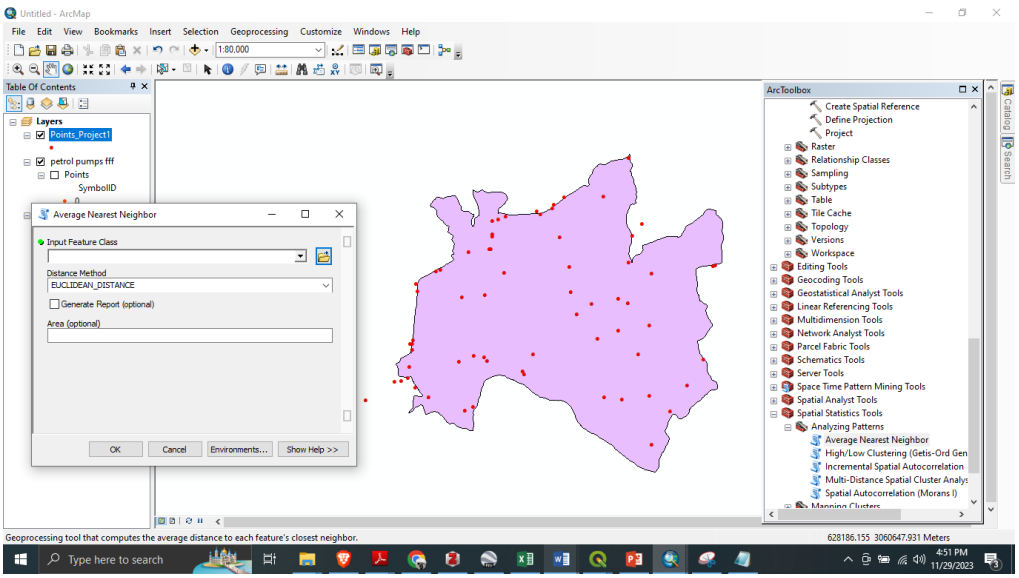
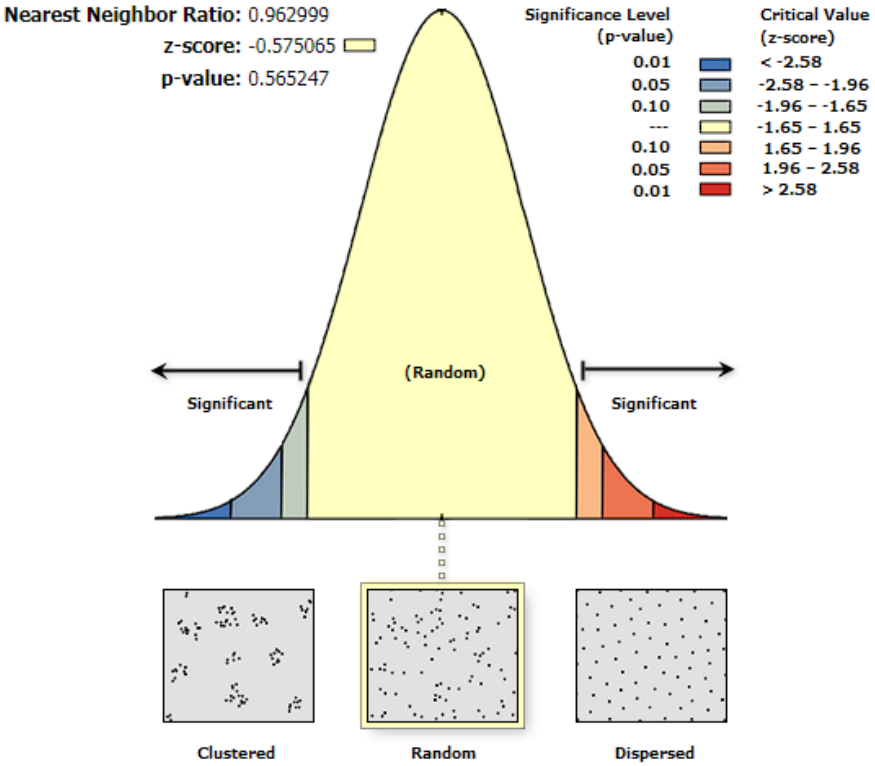


Figure 5- 2 Nearest Neighbor analysis using ARCGIS

Average Nearest Neighbor Summary



Average Nearest Neighbor Summary

Observed Mean Distance:	416.7485 Meters
Expected Mean Distance:	432.7611 Meters
Nearest Neighbor Ratio:	0.962999
z-score:	-0.575065
p-value:	0.565247

Dataset Information

Input Feature Class:	Points_Project1
Distance Method:	EUCLIDEAN
Study Area:	49442496.503700
Selection Set:	False

The negative Z value indicates that a clustered pattern exists.

a. Administrative Division

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

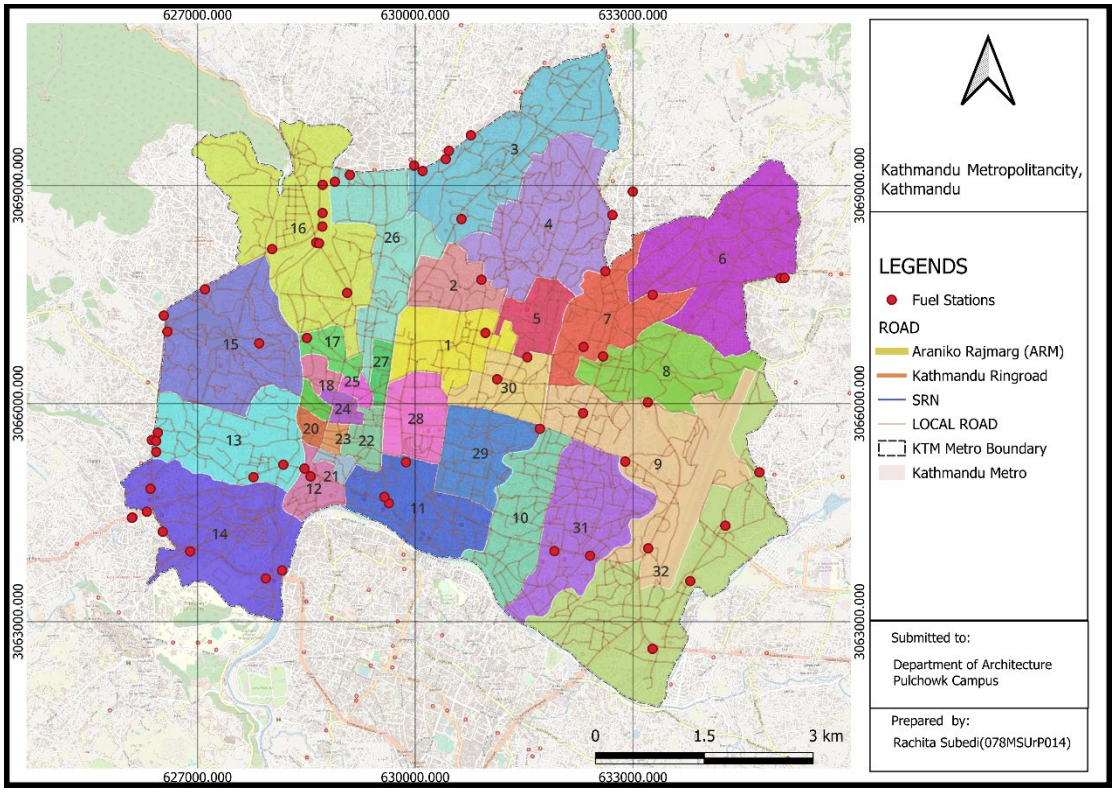


Figure 5- 3 Distribution of fuel station according to wards

From the spatial analysis of Fuel Service Station according to wards; we see maximum clustering of fuel station in wards 3, 13, 14, 15, 16, 26 whereas the core area constituting of wards 20, 21,22,23,24 25 has no fuel stations. According to NOC spokesperson, being guided by the bye law of world heritage site could be one of the reason for not having any fuel station over there. Apart from those wards each ward is connected to at least a fuel station.

b. Road

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

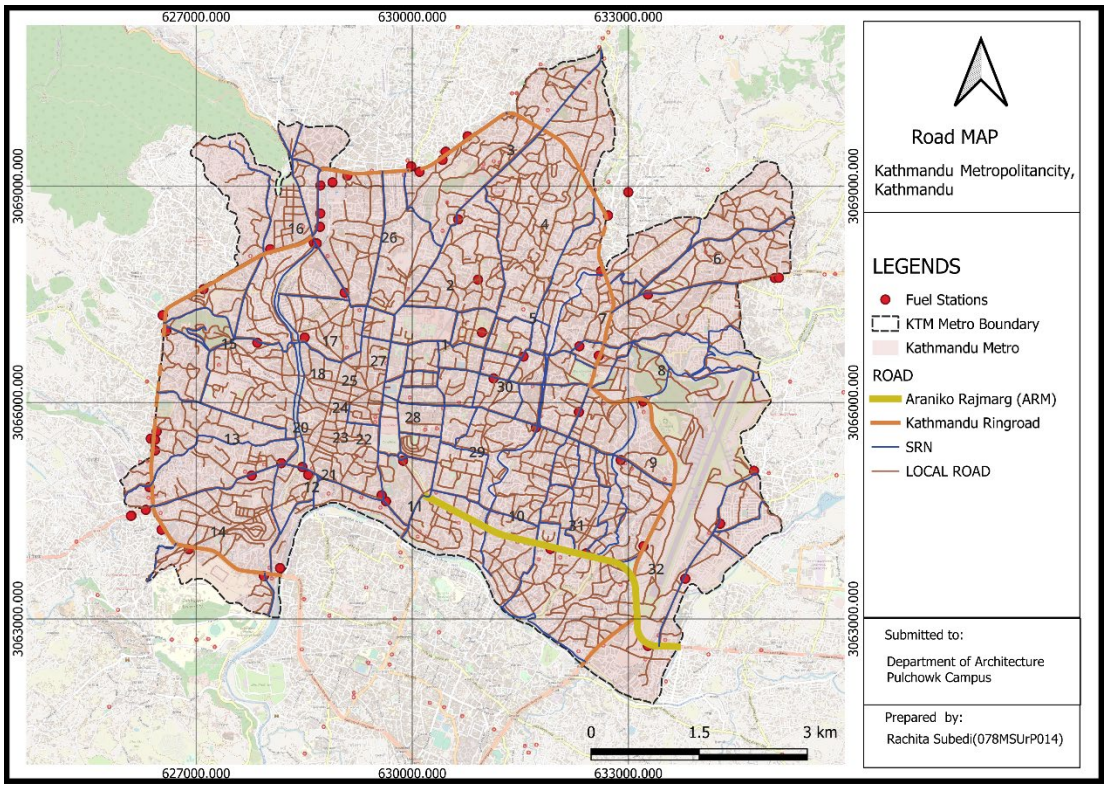


Figure 5- 4 Mapping of Fuel Service Station with respect to road

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.

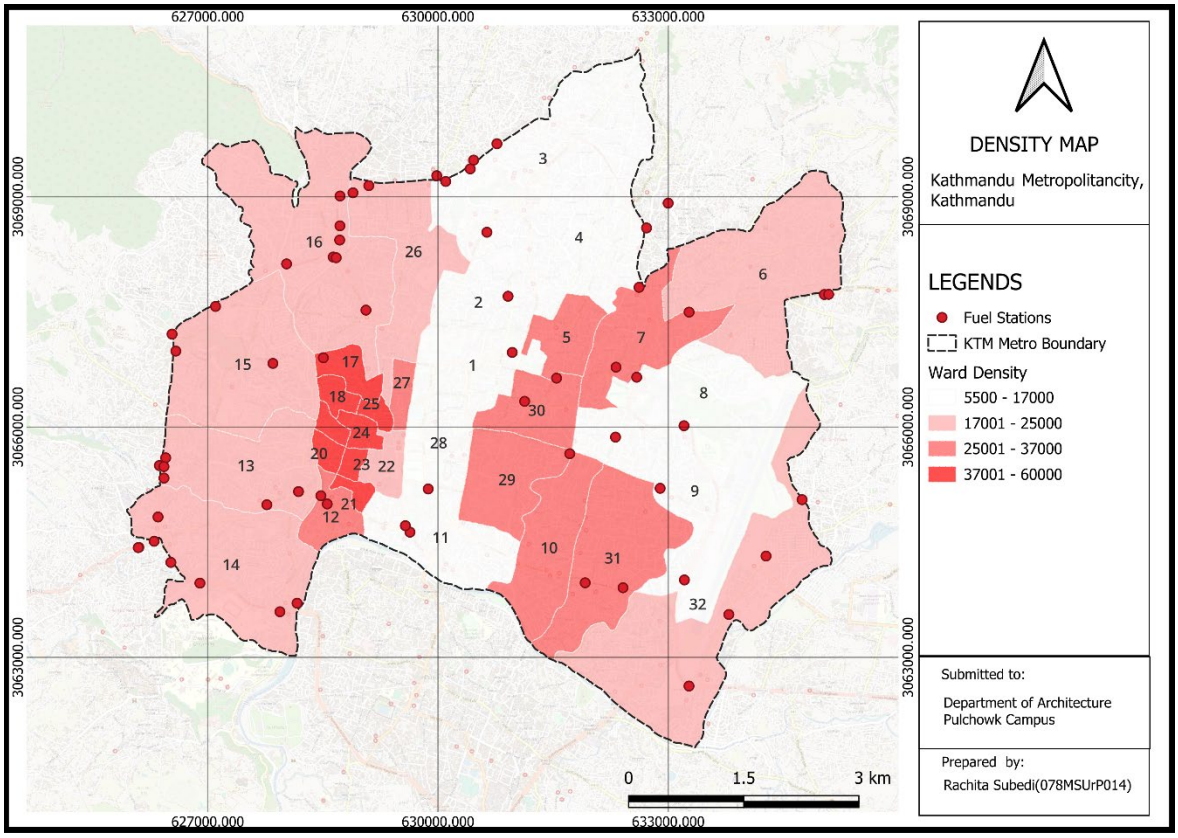


Figure 5- 5 Mapping of Fuel Service Station with respect to density of the wards

The spatial analysis of fuel service stations in correlation with ward density reveals insightful patterns in the urban landscape. The GIS mapping and statistical analysis indicate a non-uniform distribution of fuel stations across wards, with discernible clusters in specific regions. Wards characterized by highest population density (37000-60000) tend to exhibit a only one in the number of fuel stations, which consist of the heritage and religious sites. Bye laws guiding the religious site could be the reason behind it. Wards characterized by higher population density (17000-37000) exhibits higher number of Fuel stations potentially reflecting market demand or economic activities.

5.2 Locational Analysis

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.

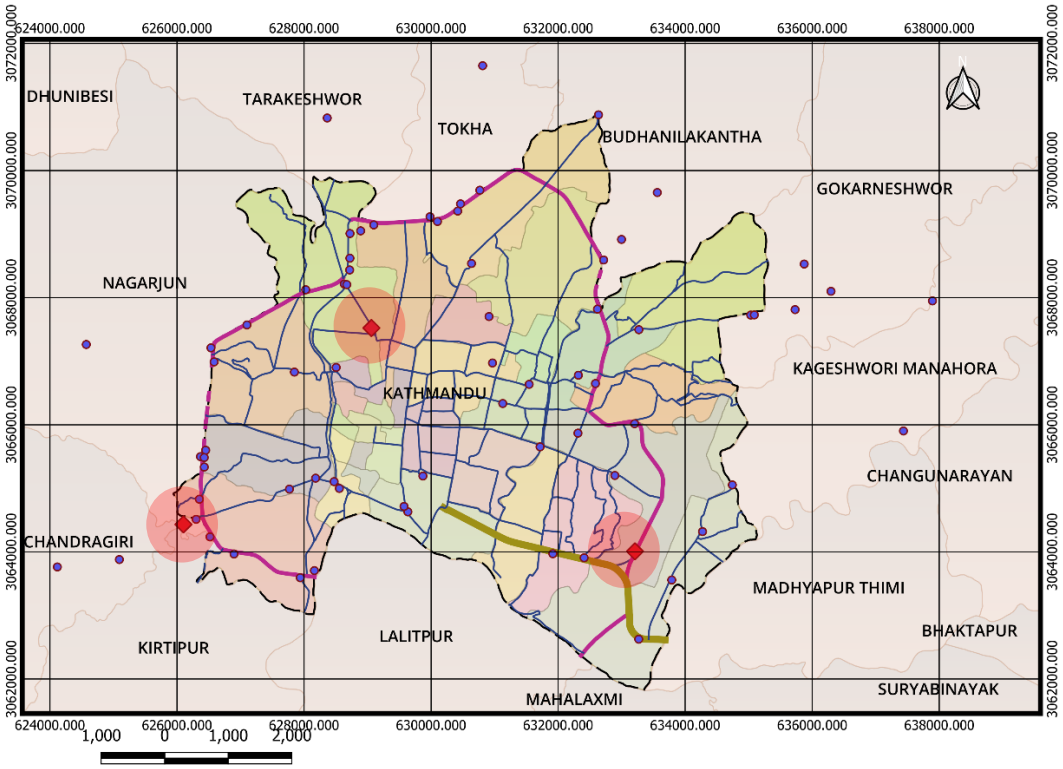


Figure 5- 6 Site for locational analysis

5.2.1 Location decision

All three of the operators responded the selected location offered easy access to major roads and with Shyama oil store accessing the highways, ensuring that it is convenient for both local residents and passing motorists to refuel their vehicles.

Shree Jay Kumari Enterprises, Nayabazar considered the area's potential for future growth, as selecting a location in an expanding population could lead to increased business over time.

The response of "no" from fuel station operators indicating that they did not encounter any challenges during the process of choosing the station's location and that the installation was easy due to the absence of regulations suggests a straightforward and unobstructed experience in selecting the location. The inference drawn from this response is that the lack of regulations at the time of installation might have contributed to a simplified location selection and installation procedure.

5.2.2 Impact on Business

They responded the location of their fuel service station had a significant impact on their business performance and customer traffic. The strategic placement of their station in a high-traffic area with easy accessibility to major roads and commercial centers has been their key driver.

The Jay Kumari Enterprises responded being situated in a densely populated area has enabled them to tap into a consistent customer base. The station's presence within a community has established as a convenient refueling option for local residents.

5.2.3 Traffic Flow and accessibility

They responded the location of their fuel service station has cause a congestion during office hours and festivals. During office hours, the station's proximity to commercial zones contribute to heightened vehicular movement as people commute to and from work. The accessibility and convenience of the station could result in increased traffic in the surrounding area, causing congestion as vehicles queue for refueling.

This inference underscores the delicate balance between the advantages of a strategically placed fuel station and the potential challenges it can introduce to traffic management. The station's role as a convenience provider needs to be weighed against its potential to exacerbate congestion, especially during peak periods.

5.2.4 Environmental Measures

All of them responded indicating the absence of specific measures to mitigate environmental impacts, such as air pollution despite the fact that oil corporation has been informing them for tree plantation (if not possible at least a potted plant).

All station operator has implemented fire safety protocols to minimize fire hazards like 30kg, 50kg, 400kg fire extinguishers as the oil corporation made the compulsion.

Shyama Oil Stores responded the additional steps implementing measures to mitigate air pollution, such as installing vapor recovery systems.

5.2.5 Land use Compatibility

All the operators responded station's operations do not negatively affect the quality of life for nearby residents or the functionality of neighboring businesses. The inference drawn from this response is that the station operator does not recognizes the potential for compatibility challenges. These challenges could include issues related to traffic congestion, safety, and environmental impacts arising from fuel station activities, especially in areas with sensitive land uses.

5.2.6 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.

5.2.7 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.

5.3 Respondent Analysis

5.3.1 Socio-Demographic Characteristics of Respondents

Although, the study was not geared towards the description of the personal characteristics of respondents, but it was imperative to highlight some of the variables that had been found to be generally associated with residents' facility located close to the fuel stations. The socio-demographic variables covered in the study included type of residents, age, sex, number of years residents lived close to fuel station, years fuel station has been in the location.

Residents have been considered as an important variable in the analysis of physical landscape for the siting of fuel stations. According to International case as per the regulations some residential facilities and public places are not allowed to be sited lesser than 15 meters close to siting of fuel stations.

The residents refer to the individual tenants or occupants of homes, schools, businesses, and public facilities. Table 4.1 presents the type of surveyed residents living close to the fuel stations.

Table 5- 2 Residential facilities Close to Fuel Stations

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

Table 4.1 illustrates that out of 53surveyed residential facilities close to fuel stations 20 (37%), businesses, 50 (56%). Overall, type of resident distribution showed that an overwhelming majority were shops while the least are the public facilities such as health facilities. The distribution shows that few schools are close to fuel stations, thus flouting some international regulations on siting of fuel station that states any public or private

development sited near the fuel station regardless of type or location should be at a distance that has received prior approval from the Municipal Council.

5.3.2 Age Distribution of Respondents

Age is an important characteristic of a person. It does not only determine the individual's physical and mental maturity, but also portrays his/her life experiences. Figure 4.1 shows that majority of residents above 50 years(42%); age 40-50 years constituted 41% and followed by those within the 20-30 years (19%) which is also followed by age 15-20 years(11%)

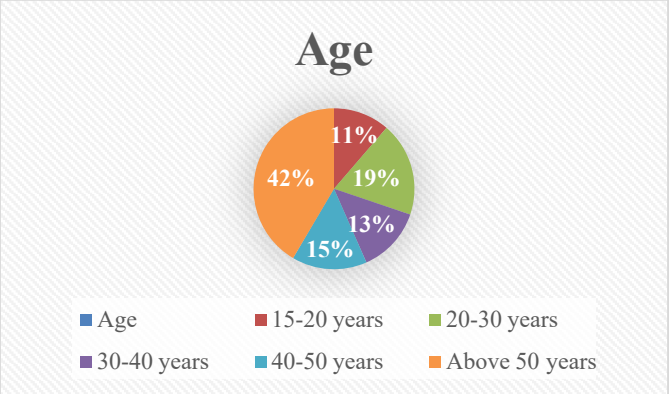


Figure 5- 7 Representation of surveyed age group

Generally, the age distribution showed that most of the residents were dependent people above age group 40.

5.3.3 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 (figure4.2). The distribution conforms to the CBS; Census of the metropolitan city where proportion of females outnumbered that of the males. The sex ratio was 5.1 females to 4.9 males. Out of every ten respondents, there were 5.1 females and 4.9 males.

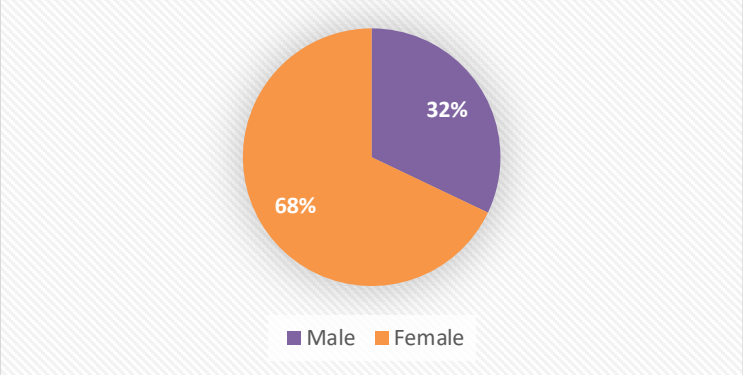


Figure 5- 8 Representation of surveyed gender

5.3.4 Number of Years Residents Lived Close to the Fuel Station

This discussion was done in order to know how long the respondents have lived close to fuel stations, and their experiences for living in such location which have some effects on the health and safety conditions of residents of the study area.

Table 5- 3 Respondents lived year near to fuel stations

Years Resident Lived Close to Fuel Station	Frequency	Percent
Less than 1 year	14	22
1-5yrs	16	30
5-10yrs	13	25
10-20yrs	8	16
Above 20	2	7

Table 4.2 shows that majority of the residents which constituted 30 percent have lived close to fuel stations between 1 to 5 years; followed by those who have lived for less than 1 year (26%) and, 5-10 years (25%). This outcome shows that majority of the residents close to fuel stations have not lived beyond 10 years. Noticeably, residents who have lived 20 years and above were quite significant a number indicating that locations where these fuel stations are sited are not entirely new.

5.3.5 Proximity to Fuel Station

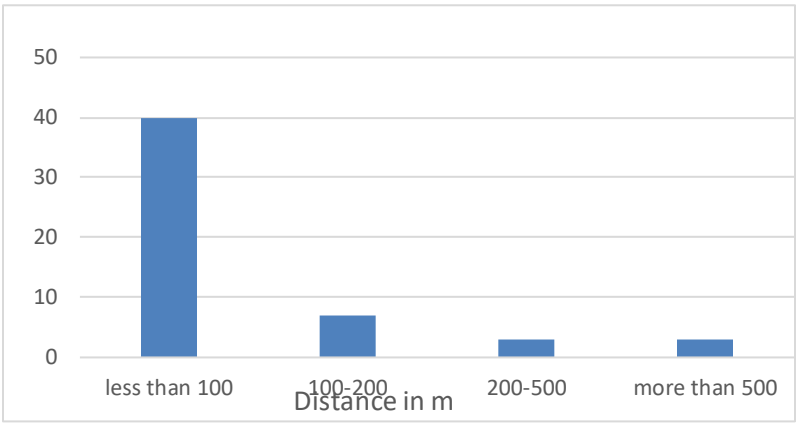


Figure 5- 9 Representation of surveyed respondents proximity to fuel station.

The analysis of proximity to fuel stations, specifically focusing on areas where the maximum number of people reside within a 100-meter distance, draws attention to a critical urban planning consideration. The findings underscore the potential implications of locating fuel service stations in close proximity to densely populated areas. The results indicate that such locations could significantly impact the immediate living environment of residents.

5.3.6 Traffic flow and accessibility

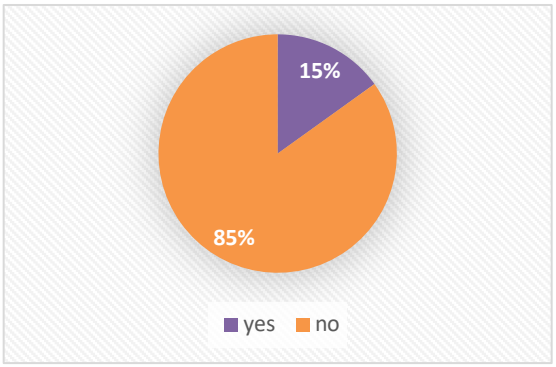


Figure 5- 10 Respondents representation in relation to accessibility

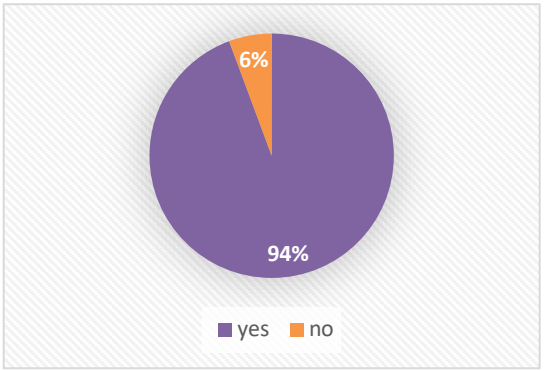


Figure 5- 11 Respondents representation in relation to congestion

The affirmative response of 94% indicating congestion around the vicinity of fuel service stations underscores a significant impact on urban mobility patterns.

The inference drawn from this high response rate suggests a causal relationship between fuel service station locations and alterations in traffic behavior. These changes could be attributed to various factors, including vehicles queuing for refueling, ingress and egress movements to and from the stations, and altered travel patterns due to station placement along key routes.

The substantial 85% response to the question regarding obstructions related to accessing residences due to the presence of fuel service stations underscores a prevalent concern among residents. This overwhelming majority indicates a significant impact on residential accessibility and points to the potential challenges posed by station locations.

5.3.7 Environmental Concerns:

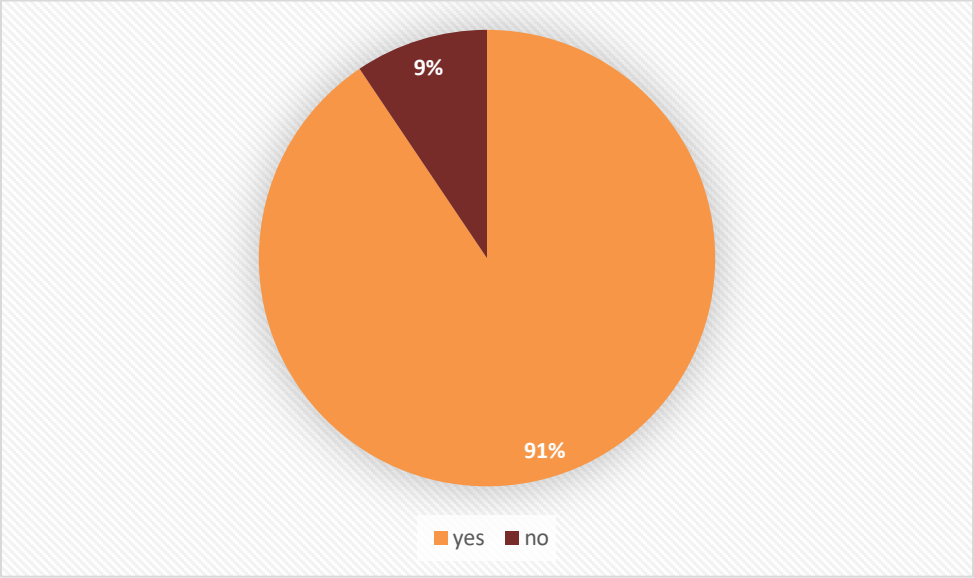


Figure 5- 12 Respondents representation for concern to pollution

The 91% affirmative response to the inquiry about concerns related to environmental issues stemming from fuel service stations, notably air and noise pollution, reflects a awareness of the potential adverse impacts on the surroundings. High response rate

underscores the prominence of environmental consciousness within the community. The reported concerns likely stem from the realization that fuel service stations can contribute to air pollution through emissions from vehicles and fuel dispensing processes, as well as generate noise pollution from vehicle movements and station activities.

5.3.8 Land Use Compatibility

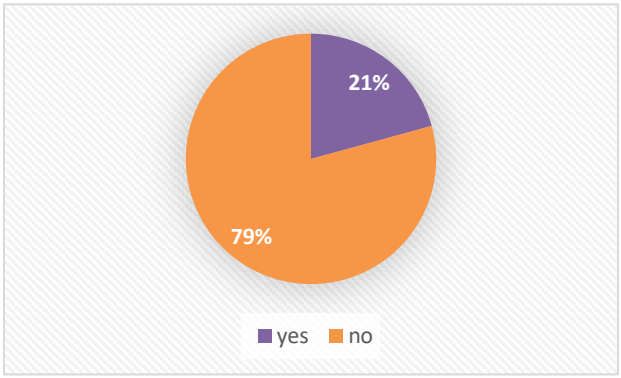


Figure 5- 13 Respondent analysis on land use compatibility

The 79% of respondents indicating that they do not believe the current location of the fuel service station is compatible with surrounding land uses, including residential areas, schools, or hospitals, highlights a significant perception of incongruence. this high response rate underscores potential conflicts between the functions of fuel service stations and the sensitive nature of surrounding land uses. The reported concerns might be rooted in worries about safety, air quality, noise, and the potential disruptions caused by station activities to these vital spaces.

5.3.9 Health and safety consideration

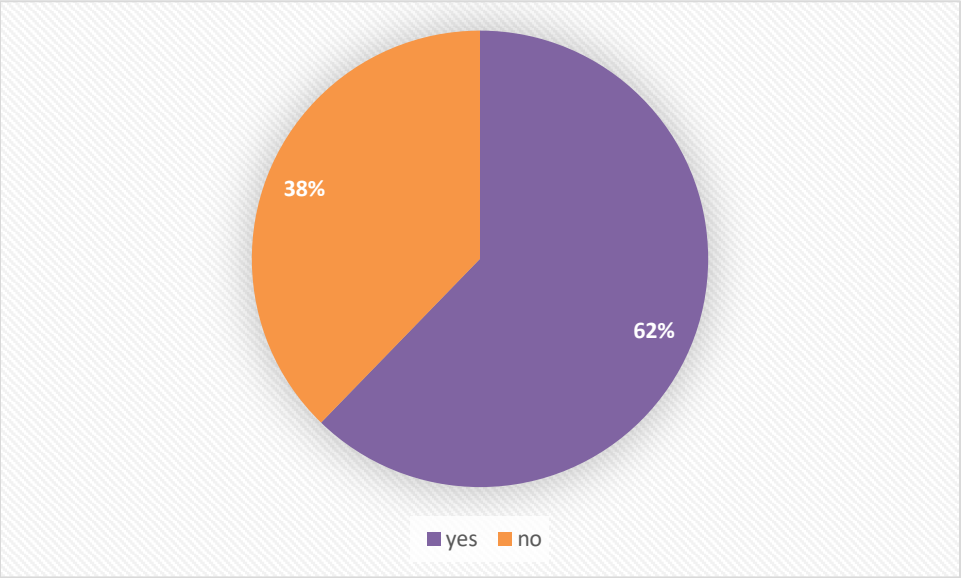


Figure 5- 14 Respondent Analysis on Health and Safety

The notable 62% affirmative response to the inquiry about perceived health risks related to the proximity of fuel service stations to residential areas or other sensitive land uses signifies a substantial awareness within the community.

This response rate underscores a heightened concern about potential adverse effects on health due to the coexistence of fuel service stations and sensitive land uses. These concerns might encompass air quality deterioration, exposure to emissions, and the potential for long-term health impacts on residents, particularly vulnerable groups like children, the elderly, and those with pre-existing health conditions.

Figure 5- 15 Respondent Analysis on awareness to Safety measures

The 49% affirmative response to the query regarding awareness of safety measures implemented by fuel service stations to safeguard customers and the surrounding community reflects a mixed level of knowledge within the surveyed population. This response rate suggests that a significant portion of respondents are cognizant of safety protocols in place, while an appreciable portion may lack awareness.

This response rate underscores the importance of transparent communication and public awareness campaigns about safety measures enacted by fuel service stations. The reported awareness could be attributed to efforts made by stations to educate their customers and nearby residents about safety precautions and emergency response plans.

5.3.10 Community Engagement:

The response of 100% indicating no involvement in community discussions or engagement activities regarding the fuel service station's location and impact signals a clear absence of direct engagement on this matter within the surveyed population. This response rate underscores a significant gap in terms of community involvement and participation in decision-making processes related to fuel service station locations.

5.4 Traffic Data Analysis

Table 5- 4 Traffic Data Analysis

S. N.	Fuel Station	Traffic Count	
		Office Hour(9-11)	Day Hour(1-3)
1	Shree Valley Rikesh Suppliers, Gairigau	178	65
2	Shree Shyama Oil., Kalanki,	65	73
3	Shree Jay Kumari Enterprises, Nayabazar	152	58

5.5 Key Informant Interview

Er. Manoj Thakur, the current spokesperson for the distribution division at NOC, brings with him 14 years of experience within the organization. He highlights the policy framework established in 2075 and sheds light on the rationale for the existing distribution model, citing the absence of guiding policies during the issuance of licenses. In addressing the impact on traffic and congestion, Thakur acknowledges complaints from the Metropolitan City. Regarding environmental considerations, he notes that the Vapor Recovery System is still in the study phase. Looking to the future, Thakur emphasizes the need for alternating the supply and recommends a government policy to relocate necessary fuel, indicating a proactive stance toward future planning and policy adjustments.

Mrs. Bini Shrestha, currently serving as the Director in the QA and Surveillance Division, brings her expertise to the interview. In discussing the policy framework

established in 2075, she notes that permits are only now granted to model fuel stations. Shrestha explains the rationale for the existing distribution, citing the absence of location standards for fuel stations. Acknowledging the impact on traffic and congestion, she mentions complaints from the Metropolitan City and suggests relocating 16 stations within the valley. Regarding environmental considerations, Shrestha emphasizes daily quality assurance (QA) practices. Looking to the future, she recommends the preparation of a new Petroleum Act and advocates for governance by the Petroleum Ministry. Shrestha proposes the formation of a committee involving municipalities, traffic and road divisions, NOC, and the government to collaboratively address future planning and policy considerations.

Figure 5- 16 KII with Spokesperson of NOC

Figure 5- 17 KII with of QA Director of NOC

CHAPTER-6: CONCLUSIONS AND RECOMMENDATIONS

In the previous chapter, results and discussion of the study were presented. This chapter summarizes the research on the spatial and locational analysis of fuel stations in Kathmandu Metropolitan City. The chapter comprises a summary of the study's aims as well as the important findings. The findings' conclusions, as well as recommendations to improve gasoline station placement in compliance with Nepal Oil Corporation in Kathmandu Metropolitan City, are also presented.

6.1 Conclusion

The spatial analysis of fuel service station distribution in Kathmandu indicates that these stations are not uniformly distributed across the city. Instead, there are observable patterns of clustering, with higher concentrations in specific regions. This non-uniform distribution could be attributed to factors such as commercial zones, transportation hubs, or historical development patterns. Recognizing these spatial variations is essential for understanding the localized impact of fuel stations on their immediate surroundings.

The evaluation of locational impact reveals that fuel service stations exert varied effects on their surroundings. Areas with a high density of stations experience heightened traffic congestion. Moreover, these locations may suffer from compromised air quality due to vehicular emissions. The impact on land use is notable, particularly in areas where stations are closely situated to residential or commercial zones. This assessment emphasizes the need for context-specific planning that considers the diverse impacts on different segments of the population.

The investigation into environmental implications underscores the dual challenges of air pollution and fire hazards associated with fuel service stations. The combustion of fossil fuels contributes to elevated levels of air pollutants, affecting both local air quality and broader environmental health. Additionally, the inherent flammability of fuel poses a risk of fire hazards. This necessitates safety measures, technological innovations, and

regulatory interventions to address these environmental concerns and ensure the well-being of both the community and the ecosystem.

Building on the insights gained from distribution patterns and impact evaluations, recommendations for planning approaches are crucial. These might involve implementing zoning regulations that dictate suitable distances from residential areas, introducing safety protocols to mitigate fire hazards, and engaging with the community during the planning process to address concerns. The aim is to harmonize fuel service station locations with the broader urban environment, fostering sustainability, reducing adverse impacts, and ensuring equitable access to services. This comprehensive planning approach is vital for creating urban spaces that balance the convenience of fuel services with the well-being of the community and the environment.

6.2 Recommendation

Effective urban planning is crucial to manage the spatial distribution of fuel service stations in Kathmandu. Implementing zoning regulations is paramount to guide the placement of these stations and prevent clustering in specific areas. By incentivizing decentralized development and periodically reviewing distribution patterns, the city can achieve a more balanced and sustainable distribution of fuel service stations, contributing to a more harmonious urban landscape.

Managing the impact of fuel service stations requires a multifaceted approach. Traffic management strategies, such as optimizing traffic flow and exploring alternative transportation solutions, can mitigate congestion issues. Additionally, environmental impact assessments should be mandated for proposed fuel station locations, considering factors like air quality and noise levels. Integrating fuel service station considerations into broader land-use planning efforts is essential to prevent incompatible coexistence with residential or environmentally sensitive zones.

Addressing the environmental implications of fuel service stations is critical for the well-being of both the community and the ecosystem. Enforcing the use of advanced emission control technologies can minimize air pollution, contributing to improved air quality. Similarly, strict safety protocols, including advanced fire suppression systems,

are essential to mitigate fire hazards. Public awareness campaigns can educate communities about these environmental risks, fostering a sense of responsibility and encouraging practices that minimize adverse impacts.

Achieving harmonious coexistence between fuel service stations and their surroundings requires a comprehensive planning approach. Community engagement is fundamental; involving local perspectives in the planning process ensures that the unique needs and concerns of communities are considered. Integrating fuel service station considerations into broader urban planning strategies is crucial for compatibility with surrounding land uses and social equity. Establishing incentive programs for operators who strategically choose locations fosters a positive symbiosis, where the benefits of fuel services are delivered without compromising the well-being of the community.

6.3 Recommendation for further study

1. A study to investigate the feasibility and impact of implementing advanced technologies in fuel service stations, such as alternative fuels and smart traffic management systems can be done.

2. Research collaborating with health professionals to conduct health studies in areas surrounding fuel service stations, assessing potential risks and long-term health impacts can be done.

3. Assessing the readiness and response mechanisms in place for potential accidents or hazards, focusing on safety measures and emergency preparedness is also a good topic for further research.

4. Since this thesis focuses on Kathmandu Metropolitan City, extending the research to compare the spatial distribution and impact of fuel service stations across different urban settings or cities can also be done.

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APPENDICES

Appendix A: Questionnaire Survey

A. Household survey questionnaire:

1. Demographic Information:

a. What is your age?

15-20 years ☐ 20-30 years ☐ 30-40 years ☐ 40-50 years ☐

Above 50 years ☐

b. What is your gender?

Male ☐ Female ☐ Other ☐

c. What is your educational level?

Illiterate ☐ Secondary level ☐ Undergraduate ☐ Graduate ☐

d. How many people live in your household?

2- 4 ☐ 4- 6 ☐ more than 6 ☐

2. Proximity to Fuel Service Stations:

a. Is there a fuel service station located near your residence? If yes, how far is it from your home?

less than 100m ☐ 100m -200 km ☐ 200 -500 km ☐ more than 500m ☐

b. How often do you visit the nearest fuel service station?

Once a week ☐ Once in 15 days ☐ Once in a month ☐ Never ☐

3. Mode of Transportation:

a. What is your primary mode of transportation for daily commuting?

Walking ☐ Cycling ☐ public transport ☐ private transpo ☐

b. Do you use a private vehicle that requires fuel services?

Yes ☐ No ☐

4. Traffic Flow and Accessibility:

a. Have you noticed any changes in traffic flow or congestion around the area where the fuel service station is located?

Yes ☐ No ☐

b. Do you face any obstruction related to accessing your residence due to the presence of the fuel service station?

Yes ☐ No ☐

5. Environmental Concerns:

a. Are you concerned about environmental issues related to fuel service stations, such as air pollution or noise pollution?

Yes ☐ No ☐

b. Have you noticed fire air quality or noise levels since the fuel service station's operation?

Yes ☐ No ☐

6. Land Use Compatibility:

a. Do you believe the current location of the fuel service station is compatible with surrounding land uses, such as residential areas, schools, or hospitals?

Yes ☐ No ☐

b. Have you observed any concerns about potential conflicts between the fuel service station and nearby land uses?

Yes ☐ No ☐

7. Health and Safety Considerations:

a. Do you perceive any health risks associated with the proximity of fuel service stations to residential areas or other sensitive land uses?

Yes ☐ No ☐

b. Are you aware of any safety measures implemented by the fuel service stations to protect customers and the surrounding community?

Yes ☐ No ☐

8. Community Engagement:

a. Have you been involved in any community discussions or engagement activities regarding the fuel service station's location and impact?

Yes ☐ No ☐

B. Fuel Service Station Questionnaire:

1. Business Information:

a. What is the name and location of your fuel service station?

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b. How long has your fuel service station been in operation?

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2. Location Decision:

a. What were the primary factors considered when selecting the current location for your fuel service station?

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b. Did you encounter any challenges during the process of choosing the station's location?

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3. Impact on Business:

a. How has the location of your fuel service station influenced your business performance and customer traffic?

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b. Do you believe the current location contributes to increased or decreased fuel sales?

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4. **Traffic Flow and Accessibility**

a. How does the location of your fuel service station impact traffic flow around the area?

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b. Are there any specific times or situations when the station experiences higher traffic congestion?

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5. Environmental Measures:

a. What environmental measures or practices does your fuel service station employ to mitigate environmental impacts, such as air pollution or emissions?

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b. Are there any additional steps that could be taken to improve the station's environmental performance?

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6. Land Use Compatibility:

a. Do you perceive any compatibility issues between the current location of your fuel service station and surrounding land uses, such as residential areas or other businesses?

b. Have there been any land use conflicts related to the station's location?

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7. Community Relations:

a. How do you engage with the local community or residents around your fuel service station?

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b. Are there any community concerns or expressions of regarding the station's location or operations?

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8. Future Development:

a. Would you consider relocating or expanding your fuel service station in the future? If so, what factors would influence this decision?

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b. What changes or improvements do you envision for the station's operations in the coming years?

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C. Key Informant Interview Questionnaire:

I. Policymakers

1. Role and Experience:

a. What is your current role and position in the government or relevant authority?

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b. How long have you been involved in policymaking related to urban planning and transportation in Kathmandu?

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2. Policy Framework and Regulations:

a. Are there any existing policies or regulations that govern the placement and operation of fuel service stations in Kathmandu?

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b. How do these policies address concerns related to spatial distribution and locational impact?

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3. Rationale for Current Distribution:

a. What factors are considered while determining the current distribution of fuel service stations in the city?

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b. What are the rationale behind the selection of specific locations for fuel service stations?

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4. **Locational Impact on Traffic and Transportation:**

a. How do you perceive the impact of fuel service station locations on traffic flow and congestion in Kathmandu?

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b. Are there any specific areas where the proximity of fuel service stations causes traffic-related challenges?

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5. **Environmental Considerations:**

a. What are your views on the environmental implications of fuel service stations, such as air pollution and emissions, in Kathmandu?

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b. Do you feel that the current distribution of fuel service stations adequately addresses environmental concerns?

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6. **Land Use Compatibility:**

a. From a policymaker's perspective, are the current locations of fuel service stations compatible with surrounding land uses, such as residential areas and educational institutions?

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b. Are there any potential land use conflicts that need to be addressed?

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7. Future Planning and Policy Recommendations:

a. In your opinion, what policy measures could optimize the spatial distribution of fuel service stations in Kathmandu?

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b. How can policies be improved to promote sustainable and efficient fuel service station placement?

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8. Stakeholder Engagement:

a. How do policymakers engage with key stakeholders, such as fuel station operators and community members, while formulating policies related to fuel service stations?

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II. Urban Planners

1. Role and Experience:

a. What is your current role and position as an urban planner in Kathmandu?

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b. How many years of experience do you have in urban planning and development?

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2. Fuel Service Stations in Urban Planning:

a. In your opinion, how significant is the spatial distribution of fuel service stations in the overall urban planning process for Kathmandu?

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b. How do fuel service stations factor into transportation planning and infrastructure development?

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3. Locational Impact on Urban Development:

a. From an urban planning perspective, what are the potential impacts of fuel service station locations on the city's development and land use patterns?

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b. Are there any specific areas where the presence of fuel service stations influences urban growth or poses challenges to development plans?

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4. Traffic Flow and Congestion:

a. How do you assess the impact of fuel service station locations on traffic flow and congestion in Kathmandu?

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b. Are there any areas where the proximity of fuel service stations contributes to traffic bottlenecks or congestion?

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5. Environmental and Sustainability Considerations:

a. How do urban planners address the environmental implications of fuel service stations, such as air pollution and emissions, in urban development plans?

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b. Do sustainable development goals influence decisions regarding fuel service station locations?

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6. Zoning and Land Use Compatibility:

a. From an urban planning perspective, do you consider the compatibility of fuel service stations with surrounding land uses, such as residential, commercial, or recreational areas?

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b. Are there any challenges related to zoning regulations for fuel service stations in the city?

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7. **Future Urban Planning Recommendations:**

   a. What changes or improvements can be made in urban planning strategies to optimize the spatial distribution of fuel service stations in Kathmandu?

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   b. How can urban planning decisions contribute to more sustainable and efficient fuel service station placement?

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8. **Stakeholder Engagement:**

a. How do urban planners engage with key stakeholders, such as policymakers, fuel station operators, and community members, while planning for fuel service station locations in the city?

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