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Socio-Environmental Impacts Assessment of Tank Farm Location and Operation in Port Harcourt Municipality, Rivers State

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ABSTRACT

Tank farms serve a key role in the storage and transportation of petroleum products, although their placement and operating influence on the surrounding environment and populations remain matters of concern. This study analyses the socio-environmental impacts coming from the location and operation of tank farms in Port Harcourt Municipality, Rivers State. Employing a passive observational research design, this research dug into the multifarious effects (both positive and negative) related with the installation and running of the tank farms in the study area. The paper investigates the positive impacts of tank farm locations, assesses the negative impacts originating from both geographical and operational characteristics, and recommends realistic strategies to offset the discovered negative impacts. Through Google earth map data, the real size of the tank farm was caught as roughly 92734.53 square meters which is 9.273453 Hectares. Through questionnaire surveys delivered to 398 heads of households in vicinity to the tank farms, the study gathered community perspectives and experiences. The findings reflect a multifaceted environment, displaying a combination of positive and negative impacts. Tank farms have significantly contributed to job possibilities and produced different economic impacts to the local economy. However, the neighborhood also cites substantial worries over air and water quality, indicating possible environmental threats. Additionally, infrastructural challenges, such as increased traffic congestion and road damage, have surfaced as tangible impacts on the area's quality of life. Proposed mitigation measures from the community underline the importance of installing air pollution control systems (42.21%), implementing regular water quality monitoring (49.75%), and holding regular community meetings (44.72%). These recommended techniques correspond with previous literature recommendations, highlighting the necessity for rigorous environmental management and improved community engagement.

Keywords: Social Impacts, Economic Impacts, Environmental Impacts, Tank Farm, Location Studies, Port Harcourt Municipality

1.0 INTRODUCTION

The initiation of any big physical project generally creates a cascade of social, economic, and environmental effects. These impacts, generally defined as social, economic, or environmental, collectively characterize the project's larger influence dubbed the 'environment.' The Nigerian oil and gas industry, divided into upstream, middle, and downstream sectors, constitutes a complex network of operations (Patidar, Agarwal, Das & Choudhury, 2024).

The upstream sector concentrates on discovering and exploiting crude oil and gas deposits, while midstream businesses offer critical logistical assistance ((Patidar, Agarwal, Das, & Choudhury, 2024)). In contrast, downstream operations entail storing, selling, and transporting refined petroleum products, underscoring the essential position of tank farms in the nation's energy infrastructure.

Tank farms, operating as key storage facilities inside Port Harcourt's oil-rich topography, carry tremendous importance. Situated within the headquarters of Rivers State, these facilities, also referred to as oil depots or terminals, house various petroleum and petrochemical products, including automotive gas oil (AGO), prime motor spirit (PMS), aviation kerosene (commonly known as Jet A1), and dual-purpose kerosene (DPK) (Okocha, 2014; Milawa, n.d). Positioned strategically near oil refineries or regions frequented by maritime vessels for cargo discharge, tank farms deploy either above or underground tanks and gantries, enabling product discharge into diverse transportation modes such as road tankers, barges, or pipelines (Narula & Narula, 2019).

Despite their apparent operational simplicity, tank farms evoke a spectrum of repercussions needing in-depth evaluation through Environmental Impact Assessment (EIA) (Idris, 2022, NURPL, 1992). EIA, a systematic examination analyzing the environmental, social, and economic implications of proposed projects, supports in decision-making by discovering optimal balances between economic gains and environmental costs (Glasson & Therivel, 2013; Wathern, 2013).

The idea of 'environment' encompasses complicated interrelations between living and non-living components comprising ecosystems and biomes. Webster's new college dictionary (2012) defines environment as the aggregate of all the external conditions and forces impacting life and development of organisms. Environment is a shared property not only of present stakeholders but also of the future generations (Okonkwo, & Etemire, 2017). Despite contemporary tank farms demonstrating greater automation and operational breakthroughs, their existence underlines the vital requirement for thorough environmental monitoring and assessment (Idris, 2022).

While tank farms ostensibly include basic operations, their existence provides a range of consequences needing Environmental Impact Assessment (EIA). EIA, defined by the International Association of Impact Assessment (2002), entails systematic examination of possible positive or negative environmental, social, and economic implications of a proposed project, supporting decision-making by comparing alternatives. Early assessment of environmental consequences and their mitigation through EIA has various benefits, including environmental protection, resource optimization, and savings in project time and costs (Wikipedia, 2013).

This research paper analysed the numerous consequences, problems, and benefits offered by tank farms in Port Harcourt within the deep complexity of Nigeria's oil and gas sector.

1.1 Problem Statement

The cohabitation of major physical projects, like tank farms, with their surroundings poses a complex problem. These projects have considerable impact, producing or attracting social, economic, and environmental effects. While they fulfil vital roles, their existence causes both advantages and difficulties across numerous areas. Issues such as environmental damage, social disturbances, transportation congestion and economic imbalances resulting from these initiatives. This drives the need to fully examine their implications and establish solutions for regulating their effects on the environment, society, and the economy. The problem lies in balancing the necessity for industrial progress and economic growth with the imperative to minimize adverse effects on the environment, uphold social well-being, and sustain economic equilibrium. The juxtaposition of industrial imperatives with urban ecosystems within Port Harcourt Municipality underscores an urgent need for an in-depth examination of the implications engendered by the strategic positioning of tank farms. This juxtaposition frequently magnifies underlying conflicts, pitting the imperatives of industrial growth against the precepts of sustainable urban development and community well-being (Wheeler, 2013).

In negotiating these complex planning consequences, the absence of a thorough synthesis of literature and empirical research explicitly addressing the unique context of tank farm location within Port Harcourt Municipality emphasizes a crucial knowledge gap.

1.2 Aim of the Study

The aim of the study is to examine the impacts associated with the location and operation of the tank farm.

1.3 Objective of the Study

To achieve this aim, the following specific objectives are;

i. Ascertain the size of the tank farm site situated off Azikiwe road by Abonnema wharf road

ii. Examine the positive impacts of tank farm location within Port Harcourt Municipality.

iii. Assess the negative socio-environmental impacts resulting from the presence and operations of tank farms in the study area.

iv. Identify and propose measures to mitigate the adverse effects on the environment and the community.

1.4 Study Area

This study covers the tank farm along Abonnema wharf road in Port Harcourt municipality.

Fig. 1.1 The Port Harcourt Tank Farm and other Land Uses

Source: Researchers Work, 2023; Map Data, 2023

2.0 LITERATURE REVIEW

2.1 Theoretical Framework

The theoretical grounding of this work relies upon different theoretical perspectives, including but not limited to environmental justice, ecological modernization theory, and sustainable development models. These frameworks were essential in examining the socio-environmental ramifications of tank farm operations within the setting of Port Harcourt Municipality, giving a lens to examine the interplay between industrial activities and social well-being.

2.1.1 Environmental Justice

Environmental justice, as articulated by Bullard (1990), contains a fundamental ethos seeking equity in the allocation of environmental gains and detriments across distinct socioeconomic strata. It vehemently opposes the unfair imposition of environmental dangers on marginalized or disadvantaged populations while pushing for an equal allocation of environmental benefits. This concept originates from the awareness that some populations, frequently characterized by socio-economic fragility or minority status, incur a disproportionate weight of environmental dangers owing to industrial activity and infrastructural development.

Schlosberg (2007) adds upon Bullard's basic work, highlighting the importance of understanding and resolving the structural inequities in environmental impacts caused by industrial processes. This expansion underlines the subtle ways in which environmental consequences are not equally perceived across society but are instead impacted by complicated socio-economic, cultural, and demographic processes. Specifically discussing tank farm operations in Port Harcourt Municipality, this theoretical lens motivates a detailed analysis of how these industrial activities could asymmetrically effect diverse populations within the area.

2.1.2 Ecological Modernization Theory

Ecological modernization theory, described by Mol (1996) and further improved by Spaargaren and Mol (1992), proposes a paradigm that challenges the traditional conflict between economic advancement and environmental protection. It presents a revolutionary narrative where enterprises may actively reconcile economic progress with environmental sustainability. When contextualized within the arena of tank farm operations in Port Harcourt Municipality, the application of ecological modernization theory entails a detailed review of how these facilities might align their activities with principles of sustainability and environmental responsibility. It involves an investigation of possible techniques that minimize the ecological impact connected with the storage and transportation of petroleum products.

2.1.3 Sustainable Development Models

The notion of sustainable development, coming from the landmark report of the World Commission on Environment and Development (WCED) in 1987, encompasses a comprehensive approach to social advancement. Sachs (2015) further amplifies this paradigm, highlighting the importance of balancing economic progress, environmental protection, and social inclusion. At its essence, sustainable development argues for a trajectory that fulfils present demands while conserving the ability of future generations to satisfy their own needs.

When applied to the prism of tank farm operations in Port Harcourt Municipality, the framework of sustainable development becomes a compass directing the assessment of these industrial activities in a larger socio-environmental context.

2.2 Conceptual Review

The conceptual review dives into the core ideas and terminologies linked with tank farm operations and their influence on the socio-environmental domain.

2.2.1 Tank Farms

Tank farms, also known as petroleum product storage depots, are facilities that store and distribute petroleum products, including gasoline, diesel, kerosene, and aviation fuel. These facilities serve a significant role in the oil and gas sector, providing a critical link between refineries and consumers. However, the siting and operation of tank farms can have substantial socio-environmental ramifications, particularly in metropolitan areas like Port Harcourt Municipality, Rivers State.

There are 124 petroleum tank farms in Nigeria, with 37 located in the South-South area. This indicates that the South-South area contains around 29.8% of all tank farms in the country (Bagshaw& Okoisama, 2023)).

A comprehensive review of tank farm mishaps was conducted from 1951 to 2003 (Persson& Lönnermark, 2004). Lightning strikes appeared as the top cause, followed by cases attributable to poor maintenance procedures, sabotage, fractures, leaks, or line ruptures, static electricity, and closeness to open flames (Persson& Lönnermark, 2004).

Furthermore, a subsequent analysis of major incidents occurring between 2005 and 2013 identified six notable tank farm accidents: Buncefield in the UK (2005), India Oil Corp in Jaipur, India (2009), China NPC (2010), Miami Airport in Florida, USA (2011), Amuay Refinery in Venezuela (2012), and India Oil Corp in Hazira, India (2013) (Nolan, 2014).

2.2.2 Types of Storage Tanks

According to Nolan, (2014), there are three major types of aboveground storage tanks used in the petroleum and petrochemical industries. They are selected depending on the service sought and the flash points of the information. These tanks comprise fixed roof, exterior floating roof, and internal floating roof.

2.2.2.1 Fixed Roof Tank

Fixed roof tanks, defined by a cylindrical base with a permanently connected cone-shaped canopy, are generally utilized for holding liquids with high flash points. These tanks provide various advantages, including:

i. Reduced environmental emissions: The cone-shaped roof efficiently decreases vapor space, hence lowering the possibility for volatile organic compounds (VOC) emissions.

ii. Enhanced structural strength: The cone-shaped roof offers additional structural support, allowing these tanks to sustain somewhat greater storage pressures than air pressure.

iii. Controlled roof separation: In the case of an internal explosion, the weak seam at the roof-to-shell connection permits controlled roof separation. This design element prevents catastrophic tank failure and isolates any subsequent flames to the exposed flammable liquid surface, saving the tank's contents and limiting environmental effect.

2.2.2.2 External Floating Roof Tank

External floating roof tanks, comprising an open-top cylindrical base and a pontoon-type roof that floats on the liquid surface, are particularly intended to hold liquids with flash points comparable to naptha, kerosene, diesel, and crude oil. These tanks offer numerous major advantages:

i. Adaptability to variable liquid levels: The floating roof's design enables it to respond to fluctuating liquid levels during tank operations, preserving a seal with the tank walls, avoiding the escape of vapors, and minimizing product loss due to evaporation.

ii. Minimized vapor space: The open-top design provides minimum vapor space within the tank, significantly lowering the possibility for VOC emissions.

iii. Effective sealing: A mechanical shoe or tube seal around the perimeter maintains a tight barrier between the floating roof and the tank walls, limiting the escape of vapors and minimizing product loss.

These various tank designs, suited to individual liquid qualities and flash point concerns, successfully balance environmental preservation, product conservation, and operational safety, assuring safe and efficient storage procedures in the industry (Nolan, 2014).

2.2.2.3 Internal Floating Roof Tanks

Internal floating roof tanks (IFRTs) are distinguished by a permanent fixed roof positioned over an internal floating roof, functioning as a protective mechanism to prevent the leakage of harmful gases into the atmosphere. Primarily employed for the storage of extreme flammable substances.

The safe construction, material selection, design, operation, and maintenance of storage tanks and associated equipment are governed by standards set by API (American Petroleum Institute), ASME (American Society of Mechanical Engineers), NFPA (National Fire Protection Association), and various international standards and insurance guidelines. These regulatory frameworks contain key aspects of loss prevention relative to tank selection, venting, position, spacing, drainage and impounding, fire protection systems, static electricity/grounding, and lightning protection (API, 2017; ASME, 2016; NFPA, 2019).

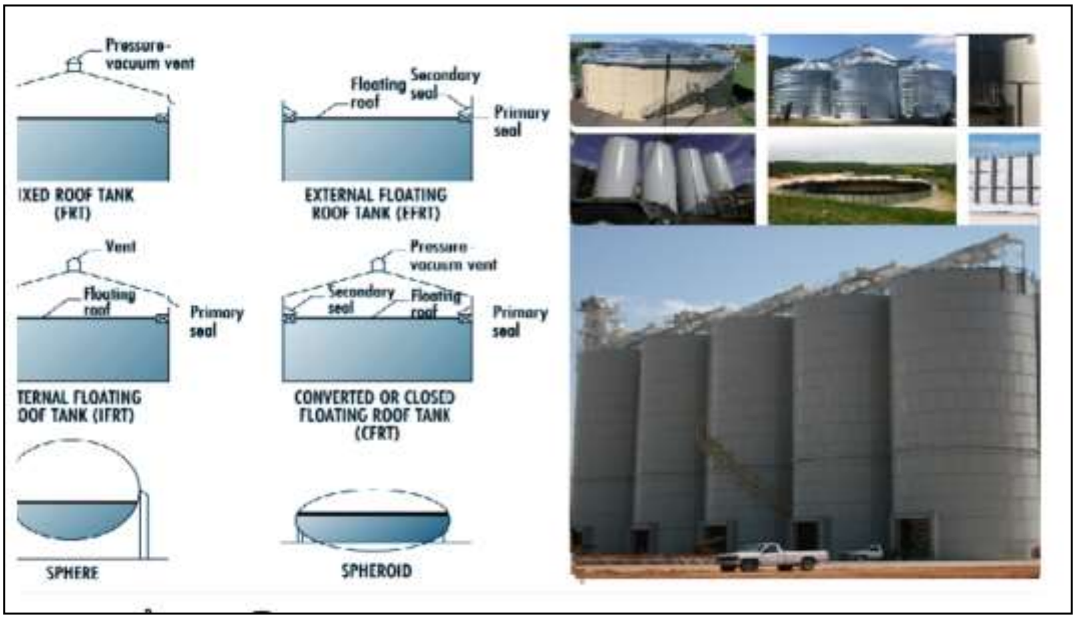

Fig. 2.1 Illustrates a Classification of Types of Tanks

Source: Luzardo, O. E. M (2020)

Furthermore, conducting a risk review of tank design and installation aids in identifying and implementing essential safety features. Fig. 1 illustrates a Classification and types of tanks (Luzardo, 2020).

2.2.3 Tank Farms and Urban Planning

Urban expansion in Nigeria has been tremendous during the past five decades. However, zoning limits and urban planning regulations are often not implemented or perpetuated, leading to repercussions like as uncontrolled urban development, congestion, pollution, and associated environmental and health concerns (Akinwale, 2021). A striking illustration of this issue is the present growth of unlicensed and dangerous tank farms inside urban areas in Nigeria.

An urban region is defined by its high population density and particular high-order human agglomeration functions that are not seen in other locations (UN-HABITAT, 2008). Southwestern Nigeria has a long history of urbanization (Mabogunje, 1968). However, urban expansion in this region has been unusually fast during the previous five decades. The fundamental driver of this phenomenon is rural-urban migration, spurred by perceived work possibilities and income differentials between urban and rural regions (Awuzie, 2013).

An oil terminal, also known as a tank farm, tankfarm, oil installation, or oil depot, is an industrial facility for the storage of oil, petroleum, and petrochemical products. These facilities function as distribution centers, transporting these items to end users or other storage facilities (Adewumi & Babajide, 2021). A typical oil terminal contains a range of above or below-ground tanks, inter-tank transfer facilities, pumping facilities, loading gantries for filling road tankers or barges, ship loading/unloading equipment at marine terminals, and pipeline connections (Itodo & Okoya, 2019).

2.2.4 Tank Farms in Africa: Infrastructure, Challenges, and Implications

Tank farms across Africa serve as crucial infrastructure for the storage, transfer, and distribution of oil and gas products within the continent and for international commerce (Smith & Osei, 2021). Positioned strategically near major ports, oil refineries, and production facilities, these tank farms permit the seamless transit of crude oil, refined products, and petrochemicals, playing a crucial role in the energy sector's logistics (Ghana Energy Commission, 2018).

Countries boasting significant tank farm infrastructure, including Nigeria, South Africa, Ghana, and Egypt, leverage these facilities as distribution hubs, effectively supplying petroleum products to both domestic and global markets (Nigerian National Petroleum Corporation, 2020; South African Petroleum Industry Association, 2017). Notably, several African nations, illustrated by Nigeria, deploy tank farms to retain strategic petroleum stocks, guaranteeing energy security during emergent crises or disruptions in the oil supply chain (Ghana National Petroleum Corporation, 2019).

However, tank farms in Africa meet major environmental and safety difficulties, with concerns focused on spills, leakage, and the larger environmental repercussions of oil and gas activities (Egyptian Environmental Affairs Agency, 2020). Rigorous efforts are conducted to guarantee strict adherence to environmental rules and safety measures, necessitating the formation of extensive regulatory frameworks controlling the sitting, building, and management of these tank farms (Ghana Environmental Protection Agency, 2018).

The regulatory frameworks adopted by African countries are designed to ensure safety, environmental preservation, and alignment with international standards, although challenges persist, particularly concerning tank farm localization in or near urban centers (South African Department of Environmental Affairs, 2019). This closeness engenders challenges in urban planning, needing a careful balance between the imperatives of the oil and gas sector, urban development goals, and the well-being of local residents.

2.2.5 Tank Farms in Nigeria

Tank farms in Nigeria comprise a critical element of the nation's oil and gas infrastructure, operating as major storage facilities for a varied array of petroleum products, covering crude oil, refined derivatives, and petrochemicals (Okafor & Adams, 2019; Ibrahim, 2020). Nigeria, recognized as a prominent oil-producing and exporting nation, heavily relies on these facilities to store, distribute, and facilitate the export of its hydrocarbon resources, underscoring their strategic importance in the nation's energy landscape (Nigerian National Petroleum Corporation, 2021; Ajayi & Obi, 2018).

Strategically situated across various regions of Nigeria, particularly prominent in areas like the Niger Delta, Lagos, Rivers State (Port Harcourt), and other coastal regions, these tank farms are strategically positioned proximate to oil production sites and major transportation arteries, thereby streamlining the efficient distribution of petroleum products (Nwosu & Mohammed, 2017).

Tank farms nestled along Nigeria's coastal regions, notably in Lagos and Port Harcourt, play a pivotal role in facilitating the import and export of oil and gas products, serving as linchpins in the nation's active participation in the global energy trade (Federal Ministry of Petroleum Resources, 2019; Nigerian Ports Authority, 2020). The utilization rates of these tank farms have enormous influence over market dynamics, exerting an impact on product price within the volatile oil and gas industry. Traders and investors constantly watch the availability of storage capacity to make educated judgements among the market's changeable trends (Okafor & Adams, 2019).

In general, the strategic placement and operational relevance of tank farms in Nigeria not only reinforce the nation's role in the global energy industry but also have enormous influence on market dynamics, rendering them key components in Nigeria's oil and gas landscape.

2.2.6 Tank Farms in Rivers State, Nigeria

Rivers State, situated in Nigeria, stands as a key location containing multiple tank farms and petroleum storage facilities, owing to its strategic posture as a paramount center within the Nigerian oil and gas sector (Obi & Nwosu, 2020; Amadi & Ogbonna, 2018). Particularly, Port Harcourt within Rivers State emerges as a key locus for tank farms and petroleum storage installations, leveraging its close proximity to oil production zones and major transportation arteries, thereby assuming a pivotal role as a strategic logistics and distribution center for oil and gas products (Okafor et al., 2019; Nigerian Petroleum Logistics Institute, 2021).

The tank farms dotting the landscape of Rivers State operate as vital distribution hubs, supporting the smooth flow of a diversity of petroleum products, including crude oil, refined derivatives, and petrochemicals, catering to local and worldwide markets (Nwosu & Mohammed, 2018). Their activities serve a critical role in supplying these important commodities to varied markets, establishing their prominence within the energy logistics network.

The presence of these tank farms in Rivers State engenders a substantial economic impact, fueling job creation, fostering tax revenues, and fostering an array of ancillary business activities entrenched within the oil and gas sector, including transportation and logistics (Nigerian Bureau of Statistics, 2020; Rivers State Ministry of Energy, 2019). The strategic proximity of tank farms to prominent seaports in Port Harcourt, like the Onne and Port Harcourt ports, significantly expedites the import and export of oil and gas products, facilitating Nigeria's active participation in the global energy trade (Rivers State Chamber of Commerce, 2017; Nigerian Ports Authority, 2020).

In essence, tank farms in Rivers State, particularly within the ambit of Port Harcourt, serve as economic drivers, not only contributing considerably to the regional economy but also playing a vital role in Nigeria's involvement in the global oil and gas market.

2.2.7 Positive Impacts of Tank Farm Location

The siting of tank farms in diverse places has been related with multiple positive consequences, contributing considerably to economic development and infrastructure advancements.

2.2.7.1 Employment Generation and Labor Market Impact

Tank farms serve as key hubs of employment, contributing to the economic landscape through a varied range of labor possibilities. The job chances linked with tank farm activities cover both direct and indirect positions, encouraging a ripple effect throughout multiple industries within their area.

2.2.7.2 Direct Employment

Within the tank farms, a considerable number of direct job possibilities occur, encompassing operational roles such as tank supervisors, technicians, engineers, and logistics coordinators. These jobs are vital for the day-to-day operating of the facility, guaranteeing smooth operations and maintenance of storage units.

Administrative tasks inside the tank farms include administrative positions, human resources, accounting, and compliance officers. These jobs monitor regulatory compliance, financial management, and general administrative operations of the institution.

2.2.7.3 Indirect Employment

The establishment of tank farms engenders job possibilities in support services. These jobs extend to transportation services, security guards, cleaning workers, and maintenance teams. For instance, transportation services entail truck drivers responsible for transferring items to and from the tank farms, therefore providing jobs in the transportation industry.

Tank farms also support employment growth in auxiliary sectors. The necessity for service providers including maintenance contractors, equipment suppliers, and technology vendors adds further to employment growth. Additionally, the need for services such as food, lodging, and healthcare for the personnel involved with tank farm operations adds to the employment spectrum.

Beyond direct employment within the tank farms, there's a spill-over effect on the nearby community. The economic buoyancy provided by these facilities typically catalyzes higher demand for products and services in adjacent towns and cities, leading to job development in retail, hotel, and other service-oriented industries.

The employment environment impacted by tank farms exhibits a broad spectrum of opportunities, including operational, administrative, support services, and related businesses. This broad job environment not only maintains the tank farm operations but also greatly contributes to the economic viability and social fiber of the neighboring regions.

2.2.7.4 Revenue Generation and Local Economic Development

The installation of tank farms frequently corresponds with greater income production and local economic growth. This infusion of income adds to the development of local infrastructure, education, and healthcare systems, ultimately boosting the general quality of life in the area.

2.2.8 Negative Socio-Environmental Impacts of Tank Farm Operations

Tank farm activities are connected with large emissions, impacting air quality in neighboring areas. Research by Green (2017) and Harper and White (2020) defined the emissions profile, stressing the production of volatile organic compounds (VOCs) and particulate matter. These emissions contribute to atmospheric pollution, harming the air quality of neighboring towns (See Fig 2.2).

Fig. 2.2 Houston Tank Farm Fire Incident

Source: Maddox S (2023)

Air Pollution

The harmful health ramifications of such emissions have been thoroughly examined in research by Lee and Clark (2018). These studies reveal heightened risks of respiratory disorders, cardiovascular problems, and even possible carcinogenic impacts among those live in close proximity to tank farm locations.

Water Contamination

The possible dangers of water pollution owing to tank farm activities have been a matter of concern. Anderson and Evans (2016) and Harris and Smith (2021) studied the causes and dangers connected with water pollution, focusing leakages, spills, or runoff from tank farm facilities. These toxins pose risks to local water bodies and aquatic ecosystems, harming aquatic life and biodiversity.

Studies by Fisher (2018), and Nguyen and Patel (2020) underlined the significant consequences of tank farm activities on water quality, emphasizing the ramifications for local populations relying on these water supplies for consumption and agricultural reasons.

Socio-Economic Effects on Communities

The existence of tank farms typically promotes socio-economic transformations among impacted communities. Research by Turner and Garcia (2017) and, Brown and Carter (2019) has dug into the changes in property prices and land use patterns in the proximity of tank farm locations. These changes, including property devaluation, changing land use, and limits on construction, profoundly influence community economies and infrastructure planning.

Moreover, socio-economic disturbances and community well-being have been thoroughly investigated by Jackson (2018) and Wilson & Hill (2020). These studies emphasize social problems, community disintegration, and psychological stress among inhabitants, adversely affecting the general well-being and social fabric of impacted communities.

2.3 Empirical Review of Related Literature

Bagshaw and Okoisama (2023) evaluated the association between operations improvement function—comprising contingency planning, benchmarking, and continuous improvement processes—and the organizational flexibility of Petroleum tank farms in South-South, Nigeria. The investigation was guided by contingency theory and the idea of routine dynamics, founded in positivism. The researchers performed a cross-sectional survey utilizing questionnaires, targeting 820 middle and top-level managers in the population. Utilizing the Krejcie & Morgan's technique, they determined a sample size of 262 respondents. Structural Equation Modeling was applied to test hypotheses, retaining a significance threshold of 0.05. The results revealed a substantial positive link between contingency planning, benchmarking, continuous improvement procedures, and the organizational flexibility of Petroleum tank farms in South-South, Nigeria.

The study finds that developing organizational flexibility in Petroleum tank farms needs a focus on implementing contingency planning, benchmarking, and continuous improvement methods. Recommendations include the deployment of resources (time, money, energy) to encourage continuous improvement systems. Additionally, prioritizing contingency planning through extensive training and information dissemination among personnel is proposed, assisting in crisis preparedness and ensuring safety measures are robust, permitting quick recovery from disasters. In summary, the study underlines the vital importance of operations improvement functions in enhancing the flexibility of Petroleum tank farms. Implementing these methods is critical for boosting resilience and responsiveness in the face of operational problems and unanticipated occurrences.

Dantsoho (2015) performed a thesis on risk-based framework for safety management in onshore tank farm operations. The paper investigates the relevance of onshore tank farm activities in the context of increased international trade involving petroleum products and hazardous chemicals. Given their vital position in the supply chain system, these facilities confront tremendous problems, illustrated by previous incidents resulting in major financial losses, environmental damage, and even disastrous results. The fundamental purpose of this project is to build a complete safety management framework for onshore tank farm operations, concentrating on risk assessment, mitigation tactics, and decision-making approaches. Dantsoho implements numerous safety/risk assessment approaches, including Failure Mode Effect Analysis (FMEA), Fault Tree Analysis (FTA), fuzzy logic, Analytic Hierarchy Process (AHP), and Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS). The study first applies FMEA-Fuzzy Rule Based (FRB) to identify and analyze possible risks in tank farm operations, highlighting crucial failure points such as automated shutdown oil safety valve failure, pipe corrosion protection system failure, among others. Subsequently, the research goes deeper into the riskiest danger, the leak detection system failure, utilizing the Fuzzy Fault Tree (FFT) model to appreciate its causes. The research underlines the necessity of adequate risk assessment and management in averting mishaps that might cause danger to staff, damage to the facility, and environmental degradation. Additionally, the research suggests the use of the AHP-TOPSIS model for improving tank farm operations by selecting the optimal Safety Control Design (SCD) among several possibilities, assuring efficiency and safety across systems and sub-systems. Dantsoho's study proposes a rigorous risk-based methodology that incorporates numerous evaluation approaches to promote safety in onshore tank farm operations. The created models and frameworks give useful insights into hazard identification, risk assessment, and safety improvement, providing a platform for more effective safety management choices in these vital facilities.

Okoisama, Umoh, and Needorn (2022) in their comprehensive study titled 'Operations Improvement Function and Environmental Sustainability of Petroleum Tank Farms in South South, Nigeria' delve into the critical relationship between operational enhancement strategies and the environmental sustainability of petroleum tank farms in a specific region of Nigeria. Their research explores two fundamental characteristics of operations improvement function—namely, preventative maintenance and benchmarking—and their influence on environmental sustainability within the context of petroleum tank farm operations. This work corresponds with larger concerns about the ecological repercussions of industrial processes, particularly in areas as vital and complicated as the storage and management of petroleum products. Grounded in the idea of routine dynamics and stakeholder theory, their study employs a positivist research philosophy, stressing empirical investigation using a cross-sectional survey approach. By deploying surveys targeting intermediate and top-level managers in chosen tank farms, the researchers acquire first-hand data from an accessible sample of 820 persons. Employing the Krejcie & Morgan's sample size calculation approach and tolerating a 10% adjustment for anticipated attritions and non-responses, the study secures a robust sample size of 288 respondents. Through painstaking statistical analysis utilizing Structural Equation Modeling, they rigorously examine hypotheses at a significance level of 0.05.

The findings of Okoisama, Umoh, and Needorn's research underline substantial connections between managerial commitment to preventative maintenance and increased environmental sustainability within petroleum tank farm operations. Moreover, their empirical research corroborates the favorable effect of benchmarking procedures on environmental sustainability measures inside these facilities. Their work culminates in tangible suggestions for the management of petroleum tank farms in South South, Nigeria. Specifically, they propose for a greater use of preventative maintenance, enabling engineers to acquire durable spare parts fulfilling high quality criteria. Additionally, the researchers recommend managers to boost benchmarking efforts by fostering active learning from peers and other firms, establishing a culture of continuous development. Overall, Okoisama, Umoh, and Needorn's work expands the conversation on sustainable practices within the petroleum business. By stressing the essential role of preventive maintenance and benchmarking in supporting environmental sustainability, their work gives useful insights that may guide realistic solutions for reconciling operational efficiency with ecological responsibility in petroleum tank farm operations.

Ibrahim and Syed (2018) delivered a study on Hazard Analysis of Crude Oil Storage Tank Farm. In their work, Ibrahim and Syed focus on the critical assessment of dangers inherent in crude oil storage facilities, admitting the historical incidence of tragic mishaps inside petrochemical storage operations. The research employs a systematic approach, incorporating Hazard and Operability Study (HAZOP), Fault Tree Analysis (FTA), and Event Tree Analysis (ETA) to comprehensively identify potential undesired accidents, analyze their root causes, estimate occurrence frequencies, and suggests preventive and mitigation measures. The project begins with a Hazard and Operability project (HAZOP) to identify possible dangers within the oil storage farm. Subsequently, Fault Tree Analysis (FTA) is applied to dissect the detected risks, finding the fundamental events (BEs) contributing to these hazards. This entails the construction of Minimal Path Sets (MPSs) and the computation of Structural Importance Degree (SID) for each BE. Additionally, Event Tree Analysis (ETA) is undertaken to identify accident occurrence channels and estimate their frequency. The research uncovers fire and explosion as the most significant incidents in the storage farm, with qualitative analysis identifying key critical fundamental events contributing to these hazardous situations. The study underlines that the incidence frequency of pool fire surpasses other situations, showing its increased likelihood. Based on their findings, Ibrahim and Syed recommend preventative and mitigating methods targeted at lowering the severity of tank accidents. These methods are intended to increase safety within the storage tank farm, reducing potential repercussions and enhancing the overall safety climate. This empirical study underlines the value of systematic hazard analysis approaches like HAZOP, FTA, and ETA in finding, analyzing, and managing hazards inside crude oil storage tank farms. The study's suggestions give practical insights for adopting actions to increase safety and lessen the environmental and human consequences of probable incidents at petrochemical facilities.

2.4 Research Gap

Bagshaw and Okoisama (2023) evaluated the association between operations improvement function—comprising contingency planning, benchmarking, and continuous improvement processes—and the organizational flexibility of Petroleum tank farms in South-South, Nigeria.

Okoisama, Umoh, and Needorn (2022) in their thorough study look into the vital link between operational optimization techniques and the environmental sustainability of petroleum tank farms in a specific location of Nigeria.

Dantsoho (2015) thesis centered on risk-based framework for safety management in onshore tank farm operations. Ibrahim and Syed (2018) focused on hazard assessments within crude oil storage tank farms.

However, from the general examination of literature to the empirical analysis of relevant literature, it has been vividly noticed that no one has under investigated and analyzed the Socio-Environmental Impacts of Tank Farm Location and Operation in Port Harcourt Municipality, Rivers State.

This indicates a research need that this study, analyzing the socio-environmental impact of tank farm locations and operation within Port Harcourt Municipality, Rivers State fills.

3.0 METHODOLOGY

This section provides an in-depth exploration of the research methods applied throughout the study, encompassing the research design, the study's target population, sample size determination and selection, instrumentation (questionnaire design), data collection methods, and data analysis techniques.

3.1 Research Design

This study adopted a passive observational research design, as outlined by Kumar, Leone, Aaker and Day, (2018) and developed upon by Creswell and Clark (2007) and Creswell (2012).

3.2 Population of the Study

The research's population, from which generalized findings are made, covers the aggregate number of 47788 households' heads (See Table 3.1) within the study area of Orije GRA, Rumuwoji and Bundu, all in Port Harcourt City LGA.

The Port Harcourt City Local Government Area contains 25 separate localities. Purposefully, these 3 villages around the research region became the sample communities. The selection of sample communities was carried out based on proximity and likely nearest neighbourhood influence. (Refer to Table 3.1 for the List of Selected Communities for the research). To generate the population for which generalization is made, the exponential growth model was employed to forecast the population of the 1991 census data to the study year 2023.

Table 3.1: List of Communities in the Study Area and Projected Population

S/n	Communities/ Residential Neighbourhoods	1991 Population	Projected Population 2023	No. of Households Pop÷6
1.	Oroabali (Orije Old GRA)	6482	32774	5462
2.	Port Harcourt Township Bundu	16266	82576	13763
3.	Rumuwoji 1	33776	171379	28563
	Total	**56524**	**286729**	**47788**

Source: NPC, 1991, Authors' Projected Population, 2023

3.3 Sample Size Determination and Selection

The sample size was computed using the sample size calculator inside the Creative Research Survey System (2016) Software, Version 12. This specialist program, built for survey research, allows questionnaire preparation, data administration, processing, and display of survey research findings. It also computes the needed sample size by considering the specified confidence level (ranging from 80% to 99%), the confidence interval (margin of error) between 5% and 10%, and the population size. At 95% Confidence level, 5% margin of error, population proportion 50% and population of 286729 (47788 homes), the sample was 398. The population under inspection comprises of two separate categories: the residents (household heads) of the Port Harcourt metropolitan.

3.4 Sampling

In this study, the sampling strategy adopted is the stratified random sampling method, which is a probability-based approach. The population was separated into three strata depending on the communities. A total of 398 questionnaires were handed to 'heads of families' within the three communities of Orije GRA, Rumuwoji and Bundu, all in Port Harcourt City Local Government Area (LGA). The sample size was allocated to each stratum proportionally to their size in the overall population. Within each stratum, a simple random sample of households was selected.

Table 3.2 Summary of Samples Per Community

S/n	Communities/ Residential Neighbourhoods	1991 Population	Projected Population 2023	No. of Households Pop÷6	Sample No. Of Households
4.	Oroabali (Orije Old GRA)	6482	32774	5462	**46**
5.	Port Harcourt Township Bundu	16266	82576	13763	**114**
6.	Rumuwoji	33776	171379	28563	**238**
	Total	**56524**	**286729**	**47788**	**398**

Source: Projected Population from (NPC, 1991), Researchers, (2022)

3.6 Data Collection

This study relies mostly on a questionnaire survey instrument to obtain data from the Heads of Households within the study area. Data collecting includes both primary and secondary sources. Primary data was acquired through the delivery of questionnaires and direct personal observations. Secondary data was obtained from a range of sources, including google earth, magazines, journals, relevant textbooks, reports, and internet resources, comprising both published and unpublished research works pertinent to solid waste management within the study region.

3.7 Method of Data Analysis

In this study, the analysis of data utilized descriptive statistics, which comprised the presentation of findings in tables, frequencies (responses), and percentages. Simple percentage computations were applied to illustrate the distribution and prevalence of replies to numerous survey topics. Again, Google earth map data was utilized to estimate the approximate quantity of land occupied by the tank farm.

4.0 RESULT OF THE STUDY

4.1 Size of Land Occupied by the Tank Farm

Respondents provided estimates of the tank farm's size in terms of acres or hectares. Table 4.1 shows that most respondents (36.43%) suggested that the tank farm might be within the range of 1-5 acres (0.4-2 hectares), while 30.90% estimated it to be within 5-10 acres (2-4 hectares).

Table 4.1: Size of Land Occupied by the Tank Farm

Question Number	Response Options	Number of Responses	Percentage
Q1.1	Less than 1 acre (0.4 hectares)	23	5.78%
Q1.1	1-5 acres (0.4-2 hectares)	145	36.43%
Q1.1	5-10 acres (2-4 hectares)	123	30.90%
Q1.1	10-20 acres (4-8 hectares)	84	21.11%
Q1.1	Over 20 acres (8 hectares)	23	5.78%
Total	**-**	**398**	**100%**

Source: Researchers Field Work, 2023

4.2 The Positive Impacts associated with the Tank Farm

Opinions regarding the tank farm's positive impacts were diverse. Table 4.2 shows that nearly 45% mentioned that some residents have been employed due to the tank farm, while about 24% indicated no noticeable employment opportunities. Additionally, approximately 47% believed in the tank farm's moderate contribution to the local economy.

Table 4.2: The Positive Impacts associated with the Tank Farm

Question Number	Response Options	Number of Responses	Percentage
Q2.1	Yes, many residents have been employed	122	30.65%
Q2.1	Yes, some residents have been employed	178	44.72%
Q2.1	No, no noticeable employment opportunities	98	24.62%
Total		**398**	**100%**
Q2.2	Significantly boosted the local economy	87	21.86%
Q2.2	Moderate contribution to the local economy	188	47.24%
Q2.2	No noticeable impact on the local economy	123	30.90%
Total	**-**	**398**	**100%**

Source: Researchers Field Work, 2023

4.3 Assessment of the Negative Socio-environmental Impacts

Table 4.3 show a significant portion of respondents (61.56%) who reported experiencing air pollution issues since the tank farm's establishment. Concerning water quality, roughly 44.72% noticed issues or changes, while 55.28% did not observe any problems. In terms of community life impact, 47.24% highlighted some negative effects, while around 24.62% felt a significant decline in the quality of life. Traffic congestion and road damage were notably highlighted by about 64.82% of respondents.

Table 4.3: Assessment of the Negative Socio-Environmental Impacts

Question Number	Response Options	Number of Responses	Percentage
Q3.1	Experienced air pollution issues	245	61.56%
Q3.1	No air pollution issues experienced	153	38.42%
Total		**398**	**100%**
Q3.2	Observed water quality issues or changes	178	44.72%
Q3.2	No observed water quality issues	220	55.28%
Total		**398**	**100%**
Q3.3	Significantly lowered the quality of life	98	24.62%
Q3.3	Some negative impacts on the quality of life	188	47.24%
Q3.3	No noticeable impact on the quality of life	112	28.14%
Total		**398**	**100%**
Q3.4	Significantly increased traffic congestion and road damage	258	64.82%
Q3.4	Some noticeable impact on traffic congestion and road damage	98	24.62%
Q3.4	No noticeable impact on road transportation	42	10.55%
Total		**398**	**100%**

Source: Researchers Field Work, 2023

4.4 Proposed Mitigation Measures

Respondents suggested various mitigation measures. The most recommended actions according to Table 4.4 were installing air pollution control systems (42.21%), implementing regular water quality monitoring (49.75%), and holding regular community meetings (44.72%).

Table 4.4: Proposed Mitigation Measures

Question Number	Response Options	Number of Responses	Percentage
Q4.1	Install air pollution control systems	168	42.21%
Q4.1	Increase vegetation and green spaces	122	30.65%
Q4.1	Monitor air quality regularly	108	27.14%
Total		**398**	**100%**
Q4.2	Implement regular water quality monitoring	198	49.75%
Q4.2	Invest in wastewater treatment facilities	148	37.19%
Q4.2	Educate tank farm workers on proper practices	52	13.07%
Total		**398**	**100%**
Q4.3	Establish a community liaison officer or committee	148	37.19%
Q4.3	Hold regular community meetings	178	44.72%
Q4.3	Create a transparent communication channel	72	18.09%
Total	-	**398**	**100%**

Source: Researchers Field Work, 2023

In general, the responses suggest a mix of perceptions regarding the tank farm's impacts, encompassing employment generation, economic contributions, environmental concerns, and proposed mitigation strategies to address these issues.

4.6 Size of Tank Farm Site from Google Earth

Fig 4.3 shows that the actual size of the tank farm is 92734.53 square meters which is 9.273453 Hectares

Fig 4. 2 Site with Survey Coordinates

Source: Researchers Work, 2023 on Map data, 2023

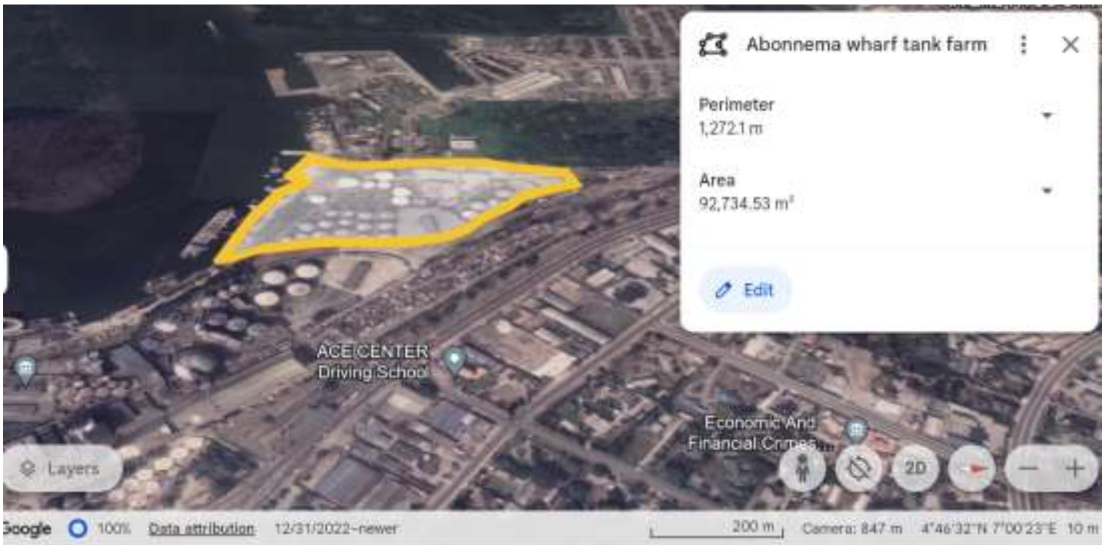

Fig 4.3 Actual size of the Port Harcourt Tank Farm

Source: Researchers Work, 2023 on Map data, 2023

4.7 Personal Observation

From personal observation, some real life images were taken during the field investigation. (See Plate 1-3)

Plate 1: Congestion as a result of irregular parking

Source: Researchers Field Work, 2023

Plate 2: Bad road due to heavy duty tankers/ trucks. See Trucks on Queue right

Source: Researchers Field Work, 2023

Plate 3: Tankers Parked on Public Right of Way

Source: Researchers Field Work, 2023

5.0 INTERPRETATION AND DISCUSSION ON FINDINGS

The survey responses from the head of household questionnaire surrounding the tank farm near Azikiwe road by Abonnema wharf road depict a diverse range of opinions and experiences related to the tank farm's impact on the community and the environment.

5.1 Size of Land Occupied by Tank Farm

Respondents provided estimates of the tank farm's size in terms of acres or hectares. Table 4.1 shows that most respondents (36.43%) suggested that the tank farm might be within the range of 1-5 acres (0.4-2 hectares), while 30.90% estimated it to be within 5-10 acres (2-4 hectares).

From Table 4.1, it is seen that the initial estimations from respondents suggest that the majority (67.33%) believed the tank farm was within the range of 1-10 acres:

36.43%: Estimated 1-5 acres (0.4-2 hectares).

30.90%: Estimated 5-10 acres (2-4 hectares).

However, the actual size of the tank farm from google map data is significantly larger at 9.273453 hectares (approximately 22.91 acres). The majority of respondents significantly underestimated the tank farm's actual size. This suggests a lack of awareness or access to accurate information about the facility. This underestimation could potentially hinder effective environmental impact assessment and planning. The actual size of the tank farm exceeds the upper limit of the most frequently mentioned range (5-10 acres) by more than double. This larger size suggests a potentially greater impact on the surrounding environment, requiring careful management and mitigation strategies.

5.2 Positive Impacts

The survey findings considerably resonate that tank farms tend to be important contributors to job possibilities, fitting closely with the insights derived from these scientific research.

Moreover, the perspectives recorded in the survey about the tank farm's economic benefit accord with the study findings of Obiand Nwosu(2020) and the reports from the Rivers State Oil and Gas Committee (2018). These scholarly sources have constantly underlined the significant role performed by tank farms in strengthening the local economy. The poll answers mirror the notion that tank farms, by nature of their activities and presence within the region, tend to provide concrete benefits to the economic growth and development of the local communities.

Therefore, the survey's comments on employment generation and economic contributions confirm previous research literature, strengthening the concept that tank farms truly occupy a crucial role in promoting employment possibilities and driving economic success within their area.

5.3 Negative Socio-Environmental Impacts

The survey findings revealed prevalent concerns regarding the negative socio-environmental impacts coming out from the presence and operations of tank farms. The respondents' reported experiences of air pollution correspond with broader environmental studies addressing emissions concerns associated with these facilities. Similarly, observations of changes in water quality resonate with the risks outlined in various scholarly sources, emphasizing potential water contamination risks linked to tank farm operations.

Furthermore, the survey reflected perceptions of a noticeable negative impact on the overall quality of life due to the tank farm's presence, echoing sentiments outlined in studies by Nwosu and Mohammed (2018). These findings corroborate current concerns regarding socio-economic disturbances that commonly follow the development of such industrial facilities. Additionally, the documented rise in traffic congestion and road damage fits with issues expressed in literature, stressing the infrastructure problems imposed by tank farms within their proximity.

5.4 Proposed Mitigation Measures

The survey results underlined potential mitigating actions to minimize the detrimental consequences connected to tank farm activities. Suggestions for installing pollution control systems, increasing green spaces, and monitoring air and water quality echo recommendations outlined in established environmental guidelines, such as those put forth by the Rivers State Ministry of Energy (2019). These techniques correlate with the suggested environmental mitigation measures meant to alleviate air and water pollution risks connected with industrial activities.

Moreover, the respondents asked for improved community participation, transparent communication, and the provision of venues for interaction between the tank farm management and local populations. These proposals match comments offered by experts such as Obi & Nwosu (2020) and the Nigerian Petroleum Logistics Institute (2021), highlighting the essential importance of community participation in creating improved relations and resolving community problems related with industrial activities.

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This study investigated the size, impacts, and community perceptions of a tank farm located along Abonnema wharf road in Port Harcourt, Nigeria. The findings reveal a significant discrepancy between residents' estimations and the actual size of the facility, highlighting the need for accurate information and transparent communication.

Actual Size: The tank farm occupies 9.273453 hectares (approximately 22.91 acres), substantially larger than resident estimations.

Positive impacts captured in the study are as follows:

i. Employment Opportunities: There's acknowledgement of employment generation, although opinions vary on the scale of employment provided by the tank farm.

ii. Moderate Economic Contribution: While some residents perceive a noticeable boost to the local economy, others indicate a moderate impact.

Negative impacts captured in the study are as follows:

iii. Environmental Concerns: Air pollution, changes in water quality, and disruptions to the overall quality of life stand out as key concerns among the community members.

iv. Infrastructure Challenges: Increased traffic congestion and road damage are highlighted as significant challenges.

Mitigation measures suggested by residents are as follows:

The community has suggested practical mitigation measures such as enhancing air and water quality management, engaging in community dialogues, and fostering better communication channels between the tank farm management and the local residents.

6.2 Recommendations

From the extant literature and from output of the field data, the following recommendations are put forward:

i. Environmental Monitoring and Mitigation: Implement strong environmental monitoring systems to frequently examine air and water quality. Additionally, invest in innovative systems to control pollutants and minimize water pollution.

ii. Community Engagement: Establish a systematic discussion mechanism between the tank farm management and the local community. Regular town hall meetings, feedback channels, and a designated community liaison officer may allow open discussion and resolve problems efficiently.

iii. Infrastructure Improvement: Collaborate with local authorities to solve road infrastructure challenges caused by increasing traffic surrounding the tank farm. Prioritize road repair and seek alternatives to reduce traffic congestion.

iv. Social activities: Initiate social activities aimed at boosting the quality of life in the community affected by the tank farm's operations. This might involve health awareness campaigns, education efforts, or community development programs.

v. Regulatory Compliance: Ensure rigorous adherence to environmental legislation and standards imposed by competent authorities. Regular audits and compliance inspections can aid to upholding environmental and safety requirements.

vi. Investment in Sustainability: Encourage the implementation of sustainable methods within the tank farm operations. This might incorporate renewable energy integration, waste reduction techniques, and eco-friendly technologies.

vii. Continuous Engagement: Foster a continuing collaboration with the community to address emergent problems swiftly. Regularly review the success of adopted measures and change strategy accordingly.

Implementing these guidelines collectively amongst the tank farm management, local authorities, and the community can build a more sustainable and amicable connection between the tank farm and the surrounding environment.

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