

Evaluating Community Perceptions and the Effectiveness of Social Impact Assessment in Sewage Treatment Plant Development

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ABSTRACT

This study investigates the awareness, perceptions, and level of public acceptability regarding the proposed upgrading of the Kuala Sawah Sewage Treatment Plant (STP). A structured survey was conducted to assess the community's knowledge of the project, perceived socio-economic, environmental, and cultural impacts, as well as their general level of support or opposition. The findings reveal a high level of community support, despite low awareness, with the majority perceiving the project as beneficial in terms of employment, infrastructure improvement, and environmental enhancement. The study emphasizes the importance of effective communication strategies and stakeholder engagement in public infrastructure projects and evaluates the effectiveness of the Social Impact Assessment (SIA) process in this context.

Keywords: Social Impact Assessment (SIA), Public Perception, Sewage Treatment Plant (STP), Community Acceptability, Infrastructure Development

INTRODUCTION

The upgrading of sewage treatment infrastructure is crucial for sustainable urban development. However, the success of such projects often hinges on the perceptions and acceptability of local communities. This paper presents findings from a survey conducted in Kuala Sawah to evaluate public awareness, perceptions, and acceptability of the STP upgrading project. It also discusses how these findings reflect the effectiveness of the Social Impact Assessment (SIA) process employed for this development. Sewage Treatment Plants (STPs) are essential infrastructure for managing wastewater and protecting environmental health. However, the operation and upgrading of STPs often raise various concerns among surrounding communities. Past research has shown that the impacts of STPs extend beyond environmental and technical aspects, influencing socio-economic conditions, health and safety, cultural values, aesthetics, and public amenities. Understanding public perception of these impacts is crucial for effective planning, implementation, and community acceptance of such projects.

Several studies have highlighted the dual nature of socio-economic impacts associated with STP operations. On one hand, STPs can contribute positively by creating employment opportunities, stimulating local businesses, and increasing property values [1] and [2]. For instance, [3] noted that the development of wastewater infrastructure in urban areas often leads to increased land values and enhanced development potential due to improved sanitation and environmental quality. On the other hand, some studies indicate negative socio-economic impacts, particularly during the construction phase, such as disruption to local livelihoods, noise, traffic, and limited access to public spaces [4]. These impacts are more prominent in densely populated or economically vulnerable communities, emphasizing the need for tailored mitigation strategies.

Health and safety are commonly cited concerns in communities living near STPs. Exposure to untreated sewage, accidents, and emissions from the plant are some of the primary issues highlighted in the literature. According to World Health Organization [5], inadequate containment or treatment of sewage can lead to the spread of communicable diseases such as cholera, typhoid, and hepatitis A. Furthermore, occupational health risks for workers and indirect health impacts on nearby residents due to air and water pollution have also been reported [6]. However, studies have shown that with modern STP technologies and proper maintenance, these risks can be significantly minimized [7].

The presence of STPs can have implications on the visual quality and cultural integrity of a locality. Several case studies [8] have reported that STPs, if not properly designed or screened, may detract from the aesthetic value of landscapes, particularly in residential or culturally significant areas. Moreover, there is evidence that poorly planned infrastructure can conflict with local traditions, disrupt spiritual practices, or encroach on culturally important sites [9]. As such, integrating cultural sensitivity and aesthetic design into project planning is essential to minimize opposition and preserve local identity.

Past research has also explored how the establishment or upgrading of STPs may affect local infrastructure and public services. Some studies suggest that these facilities could increase demand for water, electricity, and waste disposal services, particularly if large construction crews or temporary populations are involved [10]. However, other findings indicate that modern STPs are designed with energy efficiency and minimal resource consumption in mind [11]. In such cases, the net effect on utilities may be negligible or even beneficial if the plant contributes to better waste management and environmental services.

One of the most commonly cited concerns in public perception studies is odour pollution. The unpleasant smells associated with sewage treatment are known to negatively influence quality of life, property values, and community well-being [12]. Studies such as [13] emphasize that odour can act as a powerful trigger for public opposition, even in the absence of actual health risks. Advanced odour control technologies (e.g., biofilters, chemical scrubbers, sealed units) can significantly reduce such impacts, but their effectiveness depends on consistent maintenance and community trust in the plant's operational integrity.

METHODOLOGY

This study employed a quantitative descriptive research design using a structured questionnaire survey to assess public awareness, perception, and acceptability towards the development of STP. The descriptive approach is appropriate for capturing a snapshot of community views and understanding patterns in public responses [14]. Data were collected through a structured questionnaire administered to local residents. The survey included questions on awareness, perceived impacts (socio-economic, health, environmental, cultural), and general acceptance of the project. Data analysis was conducted using descriptive statistics.

A stratified random sampling technique was employed to ensure fair representation of households across different demographic groups within the community. The survey targeted household heads or adult members aged 18 and above. A total of 381 respondents participated in the study. Stratification was based on residential zones to capture spatial variation in perceptions, especially those living closest to the STP site. Sampling procedures followed guidelines outlined by [15], ensuring randomness while accounting for proportional representation.

Data were collected using a structured questionnaire, which was pre-tested for clarity and reliability prior to full deployment. The questionnaire was divided into several sections: awareness and sources of information; perceptions of socio-economic impacts; health and safety concerns; perceptions of odour pollution; perceived impacts on aesthetics, culture, utilities, and amenities; and level of acceptability and reasons for agreement or disagreement. Most items employed Likert-type scales (Yes/No/Not Sure) to quantify perceptions and attitudes, in line with standard practices in social impact assessments [16]. Data were collected through face-to-face interviews conducted by trained enumerators. This approach was chosen to minimize non-response and ensure accurate interpretation of questions, especially among older or less literate respondents. Verbal consent was obtained from all participants prior to the interviews, and ethical considerations such as anonymity, voluntary participation, and confidentiality were strictly maintained throughout the process.

The collected data were coded and analysed using descriptive statistics, including frequencies and percentages, to identify general trends in awareness, perception, and acceptability. The analysis focused on: Assessing awareness levels and sources of information, measuring perceptions across multiple dimensions (socio-economic, health, environmental, cultural), and Identifying factors contributing to acceptance or opposition of the project. The use of descriptive statistical analysis is consistent with methodologies adopted in similar community perception studies [17]-[18].

Study Area

The Regional Sewage Treatment Plant (STP) is situated in Kuala Sawah, within the Rantau state constituency in the Seremban District of Negeri Sembilan, Malaysia. It is approximately 10 km from Seremban town centre. The community in study area is a hamlet (kampung) with mixed ethnicity, including Malay, Chinese, and Indian populations, numbering around 5,000 residents. The plant services a relatively large catchment area, covering about 10,600 hectares, which includes multiple sub-areas or localities such as Paroi, Rahang, Senawang, Temiang, and others.

The STP employs an Oxidation Ditch (OD) system. For sludge management, it uses a screw-press thickener, which dewater sludge to reach approximately 20 percent dryness (20 % solid content). The treatment chain includes influent grit chambers, clarifiers, disinfection (with UV), press dryers, and a series of physical, biological, and disinfection stages before discharge. It is also the largest sewage treatment plant in Negeri Sembilan in terms of its catchment area and population equivalent served. It supports multiple localities and urbanizing zones, interfacing with expanding residential, commercial, and perhaps light industrial land uses. This gives it strategic importance from both environmental and public health perspectives.

About 351 of samples that inhabit in twenty-two (22) selected residential areas have been examined. The highest number of samples was collected from residential area distance 3-4 km which represents 34.2 percent of total samples. Figure 1 shows the sensitive receptor within the study area.

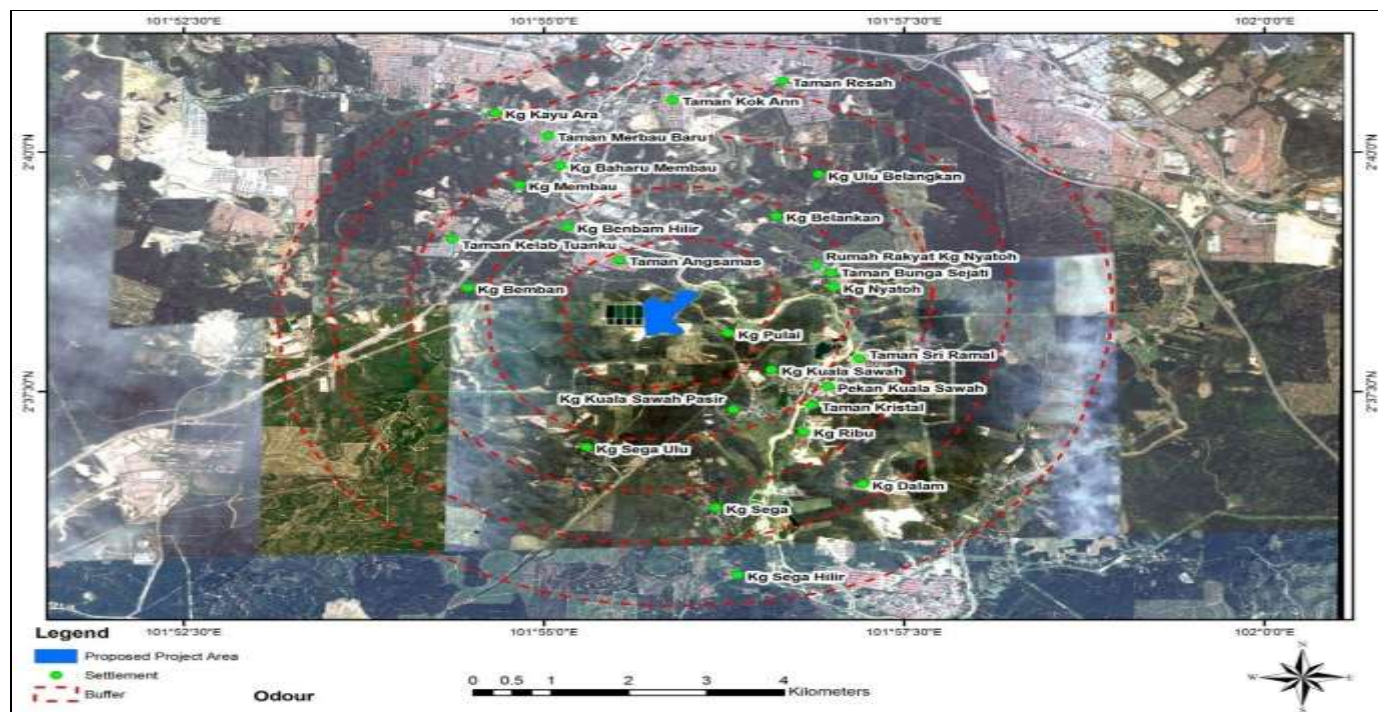


Fig. 1 Sensitive receptor within the study area

RESULTS AND DISCUSSIONS

Perception of Socio-Economic Impacts

The study indicates that a significant portion of respondents perceive the proposed upgrading of the STP as

having positive socio-economic implications. According to the survey: 46.4% believed the project would provide employment opportunities to the local population, 43.0% expected improvements in basic amenities, and 38.5% foresaw increased business opportunities. Around 38% believed the project would enhance their standard of living, house ownership opportunities, and property values (Table 1). Conversely, only a very small percentage (<1%) feared negative socio-economic impacts such as loss of employment, loss of property, or marginalization. These findings reflect a generally optimistic view of the project's socio-economic benefits, particularly regarding employment, infrastructure development, and potential economic stimulation.

Table 1 Perceived Socio-Economic Impacts

Perception	Yes	No	Not Sure
Employment for household members	38.2	34.8	27.1
Employment for local population	46.4	22.5	31.1
Improvement of basic amenities	43.0	26.2	30.8
Increased property values	37.3	31.1	31.3
Higher standard of living	38.2	30.5	30.8
Increased business opportunities	38.5	31.6	29.9
Increased house ownership opportunities	34.5	34.8	30.8
Attraction of external workers	41.6	26.5	31.9

Infrastructure projects, including STPs, are commonly linked to short-term job creation and long-term economic benefits. As noted by [19], improvements in basic services such as sanitation often create opportunities for local employment, particularly during construction and early operation phases. Similarly, [20] found that wastewater treatment projects in developing countries often contribute to indirect economic growth, by improving environmental conditions that encourage tourism, housing development, and commercial investment. However, temporary employment during construction may not always translate into sustainable long-term economic benefits unless accompanied by broader community development strategies [21]. Thus, while the positive perception of employment is valid, it may reflect short-term expectations rather than guaranteed long-term outcomes.

Improved sanitation services are linked to increased land and property values, especially in peri-urban and semi-rural areas [3]. Clean environments and reliable infrastructure contribute to a higher standard of living and enhance the attractiveness of residential zones [22]. Nonetheless, this is highly dependent on the management and aesthetic integration of the plant. If not well maintained or if it causes nuisances such as odour or noise, the opposite may occur by reducing nearby property values and lowering quality of life [23].

Although only a small portion of respondents in the study area feared displacement or marginalization, literature suggests that vulnerable groups such as low-income households or informal settlers can sometimes face unintended socio-economic exclusion during or after major infrastructure projects [16]. Such risks are often underreported, especially in studies that rely on general public surveys. Therefore, it is important that impact assessments include marginalized voices explicitly.

The perception that the STP development will bring positive socio-economic impacts aligns with existing literature, particularly in relation to employment creation, improved services, and potential increases in property values. However, the relatively low awareness of potential negative socio-economic risks highlights the importance of a more inclusive and targeted impact assessment, especially focusing on sensitive receptors who may not benefit equally from the project. Ensuring transparent recruitment, local capacity building, and equitable development planning can help maximize benefits and mitigate risks and thereby supporting both community welfare and the long-term sustainability of the project.

Perception of Health and Safety Impacts

The study results suggest that the majority of respondents do not perceive significant negative health or safety impacts from the proposed upgrading of the STP. According to the survey, the highest concern was air pollution (12.8%), followed by water pollution (11.7%), and increased communicable diseases (10.3%). Concerns over noise pollution (9.7%), traffic congestion (10.0%), and disturbance to peace (10.0%) were relatively moderate (Table 2). Then, Increased accident risk was the least concerning issue, with only 7.4% expressing worry. Overall, these results suggest a generally low level of health and safety concern among the community, with a substantial majority indicating either “No” or “Not sure” in their responses. This indicates either trust in the project’s safety protocols, lack of awareness, or desensitization due to prior exposure to the existing STP.

Table 2 Health And Safety Impact Concerns

Impact	Yes	No	Not Sure
Increased accidents	7.4	63.5	29.1
Noise pollution	9.7	61.0	29.1
Congestion	10.0	62.1	27.9
Air pollution	12.8	56.1	31.1
Water pollution	11.7	57.0	31.3
Disturbance to tranquillity	10.0	57.8	32.2
Spread of communicable disease	10.3	56.7	33.0

Sewage Treatment Plants are essential public health infrastructure, but they can pose environmental health risks if not properly managed. According to [5], improperly treated sewage can lead to the spread of communicable diseases, especially gastrointestinal illnesses and skin infections. Airborne bioaerosols (bacteria, fungi, viruses), emitted during treatment processes, may pose respiratory risks for workers and nearby residents, particularly when STPs are located in densely populated areas [24]. Moreover, volatile organic compounds (VOCs) and hydrogen sulphide (H_2S) are common emissions from STPs, and prolonged exposure may cause headaches, nausea, and mucous membrane irritation [25]. Despite these concerns, modern STPs that follow international safety and environmental standards tend to minimize these health risks effectively, particularly through enclosed systems, odour control technologies, and treated effluent monitoring [26].

Safety concerns around STP projects can also include the increased traffic during construction, which may elevate accident risks, particularly for children and the elderly. Heavy machinery and transportation vehicles can also contribute to noise pollution and road wear, affecting local mobility [27]. Wastewater overflow or equipment malfunction, though rare, can lead to localized flooding or chemical exposure. However, literature indicates that with proper construction management, safety training, and community consultation, these risks can be mitigated effectively [16].

The study findings indicate a low level of public concern regarding health and safety impacts of the development of the STP. While this reflects public confidence or limited perceived exposure, literature suggests that potential risks do exist, especially during the construction phase and in poorly managed facilities. Particular attention should be paid to sensitive receptors, including children, the elderly, and nearby institutions. Therefore, comprehensive environmental management plans, risk communication, and public health monitoring should be integral to the project implementation to ensure these groups are protected and community trust is maintained.

Perception of Odour Pollution

The study revealed that the vast majority of respondents (97.7%) perceived odour pollution from the existing STP to be negligible or non-existent, with only a small fraction (2.3%) acknowledging the presence of odour issues.

Furthermore, the reported odour intensity was overwhelmingly low, with 97.7% indicating no odour or only minor odour intensity, and odour peaks were rarely observed across different times of day.

This finding contrasts with common perceptions reported in literature, where odour from STPs is often a major source of community concern [12] and [13]. Odour nuisance is widely documented as a key factor influencing public opposition to wastewater treatment facilities, as unpleasant smells directly affect quality of life, property values, and social acceptance [28]. The minimal odour concern reported in this study may reflect effective odour control technologies or operational management at the Kuala Sawah STP, which is consistent with findings by [29] that advanced treatment and maintenance can significantly reduce odour emissions.

Sensitive receptors such as residents living in close proximity to the STP, children, the elderly, and individuals with respiratory conditions are particularly vulnerable to odour pollution. Odours can cause psychological discomfort, stress, and in some cases, exacerbate respiratory and neurological symptoms [30]. The [31] recognizes odour annoyance as a public health issue, linking persistent odour exposure to adverse health effects even when chemical concentrations are below toxic thresholds.

In this study, the low perception of odour nuisance suggests that sensitive receptors are not significantly impacted at present, which is a positive indicator of the plant's environmental performance and community relations. However, continuous monitoring is recommended because odour episodes can be intermittent and influenced by operational changes or meteorological conditions [32].

The study's finding that odour pollution is not a significant concern aligns with effective operational practices and odour control at the STP. This outcome positively impacts sensitive receptors by minimizing nuisance and associated health risks, contributing to higher community acceptability. Nevertheless, due to the fluctuating nature of odour emissions, ongoing monitoring and community engagement remain essential components of sustainable sewage treatment plant management.

Perception of Aesthetic and Cultural Impacts

The study found that the perception of aesthetic and cultural impacts resulting from the proposed upgrading of the STP in study area was relatively low among respondents. Only 21.1% believed the project would affect the landform of the area, while 20.2% felt it would affect the beauty of the landscape. Perceptions of potential negative impacts on air and water quality (15.7%), tranquillity (14.8%), and community integration (3.7%) were also minimal (Table 3). Additionally, concerns over local traditions, places of worship, and important buildings were not widely expressed, each receiving responses below 7%. These results suggest that most residents do not perceive the project as significantly disruptive to the area's cultural integrity or visual aesthetics. This may be attributed to the plant's location, the project's communication strategy, or previous familiarity with such infrastructure.

Numerous studies have highlighted the importance of aesthetics and cultural values in public acceptance of infrastructure projects. Infrastructure such as sewage treatment plants, though functionally essential, can be viewed as intrusive if they disrupt visual landscapes, heritage sites, or communal spaces [17] and [33]. STPs, due to their industrial nature, can create visual blight, especially when placed in scenic or residential areas [34]. Perceived degradation of the landscape can reduce community pride, affect mental well-being, and even lower property values [35]. However, modern planning practices have emphasized landscaping, architectural integration, and buffer zones to mitigate these effects [36]. Cultural impacts involve the potential disturbance or alteration of social structures, ritual spaces, or traditional practices. Projects located near religious sites, cemeteries, or culturally significant landmarks may face strong community resistance, especially among indigenous or long-established populations [37] and [16]. In contrast, when communities feel their heritage is respected, projects tend to face less opposition.

Sensitive receptors in this context include groups or individuals particularly affected by changes to the cultural or aesthetic environment, such as: Elderly residents with strong emotional ties to local traditions or landscapes, religious communities who use nearby places of worship, artists or cultural practitioners who rely on the landscape for inspiration or performance, youth and children, who are influenced by their surroundings in terms

of identity and attachment to place. For these groups, disruption to cultural norms, community integration, or landscape aesthetics can lead to psychological stress, loss of sense of place, or even social fragmentation [23]. This is especially true in rural or semi-rural communities, where the environment plays a central role in daily life and identity. Fortunately, the findings in the study area suggest that such negative impacts are minimal, either due to effective site selection or because the existing STP has already been socially internalized. However, continuous community consultation is critical to ensure that future upgrades do not cross previously undetected cultural or aesthetic thresholds.

While only a minority of respondents in study area perceived significant aesthetic or cultural impacts from the STP upgrade, this issue should not be overlooked. Literature confirms that infrastructure projects can lead to social and emotional impacts, particularly for sensitive receptors. Proactive planning that respects local aesthetics and cultural values, coupled with ongoing engagement with vulnerable groups, can help sustain community support and social cohesion throughout the project lifecycle.

Table 3 Aesthetic And Cultural Concerns

Impact	Yes	No	Not sure
Landform disruption	21.1	47.9	31.1
Landscape aesthetics	20.2	49.0	30.8
Air and water quality	15.7	53.0	31.0
Community integration/tradition	3.5	69.0	27.0

Perception of Utilities and Amenities Demand

Most respondents did not anticipate strain on local utilities. The findings of the survey revealed that a majority of respondents did not perceive significant increases in demand on utilities and amenities as a result of the proposed upgrading of the STP in study area. The results shown only 18.5% of respondents believed that the project would increase demand for water supply. 19.4% expected an increase in electricity demand. Perceived increase in demand for housing (13.7%), garbage disposal (14.2%), health services (13.1%), police services (14.5%), and fire-fighting services (12.0%) was also low. Also, a large proportion of responses were “Not sure”, typically above 39% for most items. This suggests a low level of concern or awareness among the local population regarding the potential strain on existing infrastructure and services. It may reflect confidence in local capacity, lack of knowledge about how STP upgrades may indirectly affect utilities, or limited perceived connection between STP operations and public service demand.

Modern infrastructure systems are interdependent. Upgrading a sewage treatment plant can affect demands on water, electricity, solid waste, and public services, especially during construction and initial operational phases [38]. For example, the construction and operation of an STP typically require an increased water use for processing and cleaning, electricity for mechanical and biological treatment systems, and solid waste removal for sludge and grit materials. Even if the STP is designed for sustainability, temporary surges in utility usage during construction or upgrades are common [26].

Large infrastructure projects can increase population density in certain areas by attracting workers and stimulating development. This can place additional pressure on local amenities, including housing, healthcare, security, and waste management [27] and [16]. However, the extent of this pressure depends on the scale of the project, the proximity to residential zones, and the local government's capacity to absorb demand. In small-scale or semi-rural settings, such as at study area the perceived and actual impacts may be minimal, which aligns with the current study findings.

According to [23], public awareness of environmental infrastructure often focuses on visible or sensory impacts (e.g., noise, odour), while more abstract consequences (e.g., increased strain on utilities) are often overlooked unless they become acute. The high percentage of “Not sure” responses in the current study suggests a knowledge gap that should be addressed through public engagement and transparency in infrastructure planning.

The findings show that local residents perceive minimal strain on utilities and amenities from the STP development, possibly due to the limited scale of the project or a lack of awareness about interlinked infrastructure impacts. While this suggests low immediate concern, literature emphasizes that infrastructure upgrades often lead to short, or medium increases in resource demand, particularly during construction phases. Policymakers and planners must ensure that sensitive receptors including low-income and high-dependency groups are protected from any potential service disruptions. Proactive engagement, capacity planning, and community-targeted communication are key strategies for ensuring equitable outcomes.

Effectiveness Of Social Impact Assessment (Sia) Process

The effectiveness of the Social Impact Assessment (SIA) process in infrastructure development, such as the development of the STP, can be evaluated based on several criteria: stakeholder awareness, public participation, identification of sensitive receptors, mitigation of adverse effects, and social acceptability of the project. Findings from the present study offer valuable insight into how well these elements were addressed during the assessment and planning stages.

Public Awareness and Access to Information

One of the foundational pillars of effective SIA is informing and educating stakeholders about the proposed development. In this study, only 6% of respondents were aware of the STP upgrading project, and the majority received information informally through villagers or household members, rather than official channels or public briefings. This indicates limited dissemination of project information, suggesting that the SIA process may have fallen short in ensuring transparency and early stakeholder engagement. According to [16], effective SIA must facilitate early and ongoing engagement, allowing stakeholders to be aware of the project's objectives, impacts, and mitigation measures. The low awareness level reflects a gap in the scoping and communication phases of the SIA, which can hinder trust and long-term project acceptance [39].

Perception of Impacts and Risk Identification

The survey revealed that the majority of respondents perceived positive socio-economic outcomes, such as increased employment and improved amenities. There was low concern for adverse impacts, including health risks, environmental degradation, or strain on utilities. While this positive outlook reflects general community support, the high percentage of "Not sure" responses across various impact categories suggests that many respondents lacked a full understanding of the potential risks. This raises concerns about whether the SIA process adequately accessed and communicated cumulative, indirect, and long-term impacts, particularly to vulnerable and sensitive receptors [40]. Moreover, the identification of sensitive groups such as the elderly, women, and low-income households was not explicitly detailed in community responses, indicating a potential oversight in the distributional impact analysis, a key principle of effective SIA [41].

Community Participation and Acceptability

The study found that 88.9% of respondents agreed with the STP project, and 97.2% believed it would have more positive than negative impacts. These are strong indicators of project acceptability, a central goal of SIA. However, acceptability alone does not imply a fully effective SIA process. If acceptability is based on limited information or lack of understanding of risks, it may not reflect informed consent. According to [42], SIA must not only seek community support but also ensure that such support is based on adequate knowledge, dialogue, and inclusion of diverse viewpoints. In this case, the limited channels of information dissemination and low awareness of certain impact domains (e.g., odour pollution, aesthetic degradation, utility strain) suggest that community consent may have been passive rather than active, raising questions about the depth of participatory processes in the project.

Predictive Accuracy and Mitigation Planning

A key function of SIA is to accurately predict potential social impacts and propose mitigation strategies before implementation. Based on the findings, residents did not perceive significant risks, and negative expectations,

such as displacement, loss of income, or health risks were minimal. While this may suggest low-risk project characteristics, literature emphasizes that underestimation of risks, especially in environmental health and urban infrastructure projects, is common when SIA processes are rushed or not participatory [43]. For instance, odour, air pollution, and increased traffic are frequently underreported in baseline surveys, yet emerge as major complaints post-construction [44]. Therefore, the effectiveness of the SIA should also be judged based on whether risk prediction models were used, whether long-term monitoring plans were developed, and whether early warning mechanisms are in place. The study does not indicate such measures were communicated or known to the public.

Post-SIA Monitoring and Adaptive Management

An effective SIA does not end with the initial assessment but includes monitoring, evaluation, and adaptation throughout the project lifecycle [45]. The lack of strong community concern over environmental or health impacts may result in lower pressure on authorities to implement rigorous monitoring frameworks. This is problematic, as sensitive receptors, including schools, healthcare facilities, and low-income households may experience long-term cumulative impacts that are not immediately perceptible during the early operational stages. Post-implementation monitoring mechanisms, if not institutionalized and transparent, risk undermining the preventive and adaptive function of the SIA.

Overall, the findings of this study suggest that the SIA process was moderately effective in ensuring social acceptability of the STP project. However, it shows limitations in early engagement, stakeholder awareness, and comprehensive risk communication. While the perception of positive socio-economic benefits is promising, the limited awareness of potential negative impacts highlights the need for enhanced participatory mechanisms, transparent information flow, and targeted engagement with sensitive groups.

Sustainability Of Sia Process

Social Impact Assessment (SIA) is a critical tool for anticipating, managing, and mitigating the social consequences of infrastructure projects such as the upgrading of a STP. However, findings from the present study, particularly the low public awareness (6%), limited stakeholder engagement, and general lack of detailed knowledge about potential impacts, indicate that there is significant room for improvement in the SIA process applied in the case of Kuala Sawah. An effective SIA is not only a procedural requirement, but a participatory, inclusive, and adaptive process that should meaningfully inform both decision-making and implementation. Based on these observations, the following sustainability of SIA process are proposed, supported by key insights from established literature.

Early and Inclusive Stakeholder Engagement

Conduct early, continuous, and inclusive stakeholder consultations involving all segments of the affected community. Early engagement allows stakeholders, especially vulnerable or marginalised groups can raise concerns, express expectations, and participate in shaping project outcomes. The study revealed that most respondents learned about the project informally, which highlights a breakdown in official communication channels. According to [16] and [41], effective SIA must begin during the project conceptualisation stage and not merely at the time of formal approval. This ensures that the process is proactive rather than reactive. Moreover, [39] argue that inclusive stakeholder engagement builds trust and enhances social license to operate. This implementation tactics will include to organise public meetings in local languages. Then, use visual and participatory tools such as maps, videos, storytelling, and involve local leaders, women's groups, schools, and health clinics to reach a wider demographic.

Enhanced Communication and Transparency

Improve the clarity, accessibility, and distribution of project-related information through multiple channels. The lack of awareness observed in the study (with 78.6% unaware of the project) reflects inadequate dissemination of information. Effective communication is essential for informed decision-making by stakeholders and for building trust between developers and the community. According to [42], states that transparent information

sharing is a cornerstone of good SIA practice. Similarly, [46] recommends that all communication be culturally appropriate, timely, and accessible, especially for non-literate or undereducated populations. This implementation tactics include to develop community notice boards, mobile updates, and house-to-house briefings. Then, need to translate technical documents into local dialects, and hold informational sessions at community centres or religious spaces.

Identification and Protection of Sensitive Receptors

The suggestion for sustainability needs to conduct thorough baseline social profiling to identify sensitive receptors such as children, the elderly, people with disabilities, and low-income households. These groups may experience disproportionate impacts from noise, odour, air pollution, or infrastructure strain. Yet, they are often underrepresented in typical consultation processes. According [45], SIA should be distributional in its analysis, meaning it must consider who gains and who bears the costs. Then, [43] also highlight the importance of targeting interventions to those most vulnerable. Also, the implementation tactics include a map proximity of schools, clinics, homes for the elderly to project sites. Use disaggregated data such as age, gender, income in impact analysis, and develop targeted mitigation plans such as noise barriers near schools.

Integration of SIA with Environmental and Engineering Processes

This recommendation is to ensure that SIA findings are integrated into technical project design and environmental management plans (EMP). Whereas the SIA is often conducted in isolation from technical decision-making, reducing its influence on actual project modifications or mitigation strategies. [44] argue for the integration of SIA with Environmental Impact Assessment (EIA) to create a holistic understanding of project impacts. [47] recommend cross disciplinary planning to prevent social risks from being overshadowed by economic or technical concerns. To integrate this, the implementation tactics need to establish joint SIA-EIA review teams. At the meantime, it is requiring developers to respond directly to SIA findings in project design, and also link social mitigation to budgeted items in the project cost.

Post-Implementation Monitoring and Adaptive Management

The implementation of monitoring and evaluation framework for social impacts, with community participation, after the project operational also an effective recommendation to integrate SIA in the development process. Without systematic follow-up, unforeseen impacts may go unaddressed, and commitments made during the planning stage may be forgotten. According to [45] and [39], an adaptive SIA system includes feedback loops for revising mitigation measures based on actual social outcomes. This enhances accountability and long-term sustainability. The implementation of this monitoring and adaptive management includes to establish a community monitoring committee, publish regular impact reports accessible to the public, and use surveys or focus groups to track changes in well-being, amenity access, and perceptions.

Capacity Building for Local Authorities and Communities

Invest in training and institutional capacity building for local governments, NGOs, and community members in SIA processes also efficient capacity building for local authorities and communities. A technically sound SIA process requires local knowledge, institutional memory, and independent oversight, which may be lacking in smaller towns or rural areas like in study area. [40] emphasises that the effectiveness of SIA is as much about process as it is about outcomes, and building local capacities ensures better participation, oversight, and ownership. The implementation tactics for capacity building include to conduct SIA training workshops for local council officers, collaborate with local universities or NGOs for technical support, and develop community led social audit frameworks.

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CONCLUSION

The study reveals a high level of public support for the STP development project, primarily driven by expectations of socio-economic benefits. However, limited awareness and community involvement indicate areas where the SIA process could be strengthened. For future infrastructure developments, a more proactive, transparent, and inclusive SIA process will be vital to maximize benefits, address concerns, and ensure long term sustainability and legitimacy. An effective SIA process must move beyond formal compliance and checklist approaches to become a dynamic, participatory, and iterative process that genuinely reflects and responds to community concerns. Based on the case study of the STP development project, it is evident that greater efforts are needed in early engagement, information sharing, and identification of social vulnerabilities. Also, by incorporating the recommendations, future SIAs can better support socially sustainable development, protect sensitive receptors, and enhance the legitimacy and acceptance of infrastructure projects. Ultimately, the effectiveness of SIA lies not just in predicting impacts, but in shaping development that is equitable, inclusive, and responsive to the needs of all stakeholders.

While the current study shows limited public concern over odour, health, or utility strain, these generalized perceptions may obscure deeper, uneven vulnerabilities. Sensitive receptors, such as the elderly, children, low-income households, or those living in closer proximity (<500m) to the STP could experience disproportionately higher impacts due to greater exposure or reduced resilience. The high proportion of “Not Sure” responses in areas such as utility strain and environmental risk suggests a lack of detailed awareness among certain groups, potentially reflecting communication gaps or informational inequities. Future SIA processes should employ disaggregated sampling and participatory mapping to ensure that spatial and demographic variations in risk perception are captured and addressed.

A comparative analysis with similar STP projects in Malaysia and Southeast Asia reveals both common challenges and context-specific successes. For example, projects in urban areas like Kuala Lumpur faced greater resistance due to odour and aesthetic concerns, while Singapore’s emphasis on design integration and public transparency fostered greater acceptance. Integrating these lessons could help tailor future SIA processes more effectively. Moreover, expanding the analysis of potential negative impacts across different demographic and spatial groups, particularly elderly, low-income residents, and those living in close proximity would provide a more equitable and nuanced understanding of social risk. To enhance the long-term utility of SIA, future efforts should include not only pre-construction assessments but also participatory post-implementation monitoring and ongoing community dialogue.

In conclusion, the effectiveness of SIA lies not just in identifying impacts but in shaping development that is equitable, inclusive, and responsive. Embedding continuous community dialogue, post implementation monitoring, and demographic specific analysis into the SIA process will better support socially sustainable development and strengthen the legitimacy of future infrastructure projects.

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