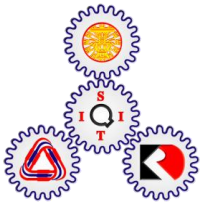

PUBLIC PERCEPTION OF A SOLID WASTE DUMP SITE IN SAMUT PRAKAN, THAILAND

BY

APANUCH SRANGSRIWONG

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ENGINEERING (LOGISTICS AND SUPPLY CHAIN SYSTEMS ENGINEERING)

SIRINDHORN INTERNATIONAL INSTITUTE OF TECHNOLOGY

THAMMASAT UNIVERSITY

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A Thesis Presented

By

APANUCH SRANGSRIWONG

Submitted to

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In partial fulfillment of the requirements for the degree of

MASTER OF ENGINEERING (LOGISTICS AND SUPPLY CHAIN SYSTEMS ENGINEERING)

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Abstract

PUBLIC PERCEPTION OF A SOLID WASTE DUMPSITE IN SAMUT PRAKAN, THAILAND

BY

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In Thailand, the continued use of unsanitary disposal sites without sufficient environmental and public health protection has led to a growing negative public perception of local municipal solid waste facilities. While the development of a more environmentally-benign system is underway, it is essential to understand how to handle and prevent negative public perception from being escalated into excessive public opposition. In this study, in-depth interviews and questionnaire-based interviews are used to gather data from 468 respondents, at 28 survey locations, within 5.7 km radius from Praeksa mai dump site. The concerns that drive negative public perception of the dump site, which can be classified into those related to health, environment, waste truck management, and property value of land, are revealed. In addition, facilities management plays important role and affect public perception. Waste truck management generates problems which affect to the resident among the waste trucks routes. To establish a waste disposal facility, it is crucial to identify the condition of wind direction to help decrease negative impacts from odor created by the dump site. Non-parametric statistical analysis techniques are used to identify significant factors influencing the perception of residents living near the dump site, and to investigate the change in perception related to 7 impact categories across different distance intervals

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from the dump site. The results show that socio-economic characteristics of respondents have an influence towards their perception of the dump site. Older respondents are more concerned about their living conditions. Respondents with higher educational level show more environmental awareness. Respondents who live near the dump site express their willingness to move out far away from the dump site. Furthermore, different living durations also impact the public perception, while odor is the most significant issue faced by the group of residents living within 1 km around the dump site. The maximum distance that respondents perceive the effect is 3.5 km away from the dump site. Beyond this distance, respondents slightly feel that they are affected by the dump site. In waste truck management, the results can be concluded that the adverse effect from noise and dirtiness of waste truck surveyed is decreased with longer distance away from waste truck route. Moreover, wind direction significantly affects odor within a range of 2,001-4,000 meters in southeast and southwest directions.

Keywords: solid waste management; dumpsite; public perception; environmental impact; health concern; odor

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Chapter 1
Introduction

In most developing countries, solid waste management has been one of the major public health and environmental quality concerns. The ongoing use of unsanitary disposal practices and facilities is normally observed, due to insufficient waste management budget and inadequate local environmental protection efforts. In Thailand, after the incident of massive fire at Praeksa dump site in 2014, government agencies and public had to re-examine their solid waste management and pollution control practices. All disposal sites are subjected to more stringent environmental regulations. The upgrading of existing municipal solid waste management (MSWM) infrastructures to be more environmentally responsible is underway, but still in the early stage. At present, the unavoidable need to rely heavily on unsanitary and inefficient MSWM practices makes it quite challenging for responsible decision makers to achieve a sustainable solid waste management plan.

The basic causes of unsanitary and inefficient MSWM are numerous. To name a few important causes, first, large-scale systematic waste segregation at source is still a very challenging goal to achieve in developing countries, largely due to insufficient sanitary budget and public awareness about the importance of waste sorting and waste minimization. Second, waste-processing technologies are used in the absence of adequate waste disposal regulations and ordinances as well as environmentally stimulated and enlightened public, resulting in a long-term decline of the well-being of residents around waste sites. Third, the management of solid waste is not entirely conducted by local government. Private sector participation is normally examined as a means of improving cost efficiency in MSWM operations, mainly waste collection, separation, and disposal. However, the role of private contractors in improving existing pollution control practices and becoming more environmentally responsible remains questionable.

The selection of suitable disposal site locations serves as an important component for efficient MSWM and urban planning. Siting waste disposal facilities, especially in an urban area, is a very complex task, due to the intensive stakeholder involvement in the protection of public health and ecosystem. The process of site

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selection requires a thorough consideration of various environmental and socio-economic criteria. The site selection process also involves the geographic analysis of large amount of spatial and other relevant attribute data governing the suitability of a site (Ojha et al. 2007). Despite the rigorous evaluation and screening process, a siting decision usually has to be made against significant public resistance, largely due to the long-term unresolved MSWM issues that has eroded the confidence of local communities in being in close proximity to waste sites. As a result, the siting process is increasingly complex and more dependent on public support.

The understanding of public perception and concern is essential to ensure environmentally and socially sound site selection and effective collaborative efforts in solving MSWM issues. Based on the literature concerning the public perception of solid waste disposal, a number of previous studies have attempted to gain an improved understanding of the nature of public perception of environmental and health risks from solid waste disposal. The identification of factors influencing public perception is the first step in a systematic approach to promoting more socially and environmentally sound MSWM. Among the widely recognized negative impacts of unsanitary MSWM, odor and inadequate air quality have been identified as a major source of public and opposition to landfill siting complaint (Badach et al., 2018). The degree of odor offensiveness perceived by an individual is dependent on various factors. From the chemical viewpoint, the intensity of odor is strongly related to the constituents of wastes and the amount of odorous gases released. Hydrogen sulfides and ammonia are known to be the main contributors to landfill odor. At any rate, human response to odor and other environmental stressors can be quite subjective and variable, depending on number of factors from age and health status to living duration and past experience. Based on previous survey studies, the other factors affecting the level of perceived odor annoyance include the frequency of exposure and odor intensity (Aatamila et al., 2012), distance from waste sites (Che et at., 2013), and meteorological parameters such as wind (Sakawi et al., 2011), and weather conditions (Naddeo et al., 2016). In addition to odor, previous perception studies show that people perception about environmental and health risks is also subjective and differs for individuals, depending on many factors, including socioeconomic status, past experience, and residential proximity to hazardous waste sites.

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In the literature concerning the effects of residential proximity to hazardous waste sites, public opinion data have consistently shown that respondents who live closer to waste disposal sites are likely to view the potential health and environmental impacts with greater concern. However, there are surprisingly few studies that have carefully investigated the relation between residential proximity to waste sites and public perception towards the impacts of MSWM. This leaves unanswered the question to which spatial extent, negative public perception towards a waste site still exists. When identifying factors influencing the spatial distributions of perceived environmental and health risks, researchers classify respondents based on municipal boundary. Rahardyan et al., 2004 used questionnaire survey to evaluate the environmental and health concerns of MSWM facilities among people from different municipalities. People living in municipalities which receive wastes from other cities are subject to significantly higher environmental stress and have a higher tendency to develop negative impression about MSWM facilities. Feo et al., 2013 evaluated the effects of being in close proximity to waste sites for residents in three different communities. Their findings suggest that communities may have an interest in accepting unequal distribution of environmental impacts in return for economic compensation. A single specific distance is also used when evaluating the effects of residential proximity to hazardous waste sites. Sankoh et al., 2013 evaluated the perception of unsanitary waste disposal within two groups of respondents: those who reside within and outside 50 meters of a dump site in Sierra Leone. Al-Khatib et al., 2014 asked their respondents to indicate whether they are against the construction of MSWM facilities within 1 kilometer from their home. However, any distance, at best, tends to be an inadequate proxy for public perceptions of risk associated with hazardous waste sites. There is a need to capture responses from respondents with different residential proximities to a waste site, to investigate the spatial extent to which negative public perceptions towards a waste site still take place.

1.1 Background of Praeksa mai dump site

Praeksa mai dumpsite was established in 2004 in Samut Prakan province, northern part of the Bangkok metropolitan region. At present, the province

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has a population of about 1.3 million people. There are three dump sites located in Wat Chiruang, Praeksa, and Praeksa mai districts. Praeksa mai dump site covers a total area of 512,000 square meters and is the only active site that still daily receives about 4,000 tons of municipal solid wastes from 18 municipalities in Samut Prakan. Of which, only about 500 tons (12%) of the wastes are properly sorted into organics, recyclable, and combustible wastes. The remaining 3,500 tons (88%) are directly disposed at the dump site. In sorting process, wastes are separated into organics (30%), recyclable waste (10%), and Refuse Derived Fuel (RDF) (60%). Today, the dump site has in total of over 10 million tons of residual waste, which also consists of recyclable waste, plastics, and RDP fuel. The surrounding areas of the dump site consist predominantly of residential properties of various characters, with some industrial facilities. The issues of municipal solid waste accumulation and inadequate waste disposal have been the topic of many public concerns and debates, amid the steadily changing socio-economic context of population and rapid growth of solid waste generation. There is a clear research need to obtain an accurate objective knowledge about local community reaction to specific MSWM issues. Therefore, the surrounding area of the dump site is chosen to be the site for public perception assessment in this study. In Thailand, over 27.06 million tons of municipal solid waste generated in 2016 (PCD, 2016) and the amount of waste are increasing in trend every year with 0.7 % of waste in 2016. Open dump sites are widely practiced system to get rid of the amount of solid waste in provincial areas. (Municipal waste management in Asia, 2004) Samut Prakan is one part of the Bangkok Metropolitan Region. The province has been ranked as the fifth most critical provinces in Thailand regarding remaining amount of waste in disposal site. Well known Praeksa mai dump site, located in Praeksa mai district, Samut Prakan province, was chosen in this study because the site is surrounded by many communities with different types of residents, companies, and industrial estate. The northern part of Samut Prakan province is adjacent to Bangkok, which is approximately 15 kilometers away. The dump site was taken over and managed by a private sector called Eastern Energy Plus Co. Lld. and was established in March 2011. The dump site is divided into four sections; including a 9.98-megawatts RDF power plant, a waste sorting plant, a waste open dump area, and a wastewater treatment plant.

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1.2 Problem Statement

Across the developing countries, rapid urbanization creates new administration problems. The growing volume of waste being produced affects to siting of a new solid waste management facility. Waste treatment processes can produce chemical and biological emissions to the environment and may affect the residents of nearby neighborhoods, creating health problem, which will increase negative long-term effects to the local communities (Suffet et al., 2009). Solid waste management also has been a major challenge to public health and environmental quality, especially in developing countries. From the various impacts, they can be categorized into two main types; which are physical impacts and non-physical impact. The physical impacts take various forms: odor, noise, vibration, rubbish, and pests. But for the non-physical impact, it could be the damage of landscape, unsightly views of solid waste management facility, or a decrease in property value.

The case control study on municipal solid waste landfills shows that people's concerns towards solid waste management facilities and their relations with attitudes towards the facilities were analyzed. As for personal attributes, identified that people in age 40 to 50 years old, who had lived 10 to 20 years at their current address, get negative attitude toward facilities. Furthermore, from the statistic can suggest that people who did not have a clear attitude toward landfill were those who had less concern about impacts of the facilities.

To seek a socially and environmentally sound MSWM, various survey research attempts have been made, to gain an improved understanding of the public perception towards solid waste management of solid waste odors and environmental pollution attributed to currently used disposal practices. The public preference on siting landfills is primarily based on the traveling distances between collection centers and residential areas. A questionnaire survey conducted in Malaysia by *Sakawi et al., 2011* demonstrates that odor from landfill sites can significantly affect the daily activities and quality of life of communities. The questionnaire survey by *Che et at., 2013* shows that there is a positive correlation between public perceptions of odor annoyance and the distance from waste disposal facilities. Geographic information system (GIS) is used to map the level of public perception, interpolated over the surrounding geographical areas

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of a landfill in Shanghai. The results of these studies can help decision makers in solving waste disposal siting problems. Some questionnaire surveys are conducted in response to the need to improve people's awareness and understanding of solid waste management impacts. *De Feo and De Gisi, 2010* conduct a questionnaire survey in Southern Italy to determine the levels of waste management knowledge among different classifications of respondents, to suggest appropriate educational plans for each. *Zhang et al., 2012* use a questionnaire survey to investigate public opinions and the current kitchen waste separation practices of people in Shanghai, with an aim to reduce the generation of municipal solid wastes. Based on the findings of the previous studies on public perception survey, there is still research need to investigate the correlation between public perception and relevant factors, including the demographic, health information, and the perception toward the open dump of the affected residents. The change in perception of residents towards waste disposal facilities, with variation of their surrounding environmental settings, should also be further investigated. In light of these findings, decision makings related to solid waste management practices and disposal site selection can be performed in a social sustainable manner.

1.3 Objectives

This study therefore aims to contribute to the field by presenting the findings of in-depth interviews and questionnaire-based interviews carried out in the surrounding areas of Praeksa mai dump site in Samut Prakan province, Thailand, from November 2017 to January 2018. The studying goals are to gain an improved understanding about 1) the current environmental and health concerns associated with the dump site, 2) the factors influencing these public concerns, and 3) the spatial extent to which local residents perceive the dump site to be a threat to their quality of life. These findings will be useful for setting up the basis for analyzing the impact area and the number of affected population.

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Chapter 2
Literature Review

2.1 Municipal solid waste management problems

The problem of inefficient municipal solid waste management (MSWM) has been one of the most neglected obstacles to sustainable urban development. The lack of information regarding waste quantity and composition is the first common barrier to planning and executing proper waste management schemes. The insufficient management of dump site is not able to provide process of weight the waste truck before dumping the waste into the site. In addition, increasing rate of disposal and the corresponding decrease in disposal capacity. (Naushad K., 2010) Due to the people lifestyle of using more plastic material, the amount of plastic waste is estimated 20-30% of the total waste in an open dump site. (Tomonori I., 2004) Because the plastics waste cannot degrade inside an open dump site, it decreases the availability of space for waste disposal. Limited budget allocation for MSWM operations is another main cause of inadequate solid waste management practices. Government cannot provide a well public service in urban areas because of mismanagement in terms of financial and institutional constraints. The government spends only 2-8% of total budget for the solid waste management, but collection and transportation activities constitute approximately 80-95% of the total budget of MSWM. (Mufeed Sharholu., 2008) Therefore, the waste collection services are lack of funds to expand and improve MSWM. (Rotich K.,2006) Unpolitical situation with inefficient service collection of waste lack of capacity to keep all the trucks running. Improper infrastructure condition of the road can delay the service and maintenance of waste collection vehicles. Most people do not have a good knowledge about proper waste segregation. Without knowing the segregation properties, the amount of waste is still increasing and needs more costs of providing various service improvements. (Rafia A.,2013) Providing an education to public knowledge of the households can improve the public concerns and will be helpful for improvement of waste management, which can reduce the amount of waste in open dump site. The knowledge should be easily integrated in the main

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concept of waste education for all section of societies. (S.E. Hasan.,2004) With the rapid growth of urbanization and household consumption, there is a great public concern that MSWM will pose serious risk to the environment, public health, and quality of life of urban residents. Nearly 90% of the respondents cannot make a correct separation of food waste (Zhang H.,2017). In an urban context, it is more difficult for communities and local governments to ensure an efficient management of waste. Due to urbanization, the change in urban waste composition is particularly significant, normally with a larger fraction of plastic and non-decomposable contents (Tomonori I., 2004). The lack of current information regarding the composition and quantity of waste can complicate the attempt to plan and execute suitable waste management schemes (Naushad K., 2010). The misallocation of resource and budget for MSWM operations is often based on inadequate information, as well (Mufeed Sharholu., 2008). In previous waste management researches, attempts have been made to propose solutions to these causes.

To seek a socially and environmentally sound approach to solid waste management, various survey research attempts have been made, to gain an improved understanding of the nature of public perception of solid waste odors and environmental pollution attributed to currently used disposal practices. The public preference on siting landfills is primarily based on the traveling distances between collection centers and residential areas. A questionnaire survey conducted in Malaysia by Sakawi et al., 2011 demonstrates that odor from landfill sites can significantly affect the daily activities and quality of life of communities. The questionnaire survey by Che et at., 2013 shows that there is a positive correlation between public perceptions of odor annoyance and the distance from waste disposal facilities. Geographic information system (GIS) is used to map the level of public perception, interpolated over the surrounding geographical areas of a landfill in Shanghai. The results of these studies can help decision makers in solving waste disposal siting problems. Some questionnaire surveys are conducted in response to the need to improve people's awareness and understanding of solid waste management impacts. De Feo and De Gisi, 2010 conduct a questionnaire survey in Southern Italy to determine the levels of waste management knowledge among different classifications of respondents, in order to suggest appropriate educational plans for each. Zhang et al., 2014 use a questionnaire survey to investigate public opinions and

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2.2 Effects and causes of inefficient MSWM

The disposal of municipal solid waste in landfills may contribute to a substantial annoyance for neighboring residents. Organic wastes are subjected to aerobic and anaerobic degradations, resulting in an intensive production rate of landfill gases. The emission typically includes microbe particle and odor substances; which are methane, carbon dioxide and volatile organic compounds. The negative health effects may be related to pathophysiological reasons, stress-induced illness, as well as mass psychological hysteria (Dennis S., 2001). Furthermore, public perceptions regarding the risk of exposure to waste as heightened as communities and society realize that hazardous waste do not simply degrade into harmless substances, and do not remain where stored. Developing countries are seriously facing the associated problems in collection, transportation and disposal of communal solid waste (Naeem N., 2012). The major causes for the inefficient municipal solid waste management systems in Samut Prakan province are the unintended invasion of the city, rapid industrialization, severe weather conditions, lack of social awareness involvement, improper resources including improper equipment and lack of funds.

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2.3 Environment and public health impact

The dump site has a significant impact on the quality of local public health. Levis et al., 2017 show that uncontrolled dump sites are a major source of greenhouse gases, particulate matter, and leachate containing heavy metals and organic pollutants, that can contaminate soil and nearby surface and groundwater. The poses serious threat to public health, in terms of heavy metal contamination in food items and ecosystem. A literature review conducted by Ncube et al., 2017 indicates that the operations of open dumps and other waste disposal facilities pose various health risks to municipal waste workers and surrounding communities. The major health problems include cancer, low birth weight, congenital anomalies, Down's syndrome, musculoskeletal disorders, respiratory diseases, intestinal diseases, and skin inflammation. The dumps are breeding sites for flies and pests, which carry pathogens and numerous diseases into their surrounding communities. In addition to these immediate adverse effects, there have been a growing public awareness of human health and environmental impacts of unsanitary waste dumps, particularly after the incident of massive fire at Praeksa dump site, Samut Prakarn, in 2014. The release of thick black toxic fumes from a massive garbage dump fire has prompted government agencies and public to re-examine solid waste management practices and pollution control regulations. The unpleasant sight and other factors, especially odor of garbage piles from the dumps serve as the primary source of negative public perception issues towards dump sites, which are greatly related to the degree of odor annoyance (Aatamila et al., 2010). Nearby resident of the open dump site could be faced with air pollutants emitted or contaminated soil and water. An impact of open dump site can cause pollution of all environmental components. Moreover, landfill also associated with lung cancer and respiration diseases and respiratory diseases both in adults and children. The odor from the landfill site were causing illnesses, Symptoms and diseases they associated with exposure included cancer, stress, fatigue, headaches, eye infections or irritation, coughs, stuffy nose, dry throat and nausea, sarcoidosis, asthma, gastroschisis, and spontaneous abortions. Women who live close to landfill has risk with baby. The weighting of births was less than 2500 grams, genetic damage, neurological damage, and other health

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problems. In general, the highest mortality ratios were found in more central areas of the municipality, while the landfill sites were located in more peripheral areas. For landfill management, it has risk of bladder and liver cancer, and death due to congenital malformation.

2.4 Public concern toward solid waste disposal in odor

Because of the municipal solid waste treatment facilities are increasingly an environmental and public health concern, residents living near MSWM facilities are faced with various risk perceptions, particularly, odor; the physical symptoms are mainly associated with odor annoyance not odor perception (Aatamila et al, 2011). A structured questionnaire was designed and distributed to assess the nearby resident concerns and attitudes surrounding the Preksa mai waste disposal in Samut Prakan province. The research findings also direct attention to the important role of public participation. It is important to understand why people reject waste disposal infrastructure development to avoid conflicts and build social trust. Moreover, the others that affect attitudes towards the local waste disposal facility developments include distance and socio-demographic factors. Generally, the evidence about the distance suggests a correlation between nearby residents in the geographic zone of waste disposal with distance that perceived risk and associated transportation routes. It is expected that acceptance of the facility increases as one moves away from the facility because the perception of being at risk decreases i.e. distance is a proxy for risk perception (Gawande and Jenkins-Smith, 2001) For the socio-demographic factors, age is included because the different age respondents may feel different level of potential risks from the facility; gender is included to see if there is any difference between male and female perspectives on the waste disposal. Also, a variable to indicate differences in attitudes between those respondents who have worked versus those residents who are living in the locality.

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CHAPTER 3

Methods of Approach

An in-depth interview is used to gather information for designing the questionnaire about the impact of the dump site that affected people who live nearby. After the information is collected, it is used to design and develop a questionnaire. To develop a questionnaire which can accurately reflect and describe the MSWM problems experienced by local residents, preliminary in-depth interviews are conducted for issue identification and classification. The overall research framework of this paper is presented in Figure 3.1.

The interviews are conducted using open-ended questions, which allow the respondents to engage in a wide range of discussions about how their quality of life has been affected by the dump site. The interview results are used as a basis for questionnaire development. After the questionnaire is developed, it is evaluated and commented by two experts, who are university professors that conducted research related to the dump site and environmental problems for many years. Based on the comments, the questionnaire was revised. The revised questionnaire is tested with a small sample of 80 respondents to ensure that the questions are not ambiguous. Then, the questionnaires are conducted into selected locations.

After the survey is completed, statistical analyses are applied. In this paper, ordinal logistic, linear, and quadratic regression techniques are used to analyze the factors influencing public perception. Additionally, the impacts are expected to be dependent on the distance from the house of the respondent to the dump site. Therefore, the linear regression is applied to determine the degree of the impact as a function of the distance. However, in case of the relationship between the degree of impact and the distance is non-linear, the quadratic regression will be applied.

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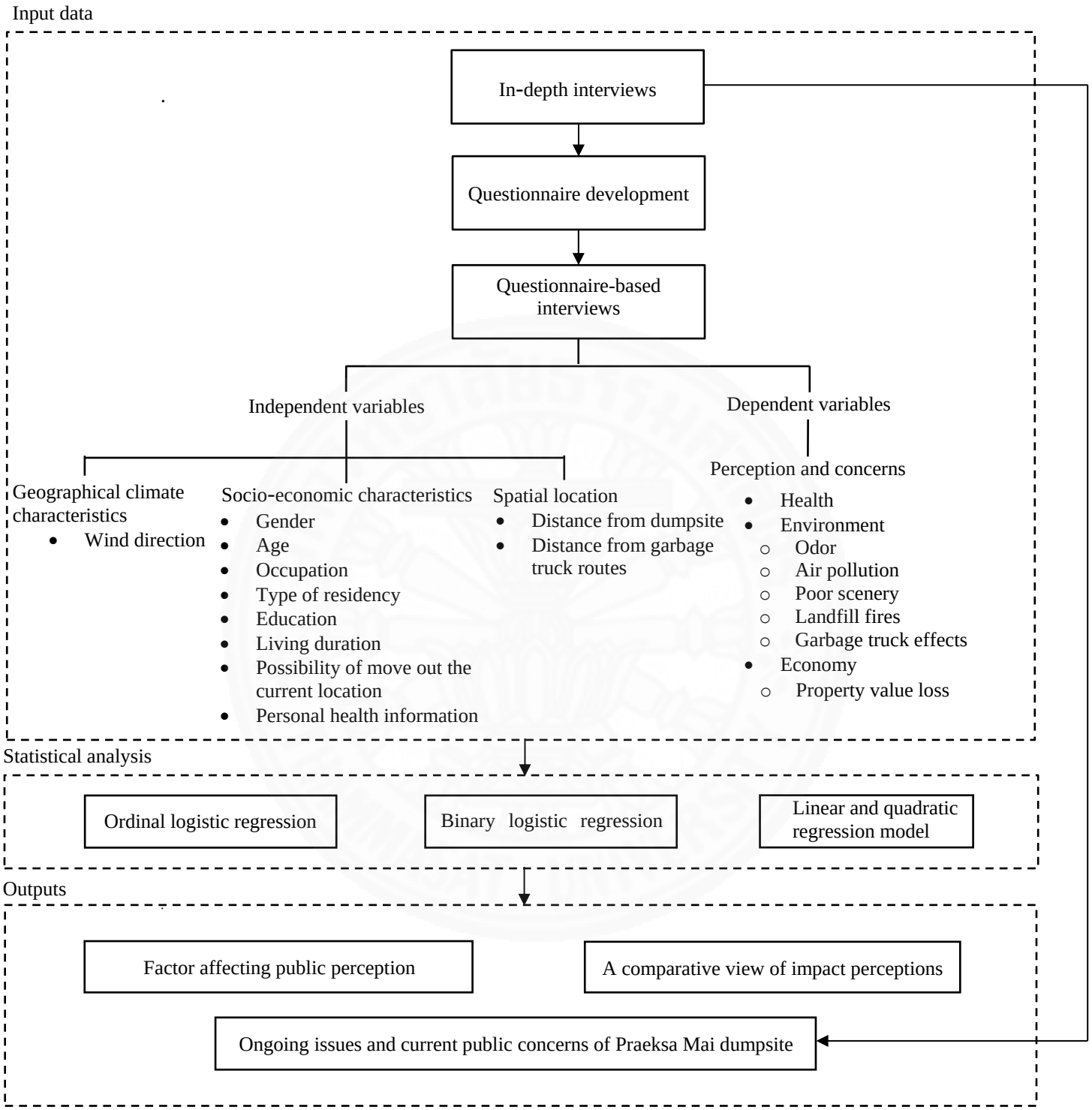

Figure 3.1: Overall Research Framework

3.1 Sample size

The required sample size is calculated using formula (1) (Cochran, 1953). This formula is selected to find the required sample size with unknown population standard

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deviation. Since the impacts of the dump site are evaluated in 7 levels, *p* and *q* in formula (1) are 1/7 and 6/7, respectively.

$$n = \frac{Z^2\sigma}{E^2} = \frac{Z^2pq}{E^2} \quad (1)$$

where,

n	Sample size
z	Standard normal score
p	The proportion of elements in the population that has a particular attribute.
q	The proportion of elements in the population that does not have a specified attribute.
e	Margin of error

Therefore, the required sample size is 188 samples, when the margin of error (*e*) is 5% at 95% confidence level (*z* =1.96)

$$n = \frac{Z^2 pq}{e^2} = \frac{1.96^2 \times \frac{1}{7} \times \frac{6}{7}}{0.05^2} = 188 \text{ samples}$$

Based on the time and budget of this research, it is possible to increase the sample size to 400-500 samples to reduce the margin of error. After the interview survey is completed, there are 468 respondents with complete information. From formula (2), which is derived from the formula (1), 468 respondents result in the error of 3.17% at 95 % confident level.

$$e = \sqrt{\frac{Z^2 pq}{n}} = \sqrt{\frac{1.96^2 \times \frac{1}{7} \times \frac{6}{7}}{468}} = 3.17\%$$

Sample size of 384 persons is calculated by formula (1) (W.G. Cochran, 1953). This formula is selected to find the sample size with unknown population standard

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deviation by using 7 % of errors and 95 % confidence level ($\alpha = 0.05$). The expected error was 5% that will give sample size of 753 observations, while the actual effective sample size is 468 observations. According to many factors, for instance, most people within the industrial areas are unwilling to do the survey as they are busy cooperating with our project. Another reason is that aliens are not capable of doing survey as they do not understand the questions. Some locations have no respondents to complete the survey, such as small forests, swamp areas, and abandoned places. Lastly, 34 out of 502 survey sets cannot be used due to errors. Based on the reasons stated above, 7% is estimated as a percentage of error for this sample size according to sampling techniques.

$$\boldsymbol{n} = \frac{\boldsymbol{Z^2\sigma}}{\boldsymbol{e^2}} = \frac{\boldsymbol{Z^2pq}}{\boldsymbol{e^2}}, \text{ which } \sigma = s^2 = \text{pq} \quad (1)$$

Where,

n=population size

$Z_{\frac{\alpha}{2}}$ 95% confident interval, $z_{0.475}$=1.96

σ =Use the selection one from seven choices.

p = The proportion of elements in the population that has a particular attribute.

q = The proportion of elements in the population that does not have a specified attribute.

e = margin of error, using 7%

So,

$$n = \frac{Z^2\text{pq}}{E^2} = \frac{1.96^2 \times \frac{1}{7} \times \frac{6}{7}}{0.035^2} = 384 \text{ samples}$$

3.2 Questionnaire survey

3.2.1 Details of questionnaire

The questionnaire is developed and divided into 3 sections to evaluate 1) socioeconomic characteristic 2) the respondent's smoking behaviors and symptoms, and 3) perception related to the effects of Praeksa Mai dump site on their health, environment, waste truck management, and property value. The first section contains independent variables: gender, occupation, possibility of move out the current location, age, type of residency, educational level, living duration, and personal health

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information. The responses to these questions are considered as independent variables. The second section consists of 16 questions with a 7-point Likert scale that ask respondents how the dump site affects their health, environment, and their property values. The Likert scale ranges from 1 to 7, with 1 being very low and 7 being the very high as shown in Table 3.1. The responses to these questions are used as dependent variables. After reviewed by a panel of experts in the MSWM field, the questionnaire is revised and tested on a sample of 80 respondents before conducting a full-scale survey. Full questionnaire is presented as an example in the Appendix. The dependent-variable questions in the questionnaire are as follows.

- Do you feel that the dump site has a negative impact on health and sanitation?
- Are you affected by the foul odor of dump site?
- To what extent are you concerned about the air contamination problem caused by dump site emissions?
- Do you think that the presence of the dump site negatively affects the scenic quality of areas surrounding your community?
- Are you concerned about dump site fire and its effects on adjacent residential properties?
- Do you think the presence of the dump site negatively affects the market value of local residential properties?

Table 3.1 Impact levels and score in survey questionnaire

Impact level	**Evaluated score**
Very high	7
High	6
Slightly high	5
Moderate	4
Slightly low	3
low	2
Very low	1

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3.2.2 Survey locations

The selection of survey locations is one of the most important tasks in this study. It is crucial that the designated survey locations provide an access to residential areas located at different directions and distances from the dump site. During this process, 28 survey locations are identified, as shown in Figure 2. The studying area is divided into 8 overlapping circular zones, where the dump site is located at the center. This covers about 113 km^2 of area around the dump site. The separation of survey locations into zones is made to investigate the changes in the level of impact perceived by people over different distances from the dump site. The displacement distance between each survey location and the dump site is also regarded as one of the independent variables. To identify the right respondents, a google map around the dump site is shown in Figure 3.2.

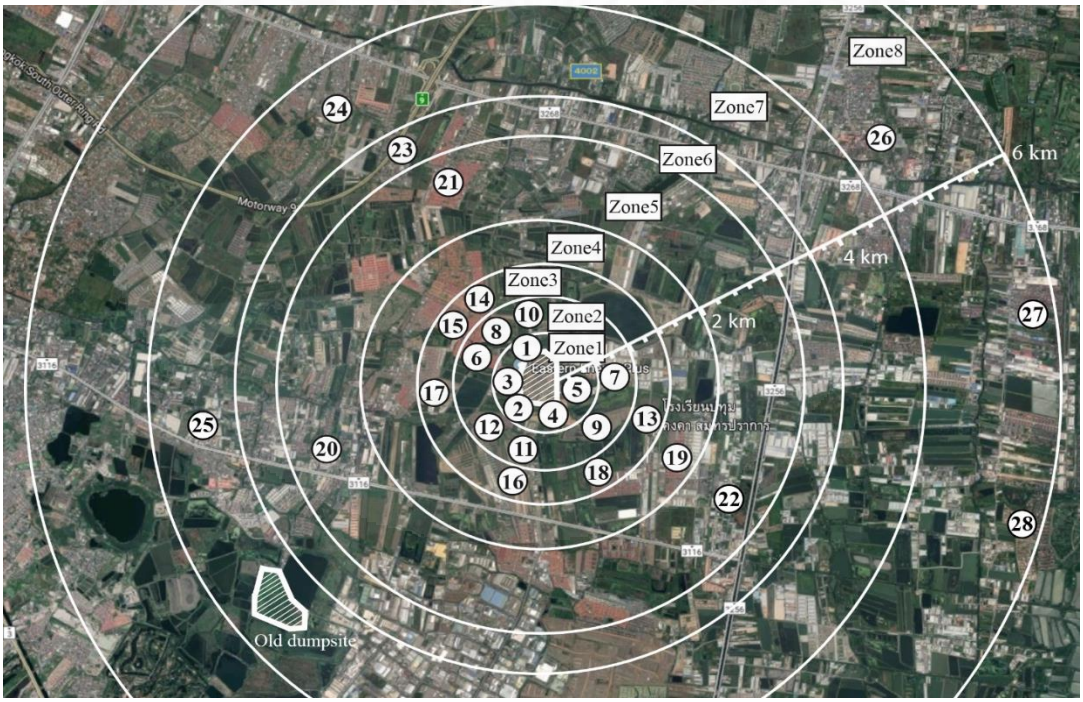

Figure 3.2: Selected locations around Praeksa mai dump site.

There are 2 criteria to select the survey locations. First, select residential areas with many houses, not factory and farm areas, since the factory may not allow conduct research on environmental problem in its site, and the worker in the factory may concern more about the impact inside the factory more than from the dump site.

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Second, try to distribute the locations in all directions (north, east, west, and south) of the dump site, and with different distances from the dump site. Based on these criteria, 28 locations are identified. There are more locations on the west than on the east side of the dump site since there are more residential areas on the west side. Then 28 locations are classified into 8 zones based on the distance from the dump site as shown in Table 3.2. The zones with different distances will be used to analyze the impact as a function of distance.

Table 3.2: Distance range in each zone of total 28 selected locations.

Zone	Location number	Distance
1	1-5	100-500
2	6-12	501-1000
3	13-18	1001-1500
4	19	1501-2000
5	20-22	2001-3000
6	23	3001-3500
7	24-25	3501-4500
8	26-28	4501-5700

During the survey period, from November 2017 to January 2018, the questionnaires were administered by interview to randomly select households from all the selected survey locations which the people are living in the house or working in the private shops or offices, not the visitors who temporarily visit that location. The houses were selected randomly to have different types including single house, trade building, town house, and apartment to ensure that the respondents represent the population in that area.

A total of 502 respondents were interviewed from all locations, but 468 respondents (93.22%) were used for analysis because some questionnaire were distributed out of selected location and some respondents who live in the areas of study are not known the Praeksa mai dump site. Then, some of the questionnaires were

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removed. During the survey, the respondents were directly interviewed. Therefore, all questionnaires are completed in answers to ensure that the opinions are all creditable.

3.3 Statistical analysis

To achieve the objectives of the study, this section utilizes statistical analysis techniques, namely ordinal logistic regression and linear and quadratic regressions. Ordinal logistic regression is mainly used to identify the significant factors influencing the public perception of the dump site. Linear and quadratic regressions are primarily used to observe the relationship between the levels of perception of the impacts and distance from the dump site. The estimation of the dump site's impact distance is made. Minitab version 17 is used in this study. A summary of the analysis details is given as follows.

3.3.1 Ordinal logistic regression

For data analysis, Minitab version 17 was used to analyze the survey results in relationship between public perceptions over several variables. Ordinal logistic regression is used for the investigation of demographic and socio-economic variables, to determine whether they significantly affect the public perception of the impacts of the dump site. In this study, independent variables are age, gender, education, living duration, and type of residency, and distance from the dump site. Dependent variables are the levels of public perception towards the impacts, which include health issues, odor, air pollution, poor scenery, landfill fire, waste truck management, and declined property value. The hypothesis of the ordinal logistic regression analysis is presented as follows.

H_0: The independent variable has no significant impact to the dependent variable.

H_1: The independent variable has significant impact to the dependent variable.

The null and alternative hypotheses of these variables are shown in Table 3.3. In order to determine whether association between the responses and factor affects public perception in model, the p-value is compared with the significant level of 0.05,

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this has a 5% (Type I error) risk of concluding that an association exists when there is no actual association to assess the null hypothesis. The p-values for all the combinations of independent and dependent variables are calculated and compared to the significant level of 0.05 which can explain that there is a sufficient evidence to reject the null hypothesis, and automatically accept an alternative hypothesis which concludes that there is a statistically significant association between the variables and public perception. If p-value is less than or equal to the significance level, there is a sufficient evidence to conclude that there is a statistically significant association between the variables. In the analysis, the regression coefficients and odds ratios are also calculated to explain the direction and strength of associations between the variables. The coefficient and odds ratio can identify the effect size of the significant factors. Coefficient values can be divided into two types, which are positive and negative values. The positive coefficient value with odds ratio greater than one indicates that higher level of factor has lower impact level of public perception. The negative coefficient value with odds ratio less than one indicate that higher level of factor has higher impact level of public perception.

Table 3.3: The hypotheses related to the dump site of ordinal logistic regression model.

Number	**Null hypothesis (H_0)**	**Alternative hypothesis (H_1)**
1	Distance does not affect public perception in terms of unhealthiness.	Distance affects public perception in terms of unhealthiness.
2	Distance does not affect odor emission.	Distance affects odor emission.
3	Distance does not affect public perception in terms of air pollution.	Distance affects public perception in terms of air pollution.
4	Distance does not affect to public perception in terms of scenery.	Distance affects public perception in terms of scenery.

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5	Distance does not affect public perception in terms of property value of land.	Distance affects public perception in terms of property value of land.
6	Distance does not affect public perception in terms of landfill fire	Distance affects public perception in terms of landfill fire.
7	Age does not associate with public perception in terms of unhealthiness.	Age associates with public perception in terms of unhealthiness.
8	Age does not associate with public perception in terms of odor emission.	Age associates with public perception in terms of odor emission.
9	Age dose not associate with public perception in terms of air pollution.	Age associates with public perception in terms of air pollution.
10	Age dose not associate with public perception in terms of scenery.	Age associates with public perception in terms of scenery.
11	Age dose not associate with public perception in terms of property value of land.	Age associates with public perception in terms of property value of land.
12	Age dose not associate to public perception in terms landfill fire.	Age associates with public perception in terms of landfill fire.
13	Gender does not associate with public perception in terms of unhealthiness.	Gender associates with public perception in terms of unhealthiness.
14	Gender dose not associate with public perception in terms of odor emission.	Gender associates with public perception in terms of odor emission.

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15	Gender dose not associate with public perception in terms of air pollution.	Gender associates with public perception in terms of air pollution.
16	Gender dose not associate with public perception in terms of scenery.	Gender associates with public perception in terms of scenery.
17	Gender dose not associate with public perception in terms of property value of land.	Gender associates with public perception in terms of property value of land.
18	Gender dose not associate to public perception in terms of landfill fire.	Gender associates with public perception in terms of landfill fire.
19	Level of education does not associate with public perception in terms of unhealthiness.	Level of education associates with public perception in terms of unhealthiness.
20	Level of education does not associate with public perception in terms of odor emission.	Level of education associates with public perception in terms of odor emission.
21	Level of education does not associate with public perception in terms of air pollution.	Level of education associates with public perception in terms of air pollution.
22	Level of education does not associate with public perception in terms of scenery.	Level of education associates with public perception in terms of scenery.
23	Level of education does not associate with public perception in terms of property value of land.	Level of education associates with public perception in terms of property value of land.

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24	Level of education dose not associate to public perception in terms of landfill fire.	Level of education associates with public perception in terms of landfill fire.
25	Living duration does not associate with public perception in terms of unhealthiness.	Living duration associates with public perception in terms of unhealthiness.
26	Living duration does not associate with public perception in terms of odor emission.	Living duration associates with public perception in terms of odor emission.
27	Living duration does not associate with public perception in terms of air pollution.	Living duration associates with public perception in terms of air pollution.
28	Living duration does not associate with public perception in terms of scenery.	Living duration associates with public perception in terms of scenery.
29	Living duration does not associate with public perception in terms of property value of land.	Living duration associates with public perception in terms of property value of land.
30	Living duration dose not associate with public perception in terms of landfill fire.	Living duration associates with public perception in terms of landfill fire.
31	Type of residency does not associate with public perception in terms of unhealthiness.	Type of residency associates with public perception in terms of unhealthiness.
32	Type of residency does not associate with public perception in terms of odor emission.	Type of residency associates with public perception in terms of odor emission.3.

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33	Type of residency does not associate with public perception in terms of air pollution.	Type of residency associates with public perception in terms of air pollution.
34	Type of residency does not associate with public perception in terms of scenery.	Type of residency associates with public perception in terms of scenery.
35	Type of residency does not associate with public perception in terms of property value of land.	Type of residency associates with public perception in terms of property value of land.
36	Type of residency dose not associate with public perception in terms of landfill fire.	Type of residency associates with public perception in terms of landfill fire.

Transportation through source of waste separation becomes one of the major concerns in the municipal solid waste management system. The study is also focusing on people's perspective toward the problems that occurred from the garbage trucks. The critical problems are represented in terms of (i) releasing of leachate and dropping of garbage, which cause slippery roads and accidents, (ii) noise from collecting household garbage, and (iii) obstructive parking of the garbage truck. The distance is considered from the dump site, and from the waste-collecting vehicle routing in Praeksa-mai district areas to the locations of interest.

The distances are divided into two types by using function of Google map to measure the distances. The first type of distance is measured from the boundary of the dump site toward the resident locations in displacement unit. The second distance is measured from garbage truck route to the centroid of selected location along the road. The ordinal logistic regression is applied to analyze the key results in term of distance factor associated with public perception. The null and alternative hypotheses are defined in Table 3.4

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Table 3.4: The hypotheses related to waste truck operation.

Number	Null hypothesis (H_0)	Alternative hypothesis (H_1)
37	Displacement distance measured from the dump site to resident locations does not affect public perception in terms of dirtiness form waste trucks.	Displacement distance measured from the dump site to resident locations affects public perception in terms of dirtiness form waste trucks.
38	Displacement distance measured from the dump site to resident locations does not affect public perception in terms of noise from waste trucks.	Displacement distance measured from the dump site to resident locations affects public perception in terms of noise from waste trucks.
39	Road distance measured from waste truck route to resident locations does not affect public perception in terms of dirtiness form waste trucks.	Road distance measured from garbage truck route to resident locations affects public perception in terms of dirtiness form waste trucks.
40	Road distance measured from garbage truck route to resident locations does not affect public perception in terms of noise from waste trucks.	Road distance measured from garbage truck route to resident locations affects public perception in terms of noise from waste trucks.

3.3.2 Linear and quadratic regression model

A regression model is applied to model and observe association between impact levels of perceptions and distances from the dump site. A regression equation is used to identify an impact that most sensitive to distance. This is to investigate the effects of distance to the dump site on resident's perception, and to determine at which spatial extent the negative public perception towards the dump site still exists when linear regression provides R-square adjusted value of less than 50%, the linear model may not be suitable. In such case, quadratic regression is applied to improve the modelling

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accuracy. To identify the most sensitive impact, the regression equation of each impacts is plotted into the graph. Note that, the x-axis of the graph indicates distance while the y-axis indicates level of impact.

3.3.3 Binary logistic regression

In addition, one question in the first section of questionnaire needs a binary logistic regression to predict the relationship between predictors and binary response. The question is that "Would you like to move out from the current address in the future?" where answers can be only yes or no response. This question would like to know the association of distance, living duration, age, level of education, gender, and possibility that the respondent will move out from their current location. The null hypothesis and alternative hypothesis definitions are shown in the Table 3.5. In terms of identifying the significant factors, the p-value is compared with significant level of 0.05, this has a 5% (Type I error) risk of concluding that an association exists when there is no actual association to assess the null hypothesis. If the p-value is less than or equal to the significant level, null hypothesis will be rejected and automatically accept the alternative hypothesis. Coefficient can indicate the effect size, where negative coefficient tends to represent greater levels in factor, resulting in the decrement of low impacts.

Table 3.5: The hypotheses of demographic factors associate with the possibility of moving out from the current location in binary logistic regression.

Number	Null hypothesis (H_0)	Alternative hypothesis (H_1)
41	Distance does not affect public perception in terms of possibility of moving out from the current location.	Distance affects public perception in terms of possibility of moving out from the current location.
42	Living duration does not affect public perception in terms of possibility of moving out from the current location.	Living duration affects public perception in terms of possibility of moving out from the current location.

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43	Age does not affect public perception in terms of possibility of moving out from the current location.	Age affects public perception in terms of possibility of moving out from the current location.
44	Level of education does not affect public perception in terms of possibility of moving out from the current location.	Level of education affects public perception in terms of possibility of moving out from the current location.
45	Gender does not affect public perception in terms of possibility of moving out from the current location.	Gender affects public perception in terms of possibility of moving out from the current location.

3.3.4 Regression analysis in wind direction

In this section, wind direction and distance are identified whether it affects public perception in term of odor. The total of 28 selected locations are divided into four quadrants which are northwest, northeast, southwest, and southeast directions of the dump site. According to the four directions of compose, 28 locations were grouped into four zones from the nearest to the furthest distance of the Praeksa dump site which marked by different color, to cover all four directions. Then, the effect from wind direction can be evaluated from the linear regression equation which a positive sign implies the higher odor impact while a negative sign implies the lower odor impact. Also, each composed direction shows the significant level compared with direction in the apportionment. The details of distance are shown in the Table 3.6. Regression model and regression equation are selected to find the range of distance and direction that wind will affect odor of public perception. The null and alternative hypotheses are defined in the Table 3.7

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Table 3.6: The distances are divided in the four zones in different colors.

Zone	Distance (meters)	Color in figure
1	0-1000	Yellow
2	1001-2000	Blue
3	2001-4000	Pink
4	4001-5700	Green

Table 3.7: The hypotheses related to wind direction in different distances.

Number	Null hypothesis (H_0)	Alternative hypothesis (H_1)
46	Wind direction does not affect public perception in terms of odor emission with distance of 0-1000 meters.	Wind direction affects public perception in terms of odor emission with distance of 0-1000 meters.
47	Wind direction does not affect public perception in terms of odor with distance of 1001-2000 meters.	Wind direction affects public perception in terms of odor with distance of 1001-2000 meters.
48	Wind direction does not affect public perception in terms of odor emission with distance of 2001-4000 meters.	Wind direction affects public perception in terms of odor emission with distance of 2001-4000 meters.
49	Wind direction does not affect public perception in terms of odor emission with distance of 4001-5700 meters.	Wind direction affects public perception in terms of odor emission with distance of 4001-5700 meters.

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Chapter 4

Result and Discussion

The results of the study are presented in three parts. First, from the in-depth interviews where current public concerns about the effects of Praeksa mai dump site on the living conditions of local people are summarized. Second, the effects of demographic, education, and residency characteristics are analysed to determine whether these factors significantly affect public perceptions and concerns on health, environmental, and economic impacts from the dump site. Third, the relationships among the degrees of public concerns on health, environmental, and economic impacts, and the distance from the dump site are evaluated.

4.1 Descriptive data of the respondents

A total of 468 samples were analyzed by utilizing descriptive statistics characteristics of the respondents. The characteristics are summarized based on gender, age, type of residence, living duration, and level of education as show in figures 4.1 and 4.2. There were 209 male respondents (44.7%) and 259 female respondents (55.3%) The age of respondents are mostly in rage of more than 40 to 50 years old (23.7%). 76.3% of total respondents live in their address and 23.7 % for working. In total, most residents are less than 5 years at current address (30.8%). Only 11.3% are residents for more than 20 years. 74.6% of respondents need to move out current address location. In term of education level, most of respondents are secondary school obtained by 36.3% of respondents and 31 % are self-employed in terms of occupation.

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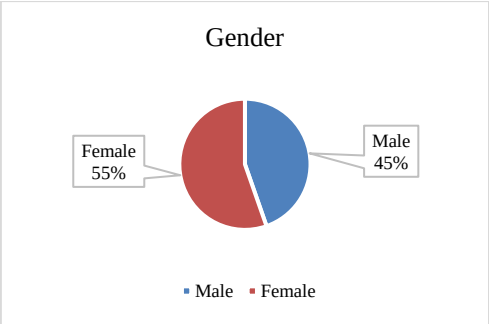
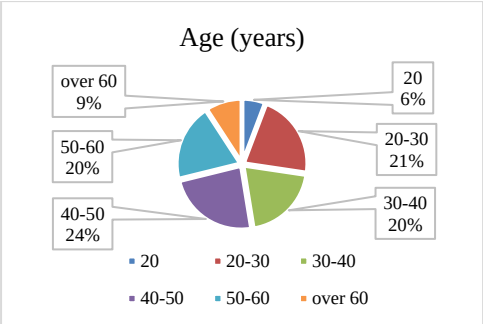
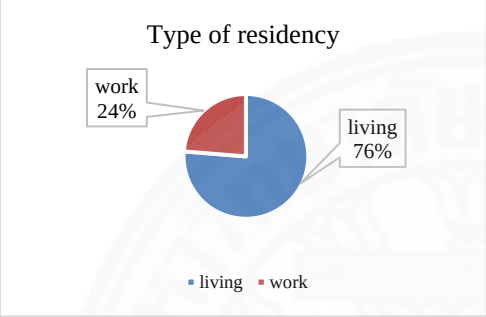


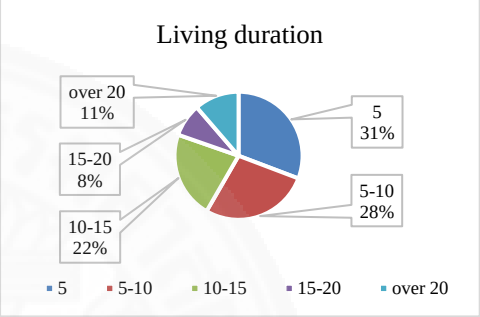
a) Relative percentage values of gender



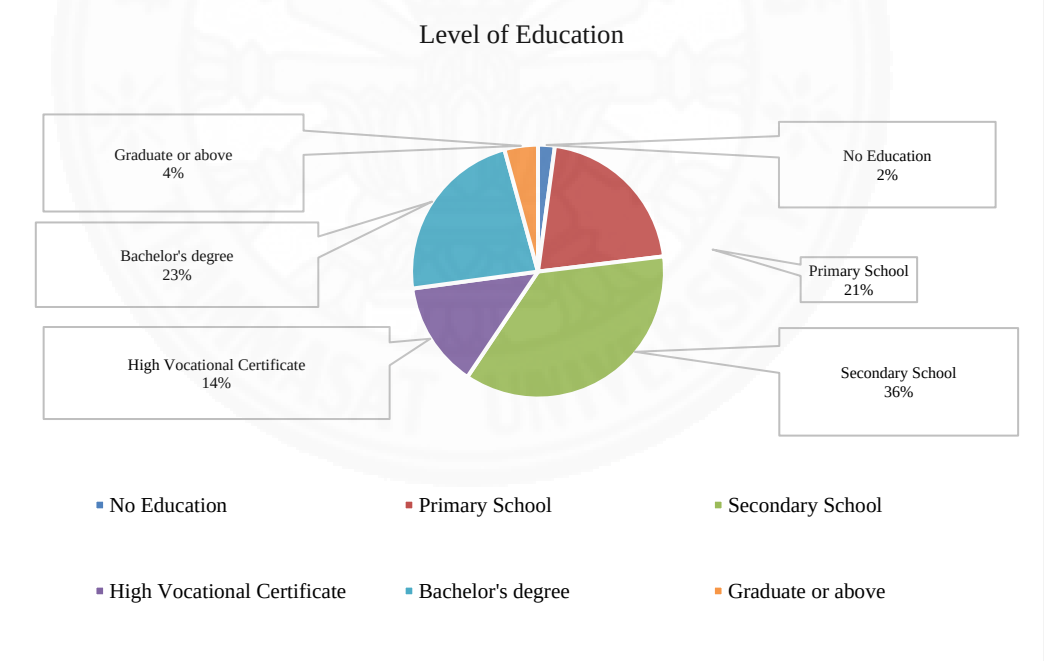
b) Relative percentage values of age



c) Relative percentage values of type of residency



d) Multiple classes of living duration



e) Relative percentage values of multiple classes of educational level

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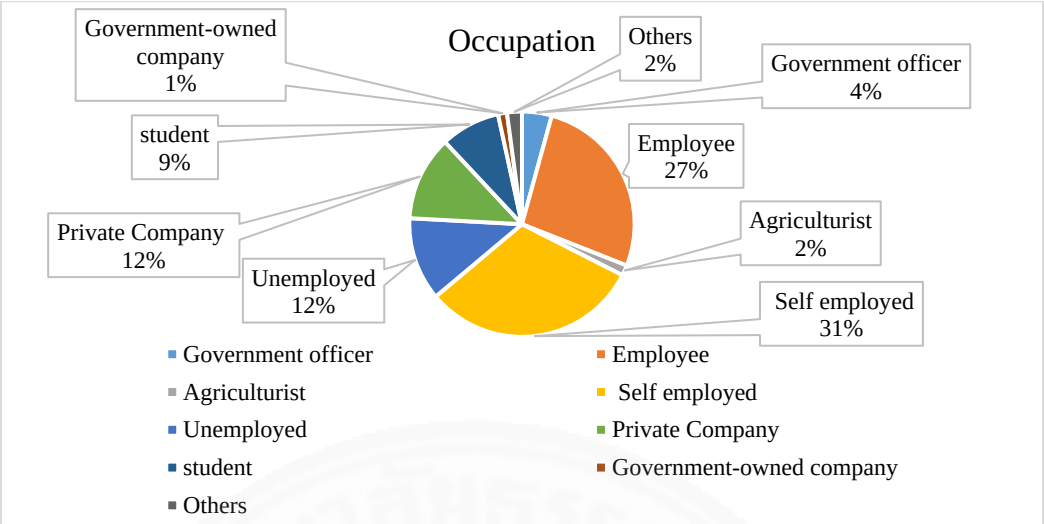

e) Relative percentage values of multiple classes of educational level

Figure 4.1: Important respondent characteristics

4.2 Significant factors affecting public perceptions using ordinal logistic regression

The total of 48 hypotheses are conducted and divided in to five main parts. The first part consists of the hypothesis numbers 1 to 6 which are related to distance variable with impacts from the dump site. The second part includes the hypothesis numbers 7 to 36 which are related to demographic and socio-economic variables influencing public perception related to the open dump site. The third part of hypothesis, numbers 37 to 40, is related to waste truck management problems with two kinds of distance. The fourth part has hypothesis numbers 41 to 45, which are related to distance and demographic factors influencing possibility that the respondent will move out from their current location. The last part, consisting of hypothesis numbers 46 to 49, is related to wind direction in different distances. The method that identify the hypothesis numbers 1 to 40 is ordinal logistic regression, that of 41 to 45 is binary logistic regression, and that of 46 to 49 is regression analysis model.

To analyze the significant effects of independent variables on the levels of public perception of the dump site's impacts in terms of health, odor, air pollution, scenery, landfill fires, and property values of land, ordinal logistic regression is applied. The details of p-values, regression coefficients, and odds ratios are shown in Table 4.1.

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Table 4.1: Results of ordinal logistic regression

Independent Variable	Hypothesis number	Impact	Coefficient	Odds ratios	P-value	Significant factor
Distance (Short-long)	1	Health	0.400	1.78	0.000	Significant
	2	Odor	0.648	1.91	0.000	Significant
	3	Air pollution	0.451	1.57	0.000	Significant
	4	Scenery	0.391	1.48	0.000	Significant
	5	Landfill fires	0.144	1.15	0.000	Significant
	6	Property values of land	0.237	1.27	0.000	Significant
Age (Young-old)	7	Health	0.020	1.02	0.711	-
	8	Odor	0.160	1.17	0.008	Significant
	9	Air pollution	0.140	1.15	0.018	Significant
	10	Scenery	0.230	1.25	0.000	Significant
	11	Landfill fires	0.000	1.00	0.972	-
	12	Property values of land	0.220	1.25	0.000	Significant
Gender (Male, female)	13	Health	-0.251	0.78	0.125	-
	14	Odor	-0.107	0.90	0.514	-
	15	Air pollution	-0.113	0.89	0.488	-
	16	Scenery	0.038	1.04	0.816	-
	17	Landfill fires	-0.185	0.83	0.260	-
	18	Property values of land	0.076	1.08	0.647	-
Level of education (Low-high)	19	Health	-0.227	0.80	0.001	Significant
	20	Odor	-0.168	0.85	0.011	Significant
	21	Air pollution	-0.205	0.81	0.002	Significant
	22	Scenery	-0.323	0.72	0.000	Significant
	23	Landfill fires	-0.111	0.90	0.095	-
	24	Property values of land	-0.372	0.69	0.000	Significant
Living duration (Short-long)	25	Health	0.075	1.08	0.230	-
	26	Odor	0.174	1.19	0.005	Significant
	27	Air pollution	-0.005	0.99	0.931	-
	28	Scenery	0.032	1.03	0.612	-
	29	Landfill fires	-0.036	0.96	0.562	-
	30	Property values of land	0.045	1.05	0.477	-
Type of residency (Living, work)	31	Health	0.516	1.67	0.001	Significant
	32	Odor	0.197	1.22	0.172	-
	33	Air pollution	0.477	1.61	0.001	Significant
	34	Scenery	0.428	1.53	0.006	Significant
	35	Landfill fires	0.384	1.47	0.009	Significant
	36	Property values of land	0.398	1.49	0.010	Significant

4.2.1 Effect of distance from the dump site

The effects of distance from the dump site on public perceptions on all impact categories are highly significant. All the p-values are zero. All the coefficients are positive. None of the odds ratios is less than one. This implies that the respondents who

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live or work closer to the dump site perceive greater impacts from the dumpsite than those who are far away. This result is consistent with the expectation that the impact of waste disposal should be higher with closer proximity to waste sites.

4.2.2 Effect of age

Age has a significant impact on public perceptions of the dump site for odor, air pollution, scenery, and property value of land. The positive coefficients and greater-than-one odds ratios imply that younger respondents are more concerned about the impacts than older people. This may be due to the fact that older people are more familiar with the living conditions in the areas.

4.2.3 Effect of gender

Gender is not a significant factor. Statistically, the levels of perception across all the impact categories are the same for male and female respondents.

4.2.4 Effect of educational level

The level of education significantly affects the public perception of the impacts related to health, odor, air pollution, scenery, and property values of land. The negative coefficients and odds ratios of less than one indicates a stronger perception of the dump site's impacts among respondents with a higher education. This result is in line with the general assumption that people with a higher educational background usually have higher environmental awareness.

4.2.5 Effect of living duration

When analyzing the effect of living duration on odor, a positive coefficient and odds ratio greater than one are obtained. This means that respondents with longer living duration are associated with a lower perceived level of odor impact. This finding supports the general assumption that people who live around the dump site for a prolonged period of time are accustomed to the odor.

4.2.6 Effect of residency type

In this study, there are two residency types: living and working. Statistically, there is no difference between the degrees to which both groups of people are concerned about odor. However, for other impacts including the negative effects on health, air

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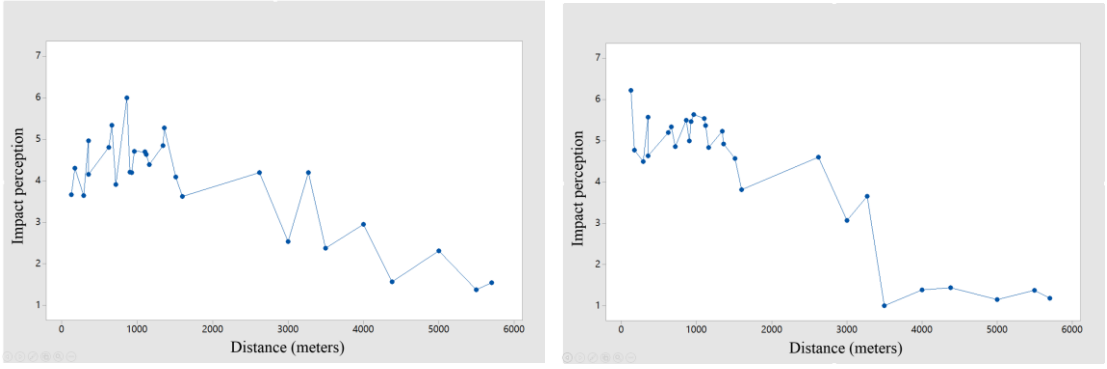
pollution, scenery, landfill fires, and property values, people who live in the area tend to be affected more than those who just come to work in the area.

4.3 Changes in the levels of perception over distance

The effects of distance on impact perception are quite significant for all impact categories, as shown in Figure 4.2. In the scatter plots, the Y-axis represents the degree of impact perception, ranging from 1 to 7. The X-axis indicates the distance from the dump site. For each impact category, the average values of impact perception of respondents from 28 survey locations are plotted. It can be observed that the average degree of all impacts, except landfill fires, tends to decrease as the distance between the dump site and the survey location increases. In Figure 4.2e, when observing the change in landfill fire impact over distance, several survey locations exhibit a degree of perception that is unusually high and significantly deviated from the downward trend of the plots. This includes the survey locations 16, 20, 22, and 25. According to the map in Figure 3.2, these survey locations are in close proximity to an old dump site which caught fire in 2014. Based on the in-depth interview, many respondents from these locations also express concerns about a recurrence of fire at any nearby waste sites. This suggests that the previous experience of fire serves as an additional factor affecting the attitudes and perceptions of residents toward the dump site. Based on the regression analysis results, the regression equations and R-square adjusted values are shown in Table 4.2. All the R-squared values are greater than 50%. It must be noted that quadratic regression is used for the landfill fire concern. The regression lines corresponding to all the regression equations are shown in Figure 4.3.



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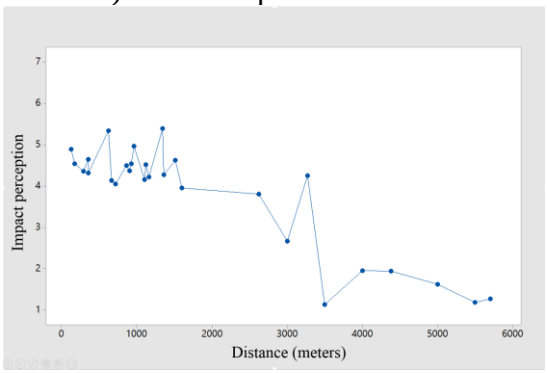
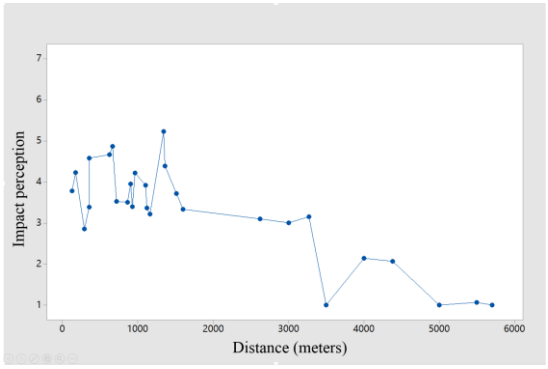
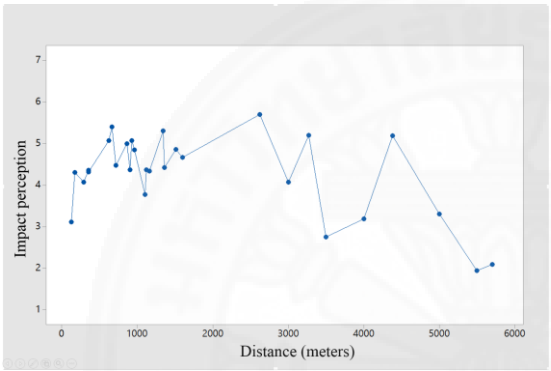
a) Health impact



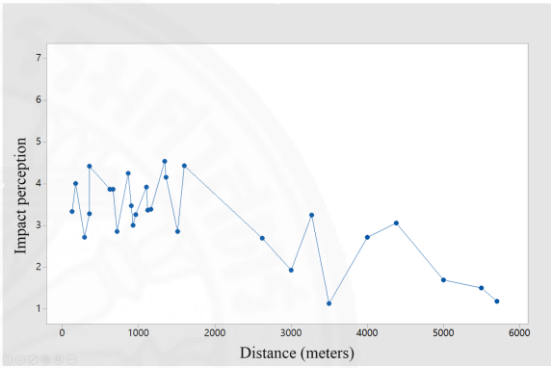
b) Odor impact



c) Air pollution impact



d) Poor scenery impact



e) Landfill fires impact

f) Property value loss impact

Figure 4.2: Scatter plots represent trends of public perceptions of respondents for distance and impact

Table 4.2: Regression equations of the degree of impacts over distance from dump site

Impacts	Regression equation	R-square adjusted
Health	$4.895 - 5.84\times10^{-4}$ d	69.00%
Odor	$5.830 - 8.94\times10^{-4}$ d	83.20%
Air pollution	$5.087 - 6.91\times10^{-4}$ d	79.40%
Scenery	$4.442 - 6.00\times10^{-4}$ d	70.90%
Property values of land	$3.975 - 4.26\times10^{-4}$ d	53.00%
Landfill fires	$4.015887 + 8.25\times10^{-4}$ d $- 2.05279\times10^{-7}d^2$	48.90%

Note: "d" in regression equation is distance

The use of regression analysis helps to visualize the relationships among the residential proximity to waste sites and the public perceptions of the impacts of

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MSWM. The relative importance of impacts over different spatial scales can be observed. The extent to which each of the impacts is perceived by residents can also be examined. Based on the analysis results, within a radius of about 1 km around the dump site, the public perception of odor impact is the highest, followed by that of air pollution and health impacts. The perception of the effects of dump site on the values of properties is the lowest. Based on both the scatter plots and the regression lines, at a distance of about 3.5 km away from the dump site, the perception levels of all impact categories are significantly reduced and become fairly close to each other. The perception level of respondents living within and beyond 3.5 km from the dump site are compared, using a two-sample t-test analysis. The results indicate that the perception levels towards the dump site of the two groups of respondents are significantly different, with p-value less than the significant level of 0.05.

It must be noted that the high perception level of landfill fire impact is associated with the experience of a previous fire incident at the old dump site. This problem has to be resolved through further discussion and clarification of safety measures, and policies need to be put in place for communities around the old dump site. To improve the overall public perception toward the dump site, it is important to prioritize the problem-solving strategies based on the degree of impacts perceived by people in the high impact areas. Based on the results of this study, the high impact area covers the distance of about 1.5 km in all directions away from the dump site. At this distance, the average level of perception for all impacts is about 4, which is described as “moderately affected” in the questionnaire.

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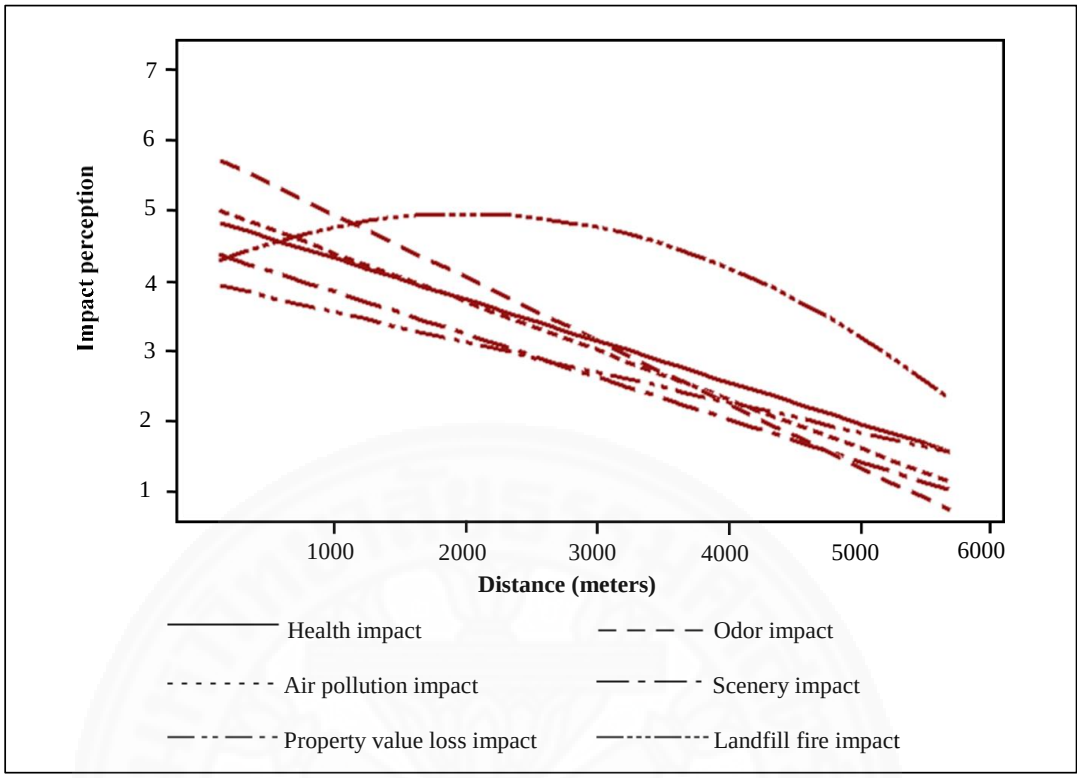

Figure 4.3: Relative comparison of perception levels for impact categories

4.3.1 Effects of distance from waste collection routes

Waste collection system is one of the major waste disposal problems especially related to the Preaksa mai dumpsite. Lacking well managed collection systems, which require an effective operation, and lacking law enforcement, which Thai households currently pay less to get rid of the waste, are the main concerns that influence waste collection system problems. In addition, increasing rate of public growth communities also generates a large volume of waste, exceeding the storage space capacity of the waste collection. The waste from households is collected under the limited capacity of waste trucks. These trucks are used for picking up the waste from residences in all Samut Prakan and only transport to Preaksa dump site. According to the in-depth interviews from residents who face problems regarding waste collection trucks around the waste collection routes near the dump site as shown in Figure 4.4, the inefficient system of the draining tank and mechanical structure of the waste trucks generates dirtiness, leachate, noise, and odor problems when the trucks travel along the road to

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the dumpsite. Moreover, the waste, sometimes, immediately drops down on the public street because of an unbalanced capacity between waste truck and the amount of carried waste, and the truck drivers also dive over limited speed. These reasons are the main causes of slippery roads, accidents, and crashes due to the waste collection trucks, which affect to the public perception.

In this study, the public perception with effects of waste collection routes is associated with distance. The distances are divided into two types and are measured using a function in Google Maps. The first type of distance is measured from the boundary of the dumpsite to the resident locations in a displacement unit, called displacement distance. The second distance is measured from the waste truck route to the centroid of selected locations along the road, called road distance. These two types of distance are identified with the public perception in terms of dirtiness and noise impact categories. Ordinal logistic regression is applied to analyze the key results in terms of distance associated with public perception.

The outputs in displacement distance show no correlation between dirtiness and noise impact generated by the waste trucks, when distance is measured from the boundary of dumpsite to the resident location in displacement unit. In contrast, the road distance significantly affects both dirtiness and noise impact, which can be concluded that respondents near the waste collection routes are more concerned about the impacts than respondents who live far away from the route. For example, in terms of dirtiness from the trucks in road distance, the significant level with positive coefficients and greater-than-one odds ratios imply that when distance is increased by 1 kilometer, 9% of respondents would choose the alternative level considering the highest impact. Details of the interpret result are shown in the Table 10. To increase the positive level of public perception towards waste collection trucks, the mechanism of draining tank should be more efficient and loading capacity should be higher to prevent leachates and exceeded waste.

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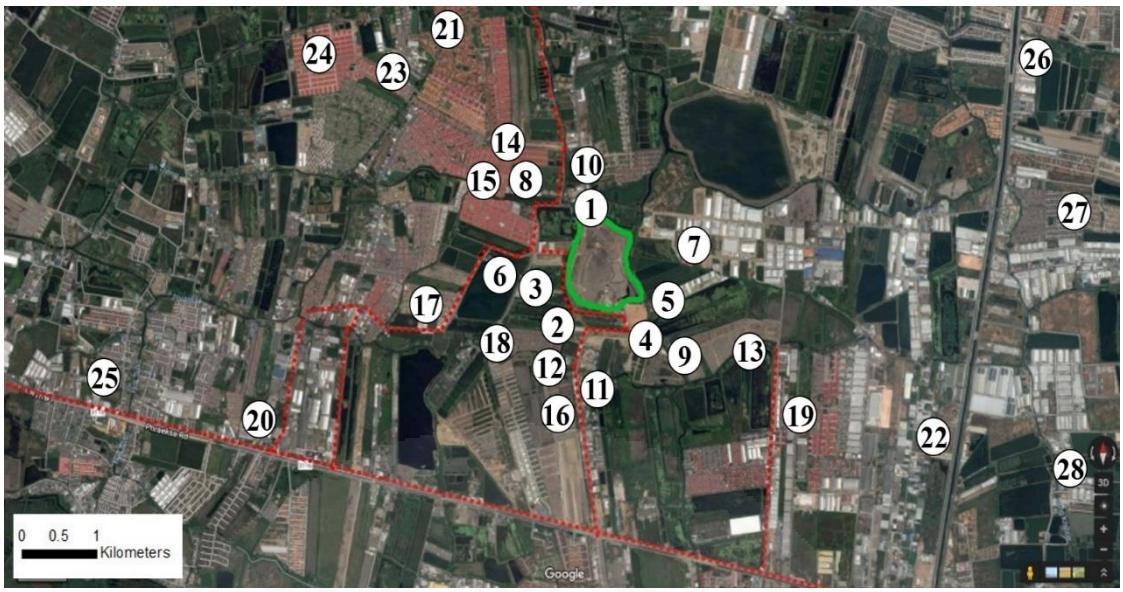

Figure 4.4: Dumpsite and route of waste truck

Table 4.3: The results of two types of distance factors with waste truck impacts to public perception.

Hypothesis number	Type of distance factor	Impact	Coefficient	Odds ratio	P-value	Significant
37	Displacement distance	Dirtiness from waste truck	0.05	1.06	0.581	-
38		Noise from waste truck	-0.05	0.95	0.59	-
39	Road distance	Dirtiness from waste truck	0.08226	1.09	0	Significant
40		Noise from waste truck	0.015029	1.16	0	Significant

4.4 Binary logistic regression

One question in first part of questionnaire has two possible responses. Binary logistic regression is used to identify whether association between possibility that respondent will move out from their current location which have only 2-way answers concerning variables are distance and demographic including gender, age, living duration, and level of education. The result reveals that there is only distance associated with possibility that respondent will move out from their current location. To interpret the result, p-value and coefficient in regression equation (2) are identified The negative

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coefficient can be indicated that longer distance levels tend to be associated with lower values of possibility that resident would like to move out of the current location. Details of p-values are shown in Table 11.

$$Y' = 4.530 - 0.5063 \text{ Zone distance} \quad (2)$$

Table 4.4: Results show p-values in each variable from binary logistic regression analysis.

Hypothesis number	Variable	P-value	Significant factor
41	Distance	0.000	Significant
42	Living duration	0.363	-
43	Age	0.598	-
44	Level of education	0.239	-
45	Gender	0.208	-

4.5 Wind direction

Wind direction and distance are focused on to evaluate their effects towards public perception (only in odor category). The total of 28 selected locations are divided into four quadrants; which are northwest, northeast, southwest, southeast directions of the dump site as shown in Figure 4.5. From the four directions, 28 locations are grouped into four zones from the nearest to the furthest distance of Praeksa mai dumpsite, which are marked by different colors to cover all four directions. The effect from wind direction can be evaluated using linear regression, where positive sign implies the higher odor impact and negative sign implies the lower impact. Also, each composed direction shows a significant level compared with direction in the apportionment. The details of distance are shown in Table 4.4. Regression model and regression equation are applied to model relationships of distance and direction that wind will affect odor, in terms of public perception.

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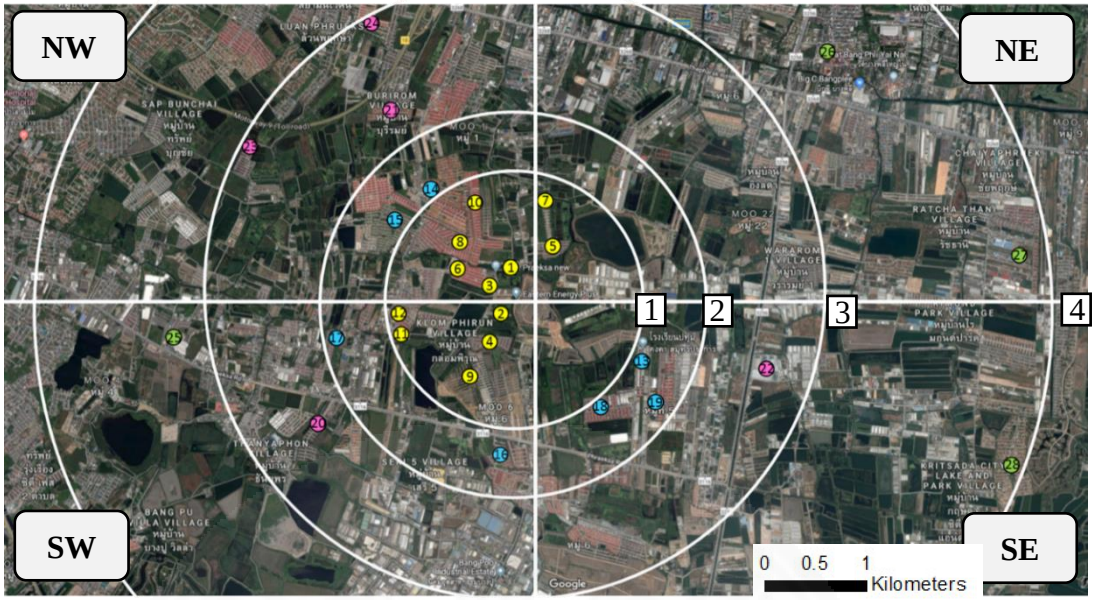

Figure 4.5: Locations are divided into four directions with four zones of distance.

This finding is consistent with the previous studies in Laogang landfill in Shanghai (Yue Che Et Al., 2013), which wind direction is correlated to the odor to location of residents especially in downwind position. In this study, wind direction was analyzed and divided into four directions of Northwest, Northeast, Southwest, and Southeast. Groups of samples were divided into four zones from the nearest to the furthest distances which are classified in different color in the map. The results from regression analysis, as shown in Table 4.4, explain that wind direction is significant, and it affects odor impact to public perception, associated with distance in range of 2001-4000 meters measured from the dumpsite. The regression equation is as follows:

Odor emission = 3.379 - 1.492 Direction_NW + 0.271 Direction_SE
+ 1.221 Direction_SW

The equation shows that southeast and southwest directions have positive coefficient which increase the odor emission. Moreover, the result is relevant to North-East monsoon wind in Thailand which flows the wind in every November to January of the year from Northeast direction to southeast and southeast directions. (Meterological department, Thailand), in which the questionnaires were conducted in November to January 2018. In the first two zones of distances within two kilometers from the boundary of the open dump site, the odor is not influenced by the wind

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direction. Although there is no wind in both areas, residents still get the odor annoyance from the dump site. Distance in 4001-5700 meters is also not affected by wind direction because the areas are far away from the open dump site. Although the wind blows in the areas, residents are not affected by the odor from the dump site.

Table 4.5: Results from regression analysis in odor emission affecting by wind direction interpret in four zones of distance.

Hypothesis number	**Distance (meters)**	**P-value**	**R-sq (adj)**	**Significant**
46	0-1000	0.224	0.42%	-
47	1001-2000	0.187	1%	-
48	2001-4000	0	28.80%	Significant
49	4001-5700	0.327	0.51%	-

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Chapter 5

Conclusions and Recommendations

5.1 Conclusion

This study aims to improve the local public perceptions of Praeksa mai dump site. A series of in-depth interviews and questionnaire-based interviews were conducted around Praeksa mai dump site, to understand the current environmental and health concerns associated with the dump site. There is a sufficiently large number of respondents distributed across distance intervals. The in-depth interviews reveal important health, environmental, and economic impacts caused by the dump site. This information serves as a basis for developing the questionnaire that was used to measure the degrees of impact perception. By using ordinal logistic regression analysis, demographic, geographical, and socio-economic factors that influence the public perception related to health, environmental, and economic impacts, are identified. Some important conclusions can be made:

- Younger respondents are more concerned about the impacts than older respondents.
- There is a stronger perception of the dump site impacts among respondents with higher education.
- The living duration significantly influences the degree to which respondents are affected by the dump site odor.
- Respondents who live or work closer to the dump site perceive greater impacts from the dump site than those who are farther away.

The determination of the spatial extent to which each of the impacts contributes to the negative public perceptions of the dump site is the main technical contribution of this paper. Questionnaire and statistical analysis techniques are demonstrated to be a viable method to accomplish this research goal. In most of the previous studies in the field of MSWM, survey and statistical analysis tools allow management to determine if any factor or impact category significantly affects public perceptions at a specific distance, but do not reveal the change in the perception level over distance intervals. In this study, the findings of the public perceptions are based on the average levels of perception concerning each impact category across 28 survey locations. Linear and

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quadratic regression techniques are used to model the relationships among the levels of perception and distance from the dump site. By applying the regression analysis, a comparison of the perceptions among different impact categories over different distance zones is possible. This enables management to understand the relative importance of impacts over different distances from the dump site. Based on the regression analysis results, the odor is the most significant issue faced by the group of residents living within 1 km around the dump site. At this distance, air pollution is the second most common concern, followed by health, scenery, and property value. The area under the regression lines can also be estimated, to serve as a guide in prioritizing and specifying what improvement efforts will most benefit local communities in each geographical area. Another important finding in this study is that, at about 3.5 km away from the dump site, the respondents feel that they are only slightly affected by the dump site in most impact categories. Outside this distance, the respondents feel that none of the impacts, except a landfill fires, is more significant than the other impacts. This distance is determined to be the impact distance of the Praeksa mai dump site. A landfill fires is the only impact that led to concerns among the respondents who live nearby the old dump site, located about 4 km southwest of the Praeksa mai dump site. These findings help determine the minimum distance for a waste site of similar quality and communities. This distance is needed in order to avoid significant negative public perceptions.

The results and discussion presented in this paper are expected to be of value to the local governments around the Praeksa mai dump site and all the stakeholders. The findings are essential for the successful development of effective strategies and approaches for improving the public perceptions of Praeksa mai or any dump site with similar characteristics and conditions. Public perception improving efforts can be more relevant in the context of target groups and can be communicated in a more appropriate and assessable way. However, several future research tasks must be addressed to obtain a more complete understanding of the public perception issues. This includes the investigation of the odor issue by considering exposure factors such as seasonal wind direction and other climate factors. Also, the effects of the garbage collection route on the living conditions of residents should be studied. Based on our in-depth interview results, the garbage truck issues have a clear effect on the negative perceptions of the

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dump site. Lastly, a quantitative analysis tool suitable for estimating the equivalent number of residents affected by the negative externalities of a waste site should also be developed. This will be useful for a future landfill site selection process, to minimize the number of affected people and public opposition to landfill siting.

In waste truck service, only road distance is significantly influencing public perception toward garbage truck service related problems. The results can be concluded that the adverse effect from noise and dirtiness of waste truck surveyed is decreased with the road distance from the waste truck route to the selected locations. For demographic variables, age is significantly associated with public perception and can be indicated that younger people are more concerned about impacts more than older people in terms of odor emission, air pollution, scenery, and property value of land. Gender is not a significant factor that influence public perception, since there is an indifference perception between male and female. Living duration significantly affects public perception on odor problem. The result indicates that residents with longer living duration are more likely to get accustomed to the impacts and feel less of being impacted. Level of education is a significant factor to all impacts, except for landfill fire. Higher educational levels are relatively more concerned about impacts. Type of residency is significant to all impacts except for odor emission and can indicate that the respondents who work during daytime tend to have lower values of impacts than the respondents who live but not work in the area.

In Binary logistic regression, the result reveals that there is no significant demographic factor influencing public perception associated with possibility that respondent will move out from their current location.

For wind direction, the results show that wind direction significantly affects odor perception problem within a range of 2,001-4,000 meters measured from the boundary of the dump site. The regression equation shows that southeast and southwest direction have more odor effect than other directions.

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5.2 Recommendation

The decision to upgrade existing uncontrolled dumps or to establish new disposal facilities elsewhere must be made with a sufficient understanding of public perceptions towards local and up-to-date solid waste management issues. Outstanding problems that need to be solved are odor annoyance and waste truck service management. The surveyed outcome shows that odor emission related to which factors that directly affect public perception. The study applies ordinal logistics regression to a set of data regarding the public perception of Praeksa mai dumpsite, which was collected using interviews guided by questionnaire based on a survey that considers factors which demonstrate effect from the dump site to its community. The practical contribution of the study is that it considers distance around the dump site in several scales, unlike the previous study by Al-Khatib et al., 2014 which considers only one distance scale. By scaling the distance into intervals, the survey is capable of representing a significant result of public perception in each area around the dump site more precisely. Moreover, the samples, or interviewees, are selected diversely and in a decent amount which can represent the whole population of Praekasa mai dumpsite. Other than the awareness of public perception caused by conducting the survey, the results from the study can be implemented to solve waste disposal management problems in a proper manner. For instance, when consider the result illustrated in Figure 7, the graph prioritizes which problem should be solved first to last, accordingly, for each distance interval. The findings are essential for the successful development of effective strategies and approaches for improving the public perceptions of Praeksa mai or any dump site with similar characteristics and conditions. Public perception improving efforts can be more relevant in the context of target groups and can be communicated in a more appropriate and assessable way. Praeksa mai dump site is located in an urbanizing area of Samut Prakan province, Thailand. The case study offers a relatively larger number of respondents than most of the previous survey studies that examine public perception towards solid waste disposal facilities. The proposed public perception evaluation methodology can be used for any waste processing site with significant localized negative externalities. It must be noted that, prior to the step of questionnaire survey, a detailed review of current issues in the area and a preliminary

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field survey are required to identify relevant impact areas and a suitable survey approach.

Wind direction should be considered as a key factor when locating a dump site. On the other hands, there are recommendations from respondents that by developing public infrastructure and services for communities can be helpful to improve public perception, for example, road maintenance, health care services, fire station, park, renewable energy from waste for household's usage, and scenery improvement from planting trees around the site.

Waste truck service can also be used to improve public perception. From the outcomes, residence areas nearby the waste truck routes are more affected by improper waste truck management, which are dirtiness and noise. The amount of waste from households and the waste truck capacity are relatively inefficient, considering the current collection systems. The trucks try to increase their handling space by using a semi-automatic system to compress garbage, thus releasing leachate to the public road, resulting in dirtiness and slippery road. Car accidents may also happen at a curve where leachate is left on the road. Also, when a waste truck is driven over its speed limit, some wastes may drop on the road, and can obstruct the traffic. In addition, the discharge of leachate generates odor around the road areas, which affects to public perception. To improve public perception, garbage trucks should have a sealant bulker tank to prevent disposal of leachate on the road. The tank should be sealed by rubber sealed to prevent leachate leakage from the truck to the road. The tank should have a proper storage level for draining waste water. Operators should perform their tasks carefully, clean and tidy and do not drive exceed the speed limit. Leachates from the truck should be disposed in a proper area. The trucks should not carry garbage over maximum weight. Truck management should arrange a proper amount of waste trucks for the amount of waste, which would require financial support from the government. Capacity of the truck can be increased through arranging waste collection more frequently, and the truck should also be frequently checked to avoid liquid and gas leakage.

Waste is generated from everyday life activities. The increasing number of population increases the amount of waste in the system. In general, lifestyle of using plastic and non-recycled materials tend to be widely practiced because the price of non-

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recycled materials is cheaper, and they are easier to use. Moreover, people are not aware of the environmental problems from garbage without separation. Thus, the amount of waste in the disposal is still increasing and only small fraction can be separated and eliminated compare to the total waste volume. Public participation and cooperation of waste separation are needed to reduce the amount of waste. To improve waste management infrastructure, waste separation should be under the responsibility of each community because waste separation can save cost of sorting operation in MSWM. for example, recycling kitchen waste and turning into valuable organic material. Product that is made from non-recyclable materials should be avoided. Based on the survey, the educational level affects public perception of the impacts from the open dump site where higher educational respondents have more concerns for environmental problems. Therefore, improving environmental education and providing guideline for separating waste process should be part of the solutions proposed and promoted to enhance environmental awareness and environmentally harmful issues (Zeng, Niu, Li, Zhou, & Zhao, 2016). In changing attitudes of social and environmental issues, education leads to better understanding of the problems and can improve people's awareness in relation to waste reduction, recycling and separation. Not only education is needed but it is also necessary to cultivate good conscience in societies to improve public awareness. Financial supports and technical expertise can increase effectiveness of the collection systems. The waste management company should upgrade garbage trucks to hermetically sealed ones to prevent leakage, sprayed biologic deodorizer to effectively get rid of the stink and constructed trees shelter belt to absorb odors gas as well as building visual interdiction.

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Appendices

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Appendix A

Questionnaire details

First part: Demographic information

Questionnaire on the effect to the communities on the dumpsite

Personal information

Sex ☐ Male ☐ Female

Age ☐ Under 20 ☐ Over 20-30 ☐ Over 30-40 ☐ Over 40-50 ☐ Over 60

Occupation

☐ Government Officer ☐ Private company employee ☐ Self employed

☐ Student ☐ Agriculturist ☐ Worker

☐ Personal business ☐ Housewife ☐ Driver

☐ Government owned company ☐ Unemployed ☐ Others

Education

☐ Uneducated ☐ Primary school ☐ Secondary

☐ Vocational certificate ☐ Bachelor degree ☐ Postgraduate

How long have you been living in your domicile

☐ Less than 5 years ☐ Over 5-10 years ☐ Over 10-15 years

☐ Over 15-20 years ☐ Over 20 years

Plan to move where else in the future

☐ No ☐ Yes

Reason

.....

.....

Second part: Personal health information

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Personal heath information

Smoking

☐ No ☐ Yes ☐ Used to for….years

Medical conditions

☐ No ☐ Yes which is

……

Have you ever been diagnosed the following diseases from staying here?

☐ Respiratory disease ☐ Asthma ☐ Allergic diseases

☐ Dengue fever ☐ Eye infection ☐ Dermatitis

☐ Diarrhea ☐ Cancer ☐ Cholera

☐ Dysentery ☐ Hepatitis A ☐ Food poisoning

Others ……

Questionnaire relating to health

ISSUE	Rate						
	Very High	High	Slightly High	Moderate	Slightly Low	Low	Very Low
1. Health problem impact							
1.1 The dumpsite has negative health effects on yourself and also cause infection							
1.2 Concern about health problem on children and family for instant, the dumpsite cause infection to children							
1.3 The dumpsite has impact to pregnancy							

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Third part: Public perception towards the dump site impacts

ISSUE	Rate						
	Very High	High	Slightly High	Moderate	Slightly Low	Low	Very Low
2. Air pollution impact							
2.1 In your resident area, how strong smell is							
2.2 Contamination level in the air.							
2.3 Level of dust in the air.							
3. Noise pollution impact							
3.1 Level of noise annoyance from the dumpsite. For instance, the noise is too loud to living in your residence.							
4. Water contamination impact							
4.1 In your resident area, there are contamination in the rain.							
4.2 The dumpsite has negative effect on quality of tap water in your residence.							
5. Pathogen impact							
5.1 The dumpsite increase flies, cockroach, mosquito, or mouse.							
6. Scenery impact							
6.1 The dumpsite worsen community scenery							
7. Effects on waste transportation							
7.1 Garbage truck cause some leakage of leachate or trash into the road							
7.2 Garbage truck lead to noise pollution that cause annoyance.							
7.3 Garbage truck lead to traffic obstacle							
8. Effects on property value							
8.1 The dumpsite decrease property value							
9. Effects on fire risk							
9.1 Concern of the risk of fire that caused from dumpsite.							

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Third part: Public perception towards the dump site impacts

Do you have any suggestion for improvement of this dumpsite?

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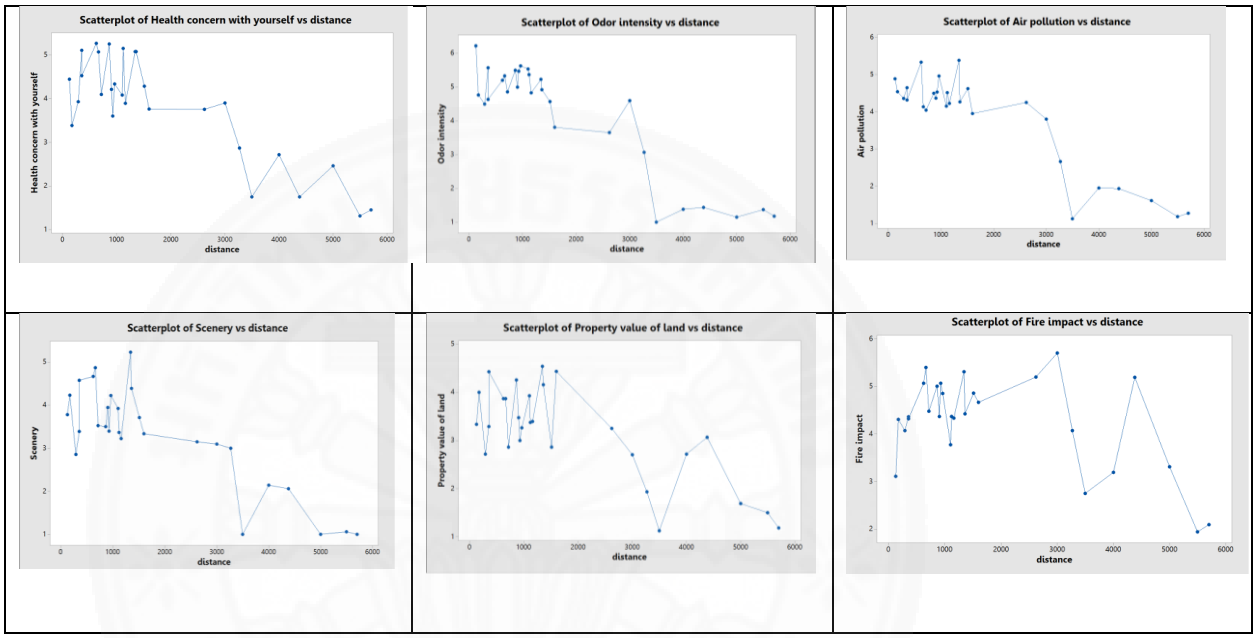
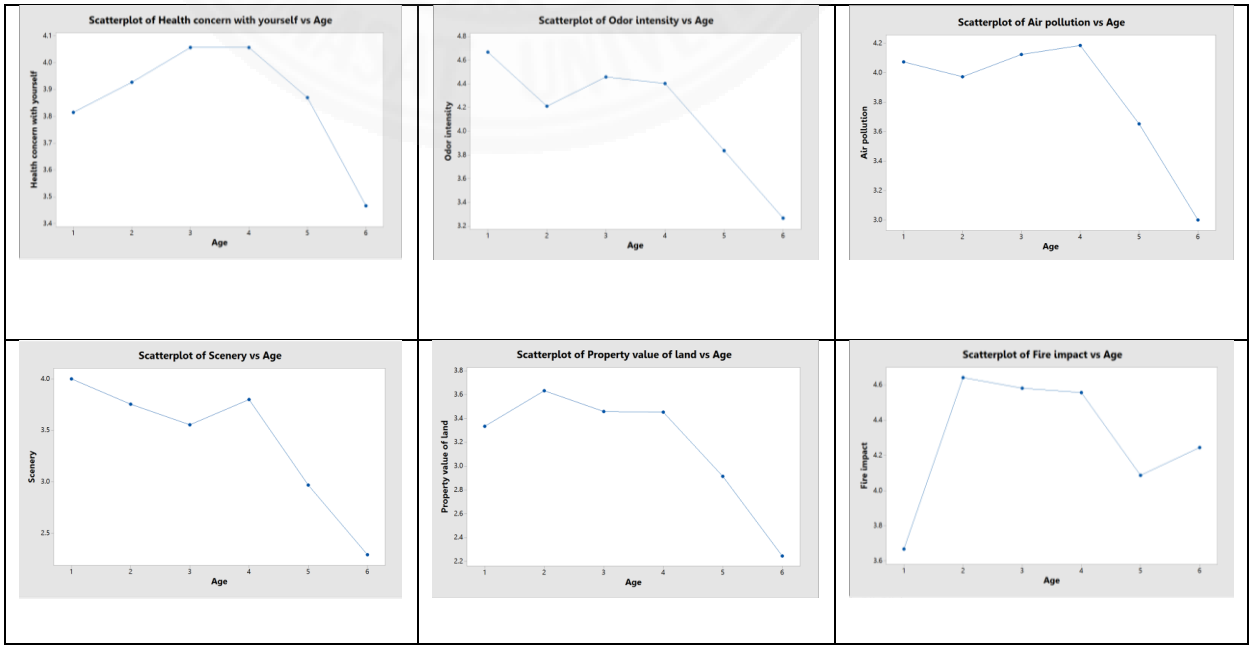
Appendix B

Scatterplot

Distance



Age



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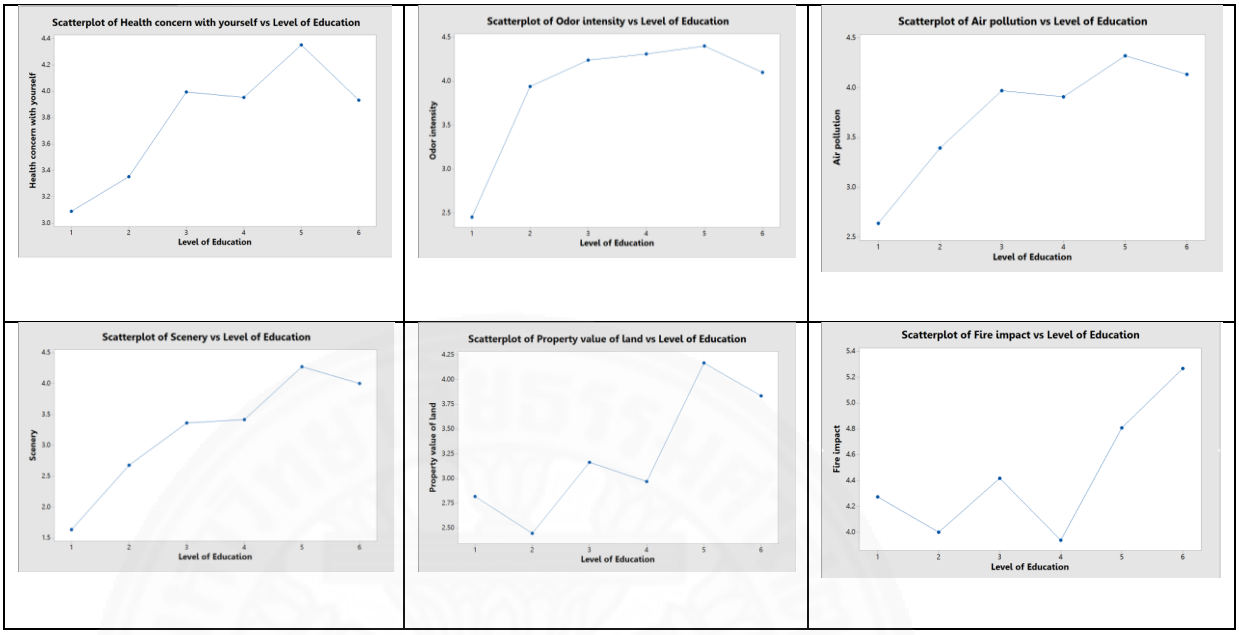
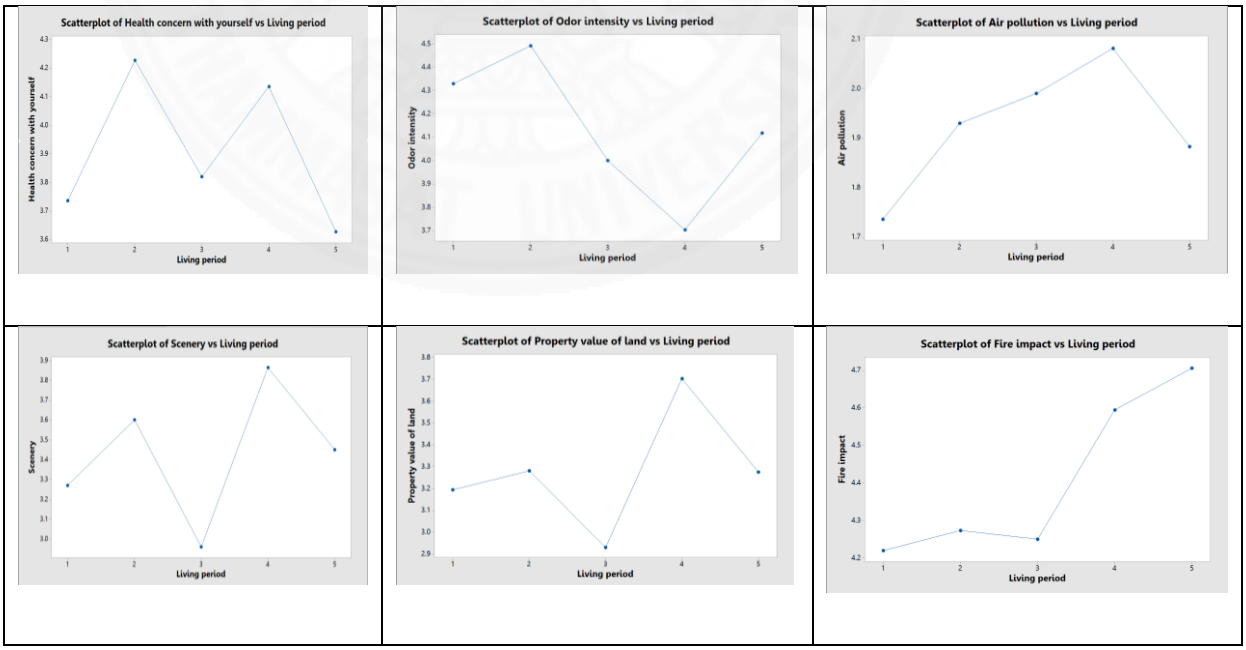
Level of education



Living duration



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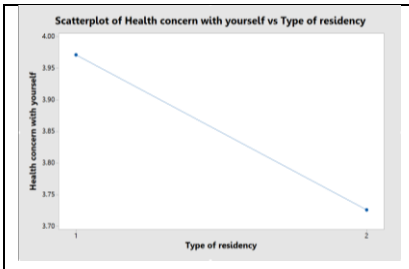

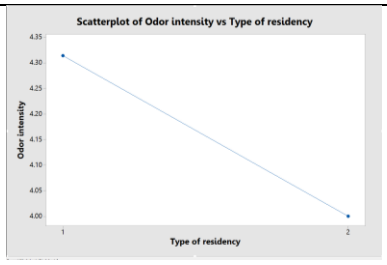

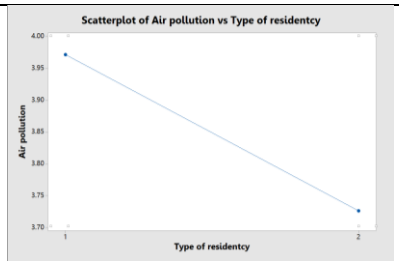

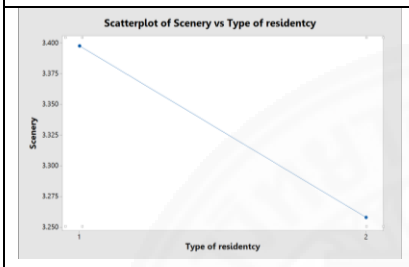

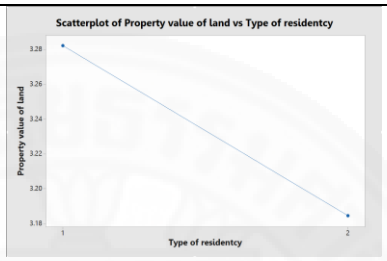

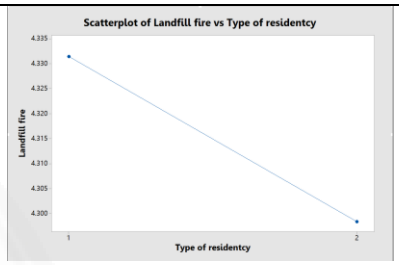

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