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Application of Buffer Distance Standard for Industrial Lands: A Case Study of Phitsanulok Logistic Station

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Abstract

A buffer distance, widely used as a method of spatial management around an industrial area, is identified to reduce negative impacts from industrial production processes on the surrounding area. Logistic station is considered a service-oriented industry. Activities in a logistic station could generate negative impacts that include noise and air pollution, to wider areas. At present, there are various standards to draw buffer distances for manufacturing types. However, a specific standard for logistic stations has not been identified. This paper aims to propose buffer zone standards for logistic stations by reviewing existing buffer zones used in industrial areas. This research analyzes buffer distances through an examination of physical characteristics of industrial areas and activity areas related to a logistic station. The proposed standard can be defined based on two main factors: i) physical properties of logistic stations, and ii) activities in logistic stations. The Phitsanulok logistic station project, which is currently being considered and planned for construction in the future, is a case study to illustrate an application of the proposed buffer distance standards.

Keywords

Logistic Station; Buffer Distance; Industrial

1. Introduction

There are various types of logistic stations and while generally classified as a service-oriented industry, there is no universal criteria to differentiate those stations. Logistic stations can be identified as high-density industrial areas shaped by different activities, for instance: distribution of goods and being a transportation terminal (Higgins & Ferguson, 2013). Such operational conditions associated with a station could bring about different negative impacts on the surrounding area. Those effects can be classified into five main categories comprising air pollution, noise pollution, security, traffic congestion, and damage to urban infrastructure (CIVITAS, 2015). Moreover, logistic stations located in urban areas may cause negative impacts to the surrounding area, particularly in relation to land use conflict (Singh, 2018). In summary, it can be pointed out that each type of logistic station, having different activity areas within the project, could bring different negative impacts on the surrounding area, in terms of form and quantity.

There are many measures and policies for mitigating negative impacts of logistic stations on the urban environment, for example: traffic measures, industrial area control measures, and spatial management measures, etc. Nonetheless, an identification of a buffer zone for the industrial area is one of the most widely used approaches for spatial management, particularly in the case of large factories. Such a measure is used to reduce air pollution, noise pollution, and the risk of hazardous emissions to surrounding areas. Defining a buffer zone entails identifying a radius distance around the industrial land to separate the areas for industrial production from the surrounding environment thereby minimizing the hazard risk since environmental impact decreases with increasing distance from the source of emission (Environmental Protection Authority, 2005).

The Phitsanulok logistic station has been proposed to be located in the Bueng Phra Subdistrict, a residential community. Regrettably, the area has not been planned for both transportation and goods distribution. As such, problems or negative impacts on local living conditions could occur. Furthermore, literature review showed that there is no standard practice to define the size of a buffer zone, with criteria differing from country to country.

The objectives of this study therefore are threefold: i) review theories and concepts relevant to standards of industrial buffer areas which are applicable to logistic stations; ii) analyze an application of industrial buffer standards for logistic stations, using the Phitsanulok logistic station as a case study; and iii) propose guidelines on buffer distance for logistic stations in general. As part of the Phitsanulok case study, a conceptual framework for creating a buffer area of Phitsanulok logistic station (one of several strategic projects named “Phitsanulok 2020 New Investment Economic Zone, Indochina Intersection.”) will be developed, based on physical characteristics and activities variables within the industrial area.

2. Research methods

The first step in this study was to conduct a literature review of methodologies and criteria used by countries throughout the world to define the size and characteristics of an industrial buffer zone. The search included indexed, peer-review literature, graduate theses, government and non- government agency reports and websites.

Considering different combinations of physical characteristics and activities variables as determined from the literature review, a series of map overlay scenarios were developed to evaluate different buffer area possibilities for the case study logistic station property. Based on the results of this case study overlay assessment, and importantly, considering data availability, several recommendations for generalized guidelines to develop industrial buffer zones are provided.

3. Theoretical concepts

3.1 Definitions and objectives of an industrial buffer

Buffer area has been widely defined and interpreted to be a space compatible with various industrial activities that reduces the impact of such activities on the surrounding area. Many definitions have been identified as follows:

Australia's Environmental Protection Authority (2005) states that buffering area means separation distances between industrial and sensitive land uses.

The Major Industrial Accidents Council of Canada (1995) explains that a buffer area is located around industrial land. It is designated to separate industrial and other uses of land; particularly residential areas should be saved from hazardous risks. Buffer area is determined according to various conditions depending on spatial context.

Klungnuch (2012) quoted two issues of buffer zone from the Seattle Municipal Code (2010) in that 1) buffer area is a zone of transformation between an industrial land and residential or commercial land 2) location of a buffer area is normally the edge of a large industrial land use, so that it separates industrial activities from other activities, and helps decrease negative industrial impacts that might happen.

The Western Australian Planning Commission (1997) identified the objectives of a buffer area as follows:

1) to designate land use patterns and the way in which they are monitored

2) to protect industrial areas from other uses that can cause land use conflicts

3) to provide areas surrounding an industrial land use with convenience and safety

4) to recognize effects of pollution emission and hazardous dangers

The aforementioned definitions show that a buffer area has a history of being utilized together with industrial development. This is because activities related to production, distribution of goods, and transportation, known as logistics, could generate negative impacts on surrounding areas. A buffer area is generally a space around an industrial zone, separating two different land use types. Such an in-between space helps mitigate negative environmental impacts that could occur.

3.2 Roles and physical characteristics of a buffer zone

There are various factors used to consider a buffer area, for instance: functions, physical characteristics, and relationship between locational points of a buffer area and other areas. However, there have not been clear and distinct criteria to definitely identify a buffer area. Despite such a uncertain identification, a buffer area is required to protect sensitive land uses from harmful hazards.

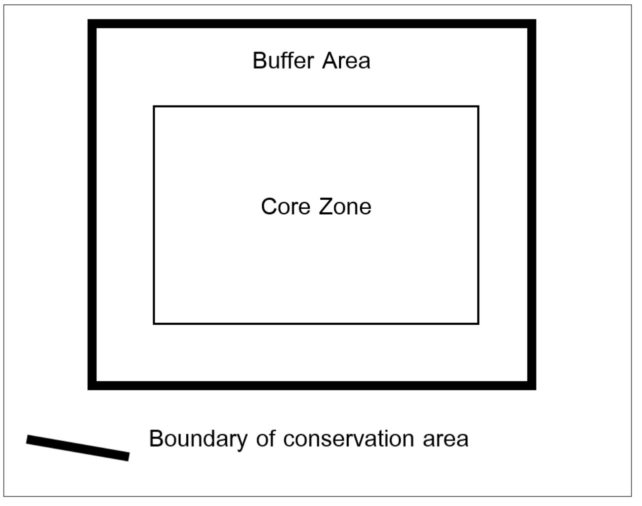
The Department of Environment Malaysia (2012) divides a sensitive area, needing good protection, into two major types:

1) Natural-based sensitive area is an area that could be negatively impacted by human activities. Plants, wildlife, natural habitat and biodiversity need to be protected. As such, the natural environment, like national forests and water resources, should be kept safe from outside negative impacts.

2) Human-based sensitive area is an area that serves human activities and human-made infrastructure, or the so-called built environment. Such an area provides human society with convenience and qualified well-being, like living places, educational places, and cultural places.

Nonetheless, the concept of a buffer area has been fundamentally utilized for natural-based sensitive areas, such as national forests and national parks. There are two types of a buffer area:

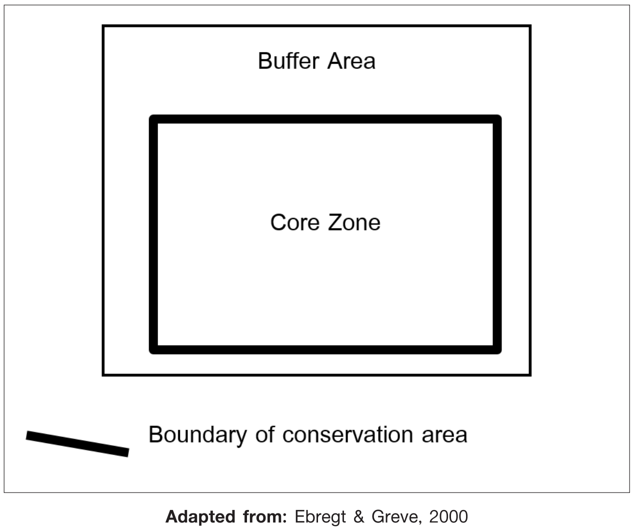
1) A buffer area with a central core zone located within the boundary of a conservation area, shown in Figture 1.



Adapted from: Ebregt & Greve, 2000

Figure 1 A buffer area within a conservation area.

2) A buffer area outside the boundary of conservation area, without a core zone (Ebregt & Greve, 2000). This type of a buffer, as shown in figture 2, firmly helps to protect a conservation zone from outside negative impacts.



Adapted from: Ebregt & Greve, 2000

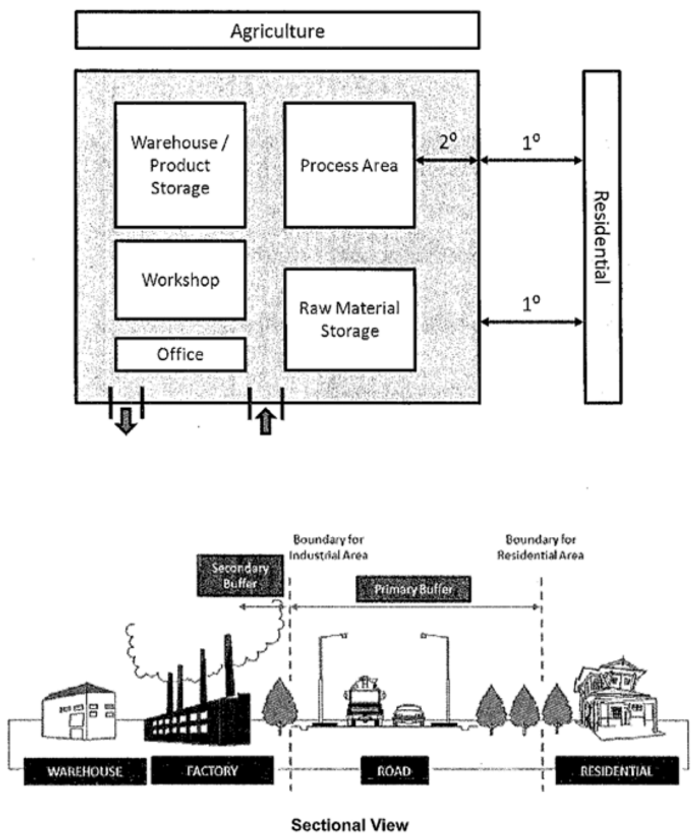
Figure 2 A buffer area outside a boundary of conservation area.

Generally speaking, a buffer area that protects the preserved core area from negative impacts acts like a transition zone helping to mitigate negative impacts. A buffer area associated with industrial land can be divided into two types, as follows:

1) Off-site buffer area or primary buffer zone is an area or a distance outside the edge of the industrial land. In general, most of an industrial space requires an off-site buffer area to reduce negative effects (e.g. noise, runoff pollution, air pollution), that can impact surrounding areas (Western Australian Planning Commission, 1997). The size of a primary buffer zone can vary according to the type, size, and activities associated with each industrial property. A buffer area does not necessarily need to be vacant, like an unused green space or unusable natural arealand, but could be a public space having limited use. Land utilization of a primary buffer zone, known as a project area, should be compatible with sensitivity of surrounding areas to disruptions. Interestingly, a primary buffer zone can be divided into groups based on sensitivity as follows (Department of Environment Malaysia, 2012):

- A buffer area close to a residential area
- A buffer area close to educational and health services, like hospitals, schools, and daycares
- A buffer area close to sensitive habitats, for example, national parks and preserved forest

2) On-Site buffer area or secondary buffer zone is an area or a distance within an industrial area, having private owners. Generally, this kind of buffer is designated to mitigate internal impacts within a project (Department of Environment Malaysia, 2012).



Source: Department of Environment Malaysia, 2012

Figture 3 The buffer area between industrial area and residential area.

Figture 3 shows both primary and secondary buffer areas that separate other sensitive areas from industrial land.

3.3 Standardized criteria for identifying buffer area and industrial area

The a mount of pollution emitted to the environment varies, depending on the different types and sizes of industrial activities. Maas (1976) collected standardized criteria for identifying a buffer area associated with industrial land, which differ by country. In the Netherlands, the standard of a buffer distance depends on the physical characteristics of each industry, ranging from light to heavy industry. Components and characteristics of an industry to be considered include:

1) size of the industrial land
2) location of the industry
3) patterns and quantity of air pollution
4) quantity of noise pollution
5) hazardous risks such as explosion

Based on these Dutch criteria, the size of the buffer area varies from 0.5 – 2.0 kilometers (see Table 1).

Table 1. Standard of buffer distance in the Netherlands

Level	Type of Industry	Space (Hectare)	Location	Types of impact:			Buffer are	
				Air pollution	Noise	Danger	Pattern	Width of area
1	Heavy industry	> 500	Out of an urban area (more than 3,200 meters)	Large amount of SO_2, H_2S, H_2SO_4, HF, NH3	Medium	Risks for fire and explosion	Economic forests, agricultural, zone, green area	More than 2 kilometers
2	Heavy industry	200 – 500	In and out of an urban area (1,600 – 3,200 meters)	Small amount of CO, SO_2	Likely serious because of traffic	Risks for fire and explosion	Economic forests, agricultural, zone, green area, park and recreational zone, sport area	More than 1 kilometer
3A	Medium-to-heavy industry (large amount of air pollution)	100 – 200	In an urban area (1,600 – 3,200 meters)	SO_2, HF, large to small amount of dust and harmful gas	Traffic noise	Risks for fire	Park with tree buffer line	500 meters or larger
3B	Medium-to-heavy industry (small amount of air pollution)		In an urban area (~1,600 meters)					200 meters or larger
4A	Light industry (medium amount of air pollution)	50 – 100	Near city or city center (400 – 1,600 meters)	Small amount of pollution and harmful gas	Medium	Risks for fire	Tree buffer line	50 – 100 meters
4B	Light industry (large amount of air pollution)							
5	Service industry such as printing work, bakery, and film laboratory	10 - 50	Near city or city center (longer than 800 meters)	Small amount	Less	None	Tree planting and gardening	More than 100 meters
6	Workshop, studio, and crafted place, etc.	1 – 10	Near city or city center (more than 400 meters)	Small amount	None	None	Small planting	More than 50 meters

Source: Maas, 1976

In the UK and Wales, standards for the buffer area are identified according to activities and their characteristics. The range of buffer distance can be 0 – 2,000 meters depending on these four factors (see also Table 2):

1) weight of annual logistic goods
2) size of an industrial and traffic area
3) number of workers
4) distance that could originate nuisance

Table 2. Standard of buffer distance in England and Wales

Level	Buffer distance (Meters)	Activity
I	0	Residential area
II	100	Urban core
III	200	Light industry: less impacts or nuisance generation
IV	300	
V	600	Industry: generate impacts and nuisances
VI	800	
VII	1,500	
VIII	2,000	Special industry having isolated location
IX	2,000	
X	2,000	

Source: Maas, 1976

In addition, the buffer zone between industrial land and communities in Germany ranges from 300 – 2,000 meters (Maas, 1976). In Israel, industrial activities are divided into 6 types according to their possibility to emit pollution to surrounding areas, with the buffer zone distance ranging between 0 – 2,000 meters. On the other hand, in Russia, Poland, and Hungary, the range of buffer zones is divided into 5 levels, consisting of 50, 100, 300, 500, and 1,000 meters. These different distances could be greater due to sensitivity of the adjacent areas; for instance, a distance between an industrial area and a hospital might be greater to reduce risks to a sensitive healthcare facility (Maas, 1976).

Despite the aforementioned standards focusing on physical characteristics of an industrial area, sub-activities within a space of production also could be considered as criteria, for example: rail tracks, petrol stations, and service stations.

Rail transportation is one of a related set of activities within a logistic station, as it helps distribute most of the industrial products. Rails could generate noise pollution and ground vibration, as well as air pollution from transportation. Derailments also can result in release of atmospheric pollutants and hazardous liquid spills. Cessnock City Council (2010) identified the b uffer distance between a rail track and an adjacent sensitive area as a minimum of 100 meters, while Lismore City Council (2000) identified the distance for a rail buffer according to the site and its surrounding environment:

- 50 meters of buffer in rural areas
- 20 meters of buffer in urban areas

In addition, other sub-activities could be considered and applied as criteria for identifying an industrial buffer zone. Each logistic station consists of various types of internal activities, particularly a transportation hub that is concerned with the distribution of goods. Table 3 shows a land-based transportation network consisting of roads and rails.

Table 3. Standard of buffer distance in a logistic station classified by activities area

Area	Spatial Characteristics	Impacts					Buffer distance (meters)
		Gas	Noise pollution	Dust	Smell	Risk	
Petrol or gas station (tanks above the ground)	Storage capacity lower than 8,000 liters				O	O	55
	Storage capacity 8,000 – 16,000 liters						85
Service station (cleaning, maintenance, and food zone)	Non-24 hrs. opening	O	O		O	O	50
	24 hrs. opening	O	O		O	O	100
Garage	Space for parking; bus, truck, etc.	O	O	O	O		200

Source: Environmental Protection Authority, 2005

In summary, a buffer zone for industrial land and other lands has been identified in terms of distance and land use type. The standard for identifying such a buffer largely focuses on the distance from the industrial land, for instance: a buffer zone used in Netherlands, UK, and Wales. In some cases, like a buffer zone in the Netherlands, a zone is considered based on land use type which is compatible with industrial and other surrounding uses.

Nonetheless, a buffer zone specifically for logistic activity has not been found from those reviewed standards. The author, thus, analyzes and classifies buffer distances based on characteristics shown in those standards for applying a buffer distance, so that a buffer zone for a logistic station can be implemented.

4. An analysis of a logistics buffer zone

According to those aforementioned theoretical concepts, a buffer zone for a large industrial area covering main and sub activities can be generally divided into two ways:

1) Buffer distance based on physical characteristics of logistic stations

This approach considers physical characteristics of logistic stations for a classification of buffer distance. In the Netherlands, UK, and Wales such a method has been applied. Within this study, the author initially analyzed those international standards by comparing the numbers and ranking them due to buffering distances, as shown in Table 4.

According to table 4, a comparison of buffer distances classified into five levels can be developed and those ranks can be considered together with the standard of the Netherlands that clearly shows details of industrial activities. As a result, the identification of buffer distances can be presented as in table 5.

Table 4. Comparison of buffer distance standards identified in each country

Netherlands		UK and Wales		Russia, Poland, Hungary	
Level	Buffer distance (meter)	Level	Buffer distance (meter)	Level	Buffer distance (meter)
1	> 2,000	X IX VIII	2,000		
2	> 1,000	VII	1,500	1	1,000
3A	> 500	VI V	800 600	2	500
3B	> 200	IV III	300 200	3	300
4A	50 – 100	II	100	4	100
4B					
5	> 100			5	50
6	> 50				

Source: Maas, 1976

Table 5. Standard of buffer distance

Level	Area (Hectares)	Site	Impact:			Buffer distance (Meters)
			Air pollution	Noise pollution	Risk	
1	> 500	Out of an urban area (more than 3,200 meters)	Large amount, including hazardous pollution	Large amount, including traffic noise	Fire and explosion	2,000
2	200 – 500	Both in and out of an urban area (1,600 – 3,200 meters)	Medium -large amount, including hazardous pollution	Medium – large amount, including traffic noise	Fire and explosion	1,000 – 1,500
4	50 - 100	In an urban area (~1,600 meters)	Small – medium amount	Small – medium amount	Risky for fire	200 – 300
5	> 50	Near the city or urban center (0 – 1,600 meters)	Small amount	Small to none	None	50 - 100

The above criteria show levels of buffer zones classified by industrial characteristics. They could be applied to logistic stations, having basic characteristics similar to industrial areas.

2) Buffer distance based on internal activities in logistic stations

This kind of buffer is based on sub-activities within an industrial area. The author considered those activities and applied them to the Phitsanulok logistic station. Within the station, there are some areas which could generate negative impacts to surrounding areas: for example, unenclosed cargo areas, rail tracks, buildings for goods distribution, service buildings, and petrol stations. This kind of buffering firstly identifies a distance for each activity in the station. Thereafter, every buffer distance will be all overlaid, and the edge of the outer distance will be drawn as a boundary of a buffer zone. Details of the buffer are shown by table 6.

Table 6. Buffer distance standard for Phitsanulok logistic station activities area)

Activities	Details	Buffer distance (meters)
Transportation station	Bus stations, hubs for trucks and other vehicles	200
Rail Transportation	Rail tracks	100
Serviced stations	24-hours serviced areas	100
Petrol or gas station	Gas tanks with a capacity of 8000 – 16000 liters	85

In summary, there are two key approaches for an identification of buffer distances, one is based on physical characteristics, and one is based on internal activities in logistic stations. The next part of this paper will therefore show the comparison of the standards and the application of an appropriate criteria.

5. An application of buffer distance to a case study

Phitsanulok logistic station covers an area of 185 rais or 29.6 hectares, 250 meters from residential communities. The station is comprised of activity areas that can generate negative impacts to the surroundings: ground cargo, rail tracks, buildings for goods distribution, service buildings, and petrol stations, as shown in figture 4.

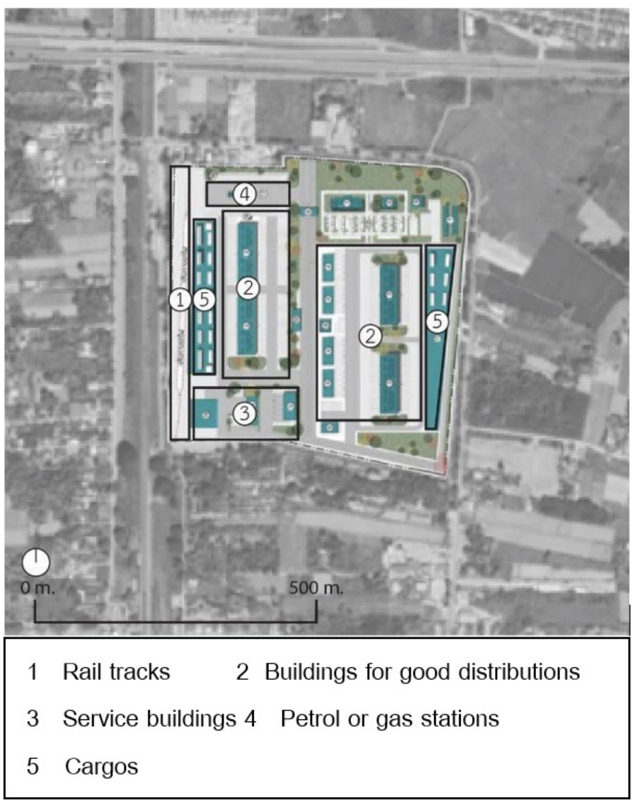


Figure 4 Phitsanulok logistic station project.

However, each area causes different kinds of negative impacts, as shown by table 7.

Table 7. Sub-activities in Phitsanulok logistic station and anticipated negative impacts

Sub activities	Negative impacts		
	Air pollution	Noise pollution	Fire risk
Rail tracks	O	O	
Buildings for good distributions	O	O	
Service buildings	O	O	
Petrol or gas stations			O
Opened-ground Cargos		O	

Within this study, the aforementioned standards will be considered as a conceptual framework, so that the identification of a buffer distance will be classified into 2 patterns:

5.1 Identification of a buffer distance based on physical characteristics of the station

This kind of identification selects physical characteristics of the industrial site which are classified into zones having similar distances to the logistic station. This study used the standard of buffer distance shown by Table 5 as a reference.

According to the table, physical characteristics in terms of size and location of the Phitsanulok logistics station can be comparable to a level 5 category. There are many kinds of negative impacts like air pollution, noise pollution, and fire risk. Such impacts are similar to buffer criteria level 4. Nonetheless, there are no major facilities using heavy machines or that are labor intensive. As such, the amount of noise and air pollution are small to medium, as well as fire risk.

Based on the characteristics discussed in the previous paragraph, the buffer distance within the logistic station at level 4-5 can be considered. Distance identification can be longer than such selected level. The minimum distance that can be drawn is 50 meters according to the criteria level 5, as shown in figure 5.

Figure 5 A 50-meters buffer distance around Phitsanulok logistic station.

5.2 Identification of a buffer distance based on sub-activities in the station

This is another approach to identify a buffer distance for a logistic station. Within a station, there are many kinds of sub-activities. The criteria in Table 6 shows that some industrial works can be comparable to activities in the Phitsanulok logistics station. Therefore, the standard of buffer distance for each activity can be applied. This method focuses on each different activity area before shaping a final buffer. In this case, every sub-buffer was overlaid. The union area of overlaid buffers was then drawn as a single boundary for the logistic station.

For the Phitsanulok logistics station case study, the standard of buffer distances for different activities, as shown in table 6, was employed to shape the appropriate buffer zone. Details of each zone can be described as follows:

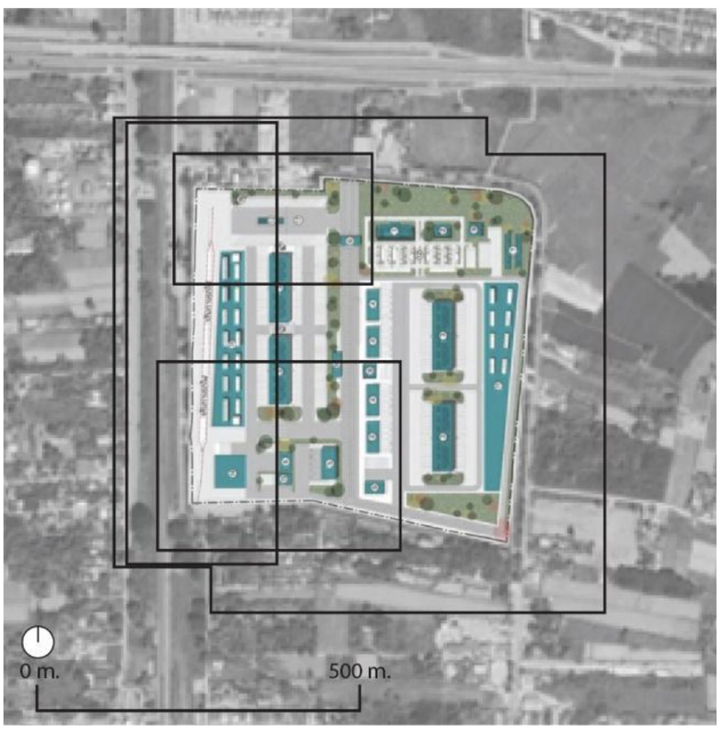
1) Rail tracks and other related transportation activities can be drawn with a 100-meter buffer distance around the railway area

2) Buildings used for goods distribution, as well as cargo, can be compared to the area of transportation hubs consisting of a station for buses, trucks, and other heavy vehicles. The standard, which specifies a 200-meter buffer distance, can be drawn for the existing buildings, cargo areas, and main roads in the station.

3) A 24-hour service station can be drawn with a 100-meter buffer distance.

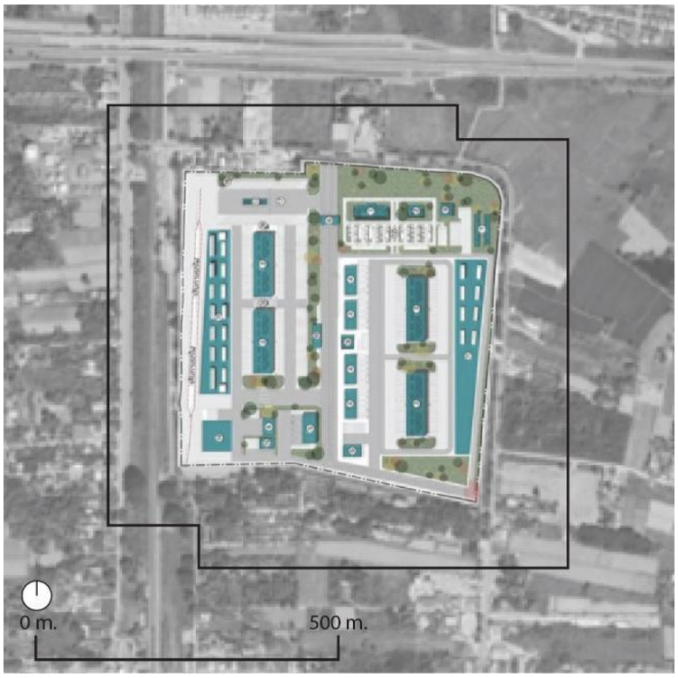
4) A gas or petrol station would include an 85-meter buffer distance.

Regrettably, unenclosed cargo cannot be assigned a buffer area because the literature has not identified any standards. Finally, the overlaid buffers for every sub-activity can be shown in figure 6.



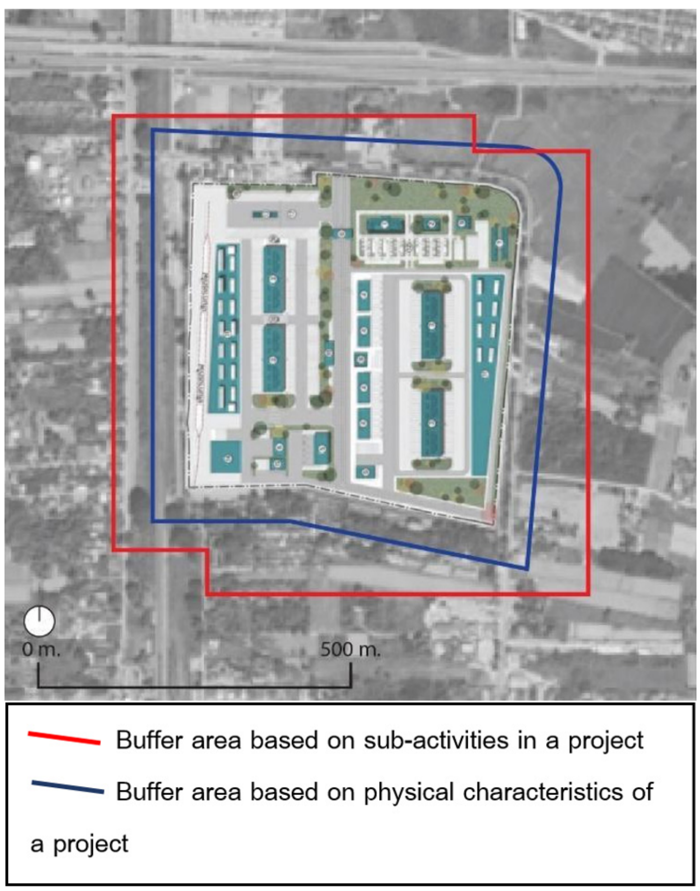
Figture 6 Buffer distances for each activity that can applied to an overlap.

In figure 6, the major sub-activity that seems to dominate all buffer distances is a cluster of buildings for goods distribution. The final buffer shape is created when all overlaid buffers are framed by the edge of an outer boundary, as shown in figure 7.



Figture 7 The boundary of buffer area identified for Phitsanulok logistic station project.

Interestingly, the buffer lines from the two identification methods is similar in terms of shape and distance. However, figture 8 illustrates that a buffer area drawn using the physical characteristics criteria is smaller than the one drawn by the method based on sub-activities.



Figture 8 Comparison of 2 approaches of buffer distance.

Within the case of Phitsanulok logistic station, the information about sub-activities is clear enough with details, comparable to the information about physical characteristics. Those sub-activities can also be compared with activities specified in the standards of buffer distance used in other countries.

7. Summary and Discussion

This study focuses on the application of buffering standards using the Phitsanulok logistics station as a case study. It was found that two approaches for identifying a buffer area should be employed. Such integrated methods provide more details that provide a helpful comparison of options in developing the buffer zone. However, the case study site seems to be compatible with the method based on sub-activities consideration. This is because of the availability of information. Moreover, the project status is still under construction, so information about negative impacts currently has not been empirically documented and the buffering method based on environmental impacts therefore cannot be employed at this time.

As such, an issue of information availability is critical. Thus, an application might be based on one single method that best matches the characteristics of the logistics station. Regrettably, in the worst case, buffer distance identification may face difficulties, particularly if there is not enough data to be compared and examined for the buffer distances.

The guidelines for identifying buffer distance outlined in this paper are conceptual recommendations collected from literature reviews. As a consequence, buffer distance can be classified into two approaches: i) based on physical characteristics; and ii) based on sub-activities.

In summary, two issues of discussion can be made.

1) The shape of the logistics station and sub-activities within the project could well-identify a buffer area, particularly if based on sub-activities. This is because sub-activities in the station are sometimes clustered. Thus, boundary of zoning might not cover all sub-areas.

2) The site of the station is a factor that significantly identifies a buffer distance. An analysis needs some details about sensitivity of the surrounding area as different distances may be required.

Author Contributions

Conceptualization, J.J.; methodology, J.J.; formal analysis, J.J.; resources, J.J.; writing – original draft, J.J.; writing – review & editing, J.J.; visualization, J.J. The author has read and agreed to the published version of the manuscript.

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