Spatial Risk Mapping of House Fly Habitat in South Seberang Perai Penang, Malaysia

Mohd Sanusi S. Ahamad and Nor Roshida Rosli

Abstract This paper presents a case study on the problem of house flies' hazard that frequently occurs in the surrounding area of South Seberang Perai (SPS). Among the important factors that were considered are the house fly breeding places, their fly distance, and their distribution patterns. It is widely known that the SPS district is famous for its animal husbandries sectors, such as pigs, poultry and cattle. The existence of these animal farms has caused the huge presence of house flies in this area. The study was specifically carried out to determine the relationship between house fly flying distances from their breeding places and the outspread to which the community settlements will be affected from this discomfort. The surveillance survey was initiated by collecting the coordinate locations of poultry farms and open garbage dumping sites using the Android GPS application. The GIS software was used in performing the various spatial analysis such as spatial classification and distance analysis. The mathematical overlay process was accomplished to determine the risk level based on the travel distances of house flies. The end results show the maps of the affected area in SPS in three different classes of risk categories i.e. very affected, moderately affected and less affected. This habitat risk map that can assist in future housing planning for favorable and healthy living.

Keywords Housefly · GIS · Spatial analysis · Risk map

1 Introduction

The house flies are a nuisance to human daily activities. It is scientifically known as "Musca Domestica Linnaeus" [1], and regarded as pests in farms and houses. It is most commonly found in the pigsty, poultry farms and in the open dumping area. Besides creating annoyance to humans, they carry viruses or bacteria on their

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bodies and their feces can contaminate foodstuffs that contribute to food-borne diseases [2]. Excessive presence of house flies will cause the uncomfortable human environment and serious public health problem [3]. Flies usually breed in dirty places that are not being conserved, such as temporary garbage container or open dumping area within the residential area since these creatures love dirty and repulsive places. Irregular disposal of food wastes that are not separated and not wrapped produces odors that will attract house flies. As a result, the open dumping places becomes the natural habitat and breeding places for house flies. Moreover, the hot weather and humidity make an ideal condition for house flies to breed [4].

The emergence of house flies in the South Seberang Perai, Penang area has disrupted the daily activities of food industries within the local communities such as restaurants, and retail food stalls. This has raised a serious unhygienic problem to residents, university students, others and has disturbed their healthy living environment [5, 6]. The dispensing of house flies is difficult as it involves many parties and certain actions must be carried out on the affected area.

To reduce the presence of house flies in an area, it is important to identify their potential breeding sites. From the environmental health perspective, it is significant to study houseflies breeding pattern and sources in order to be able to make wise control decisions [7]. A pure observation alone is insufficient as it sometimes can be misleading. The mapping of housefly habitat helps in designing effective public health practices, identify fly breeding sites, and ultimately propose the procedural control measures [8]. Spatial analysis tool in Geographical Information System (GIS) can identify potential housefly breeding places and mapped the extent of their flying zones (migration). The spatial relationship of breeding places with regards to housefly movement and distribution pattern can be studied. The relate risk to the potentially affected areas in the South Seberang Perai can be determined. As such, this paper discussed the potential application GIS in spatial mapping of house fly habitat area. The aim is to produce the habitat risk map that can assist the planning of future housing development in ensuring that the township will be sustainable and conducive to a healthy life.

2 Characteristics of House Fly

House fly is usually black or grey in color with a length between 4 to 7 mm. The width of its wings can reach 14 mm. It has 4 dark strips at the thorax with a bit of orange strip at the abdomen. The physical difference between male and female house fly is that the male house fly has eyes closely apart while the abdomen color of the female house fly is golden brown [7]. There are four main stages in the housefly breeding cycle, namely eggs, pupa, larva, pupa and adult flies [8]. House flies are insects that are easily attracted to dirty stuff and filthy wastes such as rubbish, sewage, livestock waste, and plant waste. They are considered as vector i.e.

agent spreading various dangerous diseases like cholera, diarrhea, dysentery, and gastroenteritis. They carry pathogens in their bodies and their excrement can contaminate foodstuffs and contribute to the transfer of food-borne illnesses [9].

2.1 Monitoring House Fly Habitat

Visual observation on fly habitat alone is insufficient as it sometimes can be deceptive. Instead, monitoring house fly populations help in making wise control decisions. Fly surveys determine the effectiveness of sanitation practices, identify fly breeding sites, determine the need for control measures and identify other insect species that will inadvertently be affected by specifically chosen control measures [7]. Surveys are also vital in determining baseline fly populations, track the trends in populations and measure the effectiveness of control methods [10].

A species composition survey of synanthropic fly populations was conducted in Northern Peninsular Malaysia [11]. The predominant species recovered from the surveys i.e. ranked first was the house fly (Musca Domestica). In another study made by Jin and Jaal [12] on the temporal changes in the abundance of house flies, has shown that it has an inverse relationship to the meteorological conditions such as relative humidity and total rainfall. Humidity and temperature had no significant effect on the abundance of flies in poultry farms. In the research carried out by Faridah and Hamidi [5] on the heavy presence of house flies in the engineering campus of the Universiti Sains Malaysia have concluded that the cleanliness factor plays the utmost important role. The house flies will never appear if the campus area is clean regardless of whether the breeding source (poultry farm) is adjacent to the campus. Furthermore, Leong and Grace [13] have pointed out that the main breeding sources were food garbage and spills, pet and farm animal dung, and rotten fruits. Fly populations will be sustained in the urban and agricultural districts due to human unhygienic activities. As a result, disease transmission is possible, especially in urban and agricultural areas.

2.2 House Fly Spatial Habitat Mapping

The major advantage of GIS habitat mapping is the power to manipulate and analyses the data and information it contains [14]. Maps can be spatially analyzed to reflect changes in habitat patterns (dynamics). In addition, the affected land use and the residential settlement layers can be overlaid and shown in any combination and at any scale. The results can be on numerous different versions of maps created, viewed or printed out. Data are stored digitally and enhances the capacity for data collation, dissemination and re-use. Data from different surveys can be integrated. Color and patterns for different habitat attributes can be classified and standardized for the habitat maps produced. GIS habitat map can also be queried in relation to the area or length of a feature, or the grid reference of a specific point. It can also be used to query and analyze spatial data so that the total area of a habitat type can be calculated for a region or survey area.

The GIS habitat survey and mapping were conducted by Leong and Grace [13] on the house fly occurrence in 125 districts of Oahu Island, Hawaii. The comparisons between districts and its distribution with season indicated that the fly activities were consistent across districts with low elevation areas. The level of activity was highest during the winter and summer.

Another study investigates the climatic factors (temperature, relative humidity, and light intensity) and physical factors (land use types) affecting the population trend of house fly in Chiang Mai province, Northern Thailand using the bivariate correlation analysis and ordinary GIS co-kriging approach [15]. The result had shown the existence of fly populations throughout the year with its peak in the late summer. It has a positive relation to the temperature but a negative correlation with relative humidity. The house fly was found to be abundant in every land use type from lowland to forested areas. Its density is associated with altitude and land use types.

3 Methodology

3.1 The Study Area

South Seberang Perai (SPS) is a district in Penang covering an area of 243 km^2, with a population of 165,828 (2010 Census). The district where Nibong Tebal is the main town is bordered by Bandar Baharu in the east (Kedah state border), and Parit Buntar in the south (Perak state border). The district is prospering with the fishing industry and agriculture. Oil palm plantations cover most parts of the area. The growth and development of SPS have risen over the last ten years. The establishment of USM Engineering Campus in 2004, setting up of boarding schools and community colleges has caused immense growth of new housing areas and public amenities to fulfill the needs of the residents. Consequently, Seberang Perai Selatan is also a place for the variety of animal farms such as pigs, chickens, and cows. Figure 1 shows the spatial location of animal farms within the area.

Apart from that, the existence of open dumping area within SPS is also causing the breeding of house flies (Fig. 2). House flies are known as creatures that love dirty and repulsive places. Irregular disposal of food wastes, wastes that are not separated and not wrapped produces odors that will attract house flies to breed in the area.

Fig. 1 Location of existing poultry and pig farms in SPS. *Source* SPS Penang Structure Plan 2005–2020

Fig. 2 The open dumping area

3.2 Data Collection

The comprehensive field mapping of primary house flies breeding places were carried out on the current poultry farms and pigsty located in the study area. The secondary locations were the various open dumping places found within the area. In the field mapping, the GPS coordinates were recorded, photographs taken, and the characteristics of the area were observed. The Portable Android Global Positioning System (GPS), i.e. pre-installed software application on smartphone records the geographic coordinates of the house fly breeding locations. From the GPS coordinates, the longitude and latitude value taken as the reference point was converted into the standard Malaysian plane coordinate system (Northing and Easting coordinates).

3.3 Data Analysis

Once the breeding places were accurately determined on the GIS base map, subsequently the spatial analysis procedures were performed to determine house fly's migration pattern from the location of the breeding spots and to all affected residential/communities around the study area. Spatial analysis process turns raw data into useful information. This includes resampling, digitizing, distance and other methods that can be applied to geographic data to add value to them, to support decisions, and to reveal patterns and anomalies [16]. Additionally, the data obtained from the OpenStreetMap® was resampled along with the SPS road map. A series of vector polygons that indicates the specific boundary of the residential area in SPS were produced. The total number of 70 vector polygon maps was created which was then overlaid on the similar raster map layer.

The distance from house flies breeding source was determined using the common spatial analytical method of re-classification and distance-proximity module. Re-classification divides the data by equal intervals division of the data range, or by the application of user-defined limits. Conversely, the distance operator was used to produce the distance map of breeding point and followed by the re-classification operator to create the re-classed map of various range distance from the various breeding points.

The final step produced an output file that represents the risk map by summing all the risk maps of the primary and secondary breeding points. Subsequently, it was re-classed in the range order limit that represents the risk indicator maps of breeding points. This represents the house flies' risk that helps to determine the extent of the potential house flies affected zones.

The total of 70 polygon features was prepared to represent the residential areas, business areas and educational areas in SPS. Figure 3 shows the polygon features over SPS and its attributes while the breeding source area is depicted in Figs. 4 and 5.

The distance-proximity analysis measures the distance between each cell in the image to the nearest set of target features (breeding source) using the coordinated points established. It derived new distance maps for each poultry source and the open dumping source. The movement of house flies is known to be random since they travel separately and sometimes in a group. The highest recorded distance flown by the house fly was 9.6 km with the assistance of wind factors [17]. The logical distance adopted by some studies was of 4.9 km range from the breeding site [18]. Hence, this study applied the distance between 4.9 and 8 km that was subsequently re-classed into the specific risk-range indicator.

The re-class analysis converts the distance maps into the risk indicator to designate the areas exposed to house fly's migration. The range was set from the highly affected area, moderately affected area and low affected area respectively. The aim was to classify the classes of risk from the breeding sources (poultry/dumping area) towards the living surroundings in SPS. For example, class 1 assigned to cells with distances from 0 km to less than 5 km, class 2 to cells ranged from 5 to less 9 km, and so on. Lee [18] states that the house fly is capable to travel within 1.6–4.9 km,

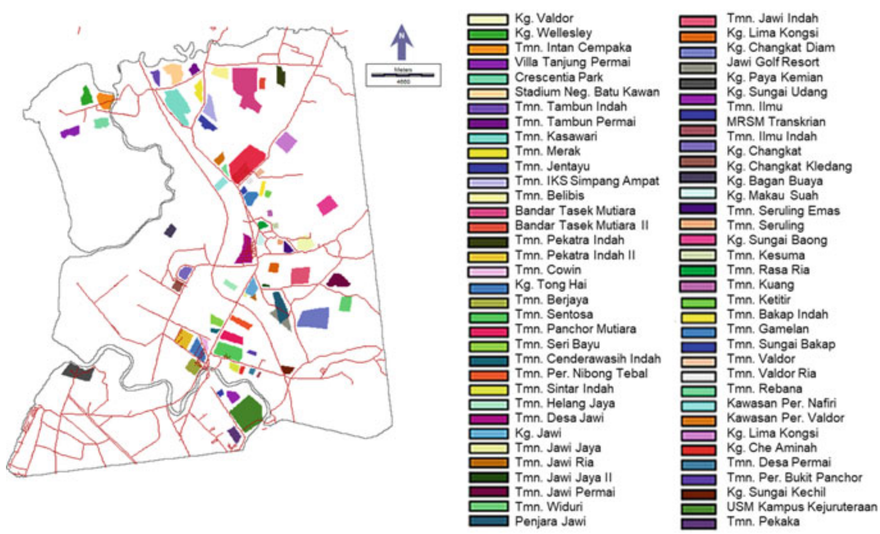
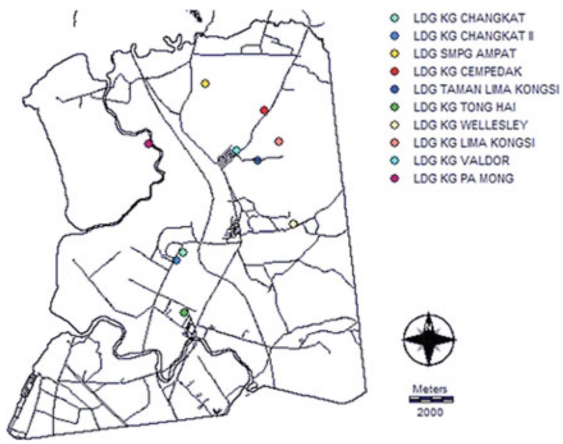


Fig. 3 Polygon areas (residential, business, and educational) in SPS

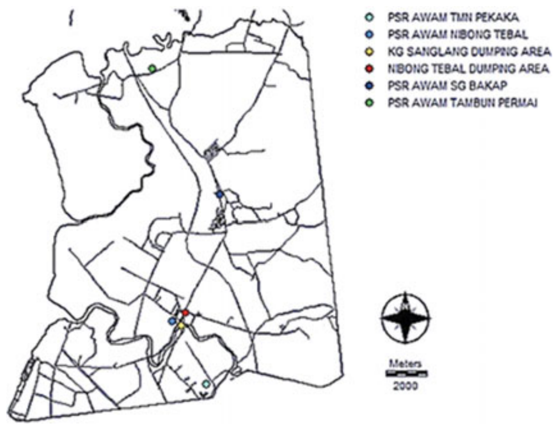


Plane Coordinate (Meters)	
North	East
575912.848	276380.139
575510.871	276021.365
583709.875	277388.617
582474.059	280154.025
580140.444	279822.359
573091.610	276385.797
577165.728	281471.850
581010.891	280810.678
580620.326	278861.909
580933.136	274753.552

Fig. 4 Breeding points (poultries)

where the longest distance of travel is almost 8 km, without external support from mediums such as the wind flow direction or transportations. The re-classed risk map is shown in Table 1.

The housefly's affected areas are presented as risk indicator map based on the respective breeding source and classed as highly affected areas, moderately affected areas and low affected areas respectively. The sample distance and the re-classed risk map derived for the poultry and open dumping source 1 is shown in Fig. 6.



Plane Coordinate (Meters)	
North	East
569024.735	278063.385
572076.952	276340.974
571858.529	276839.535
572457.628	277010.855
578188.517	278727.843
584286.210	275358.613

Fig. 5 Breeding points (dumping sources)

Table 1 Risk indicator based on distance of travel

Class	Risk indicator	Re-class distance (m)
1	Highly affected area	0–4900
2	Moderately affected area	4900–8050
3	Low affected area	>8050

4 Results

A total of 16 risk indicator maps were derived for the various breeding sources (secondary and primary). Subsequently, the respective maps were combined mathematically to produce the final risk indicator map of the house fly's exposure to the inhabitants in SPS. The summing up of the risk indicator maps were accomplished using the mathematical overlay tool in GIS software. It produced an overall map that represents the total risks from the 16 breeding sources. The risk indicator maps described three classes of affected areas and when all the 16 maps were summed up, the low affected areas (Class 3) will produce a total sum of 48 (i.e. 16×3). This represents the highest value in the mathematical overlay (summation). Likewise, using the same theory it applies to the other classes as well. This overlay approach is often used to rank attribute values or risk, adding them to produce an overall risk for each cell in the map [19, 20]. Figure 7 shows the map produced from the overlay and reclassification process. From the map legend, the color represents the summed-up risk values of the surrounding regions in SPS.

The regions with the lowest summed values obviously indicate highly affected areas, while the intermediate (middle) values denote the moderately affected areas and the highest values are the lowly affected areas. The values used in the final re-classification to represent the classes of risks is listed in Table 2. The final risk

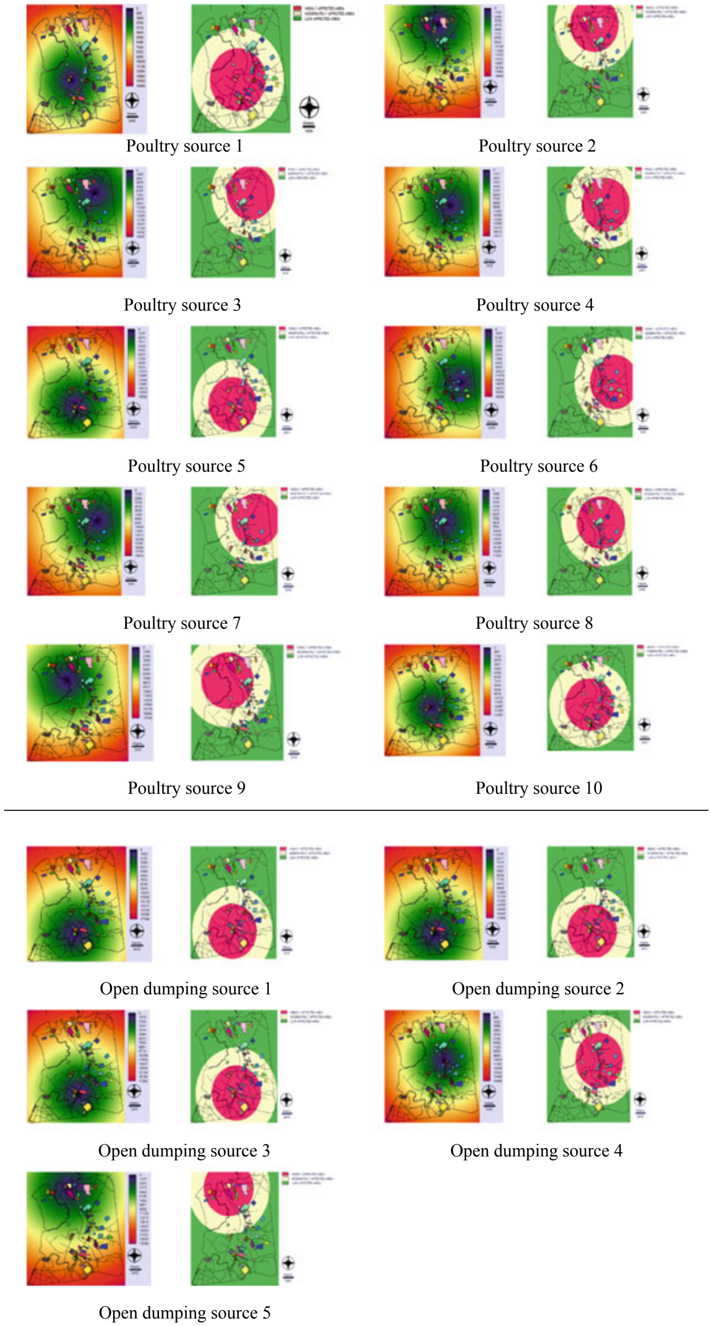


Fig. 6 Distance maps and reclassed risk maps

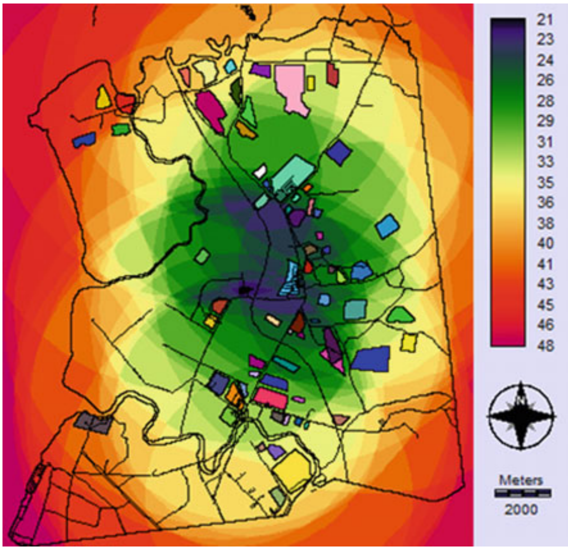


Fig. 7 The summation of the risk indicator maps using overlay process

Table 2 The final risk indicator classes

Class	Risk indicator	Reclass value
1	Highly affected area	21–30
2	Moderately affected area	31–40
3	Low affected area	41–48

indicator map of the house fly habitat study over SPS is shown in Fig. 8. Lastly, the complete list of affected areas is highlighted in Table 3.

5 Conclusions

The research was accomplished using GIS distance analysis operator that determines the spatial relationship of house fly breeding locations with their movement and distribution pattern. The heuristic steps involve preparing the house fly breeding source maps, the house fly distance maps (migration zone), and the re-classed flying distance map affecting the surrounding communities from the breeding sources. This study makes an assumption based on Lee [18] where the house fly's range of travel from 1.6–4.6 km up to 8 km from their breeding source to areas over SPS. The risk affected area was classed into three categories i.e. highly affected area, moderately affected area and the low affected area. The overall study will be very helpful in providing information to the community residence pertaining to the risk of housefly hazards towards their homes. The derived spatial information on the potential risk map of housefly breeding source in some way can advise the

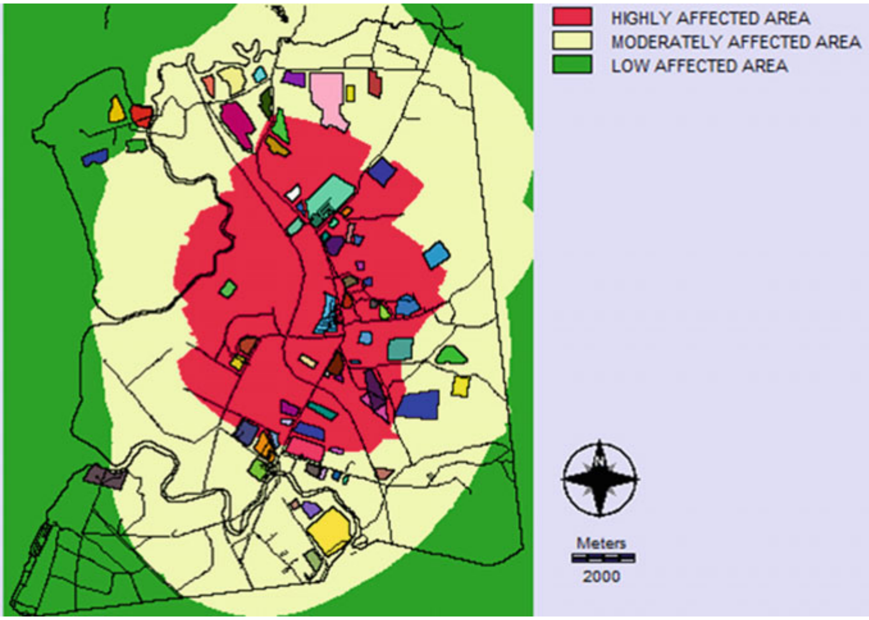


Fig. 8 The final housefly risk indicator map for SPS

Table 3 The class distribution of the house fly habitat risk for South Seberang Perai

Class I (highly affected area). No. of areas (38)	
1. Kg. Valdor	2. Tmn Jawi Indah
3. Kg. Wellesley	4. Kg. Lima Kongsi
5. Tmn IKS Simpang Ampat	6. Kg. Changkat Diam
7. Tmn Belibis	8. Kg. Paya Kemian
9. Tmn Seri Bayu	10. Kg. Changkat
11. Tmn Cenderawasih Indah	12. Kg. Changkat Kledang
13. Tmn Perindustrian Nibong Tebal	14. Kg. Bagan Buaya
15. Tmn Sintar Indah	16. Kg. Makau Suah
17. Tmn Desa Jawi	18. Tmn Seruling Emas
19. PerKg. an Jawi	20. Tmn Seruling
21. Tmn Jawi Jaya	22. Tmn Kesuma
23. Tmn Jawi Ria	24. Tmn Rasa Ria
25. Tmn Jawi Jaya II	26. Tmn Kuang
27. Tmn Jawi Permai	28. Tmn Ketitir
29. Tmn Perindustrian Bukit Panchor	30. Tmn Bakap Indah
31. Tmn Rebana	32. Tmn Gamelan
33. Kaw. Perindustrian Nafiri	34. Tmn Sungai Bakap
35. Kaw. Perindustrian Valdor	36. Tmn Valdor

(continued)

Table 3 (continued)

37. Kg. Lima Kongsi	38. Tmn Valdor Ria
Class II (moderately affected area). No. of areas (28)	
1. Stadium Neg. Batu Kawan	2. Bdr. Tasek Mutiara
3. Tmn Tambun Indah	4. Bdr. Tasek Mutiara II
5. Tmn Tambun Permai	6. Tmn Pekatra Indah
7. Tmn Kasawari	8. Tmn Pekatra Indah II
9. Tmn Merak	10. Tmn Cowin
11. Tmn Jentayu	12. Kg. Tong Hai
13. Tmn Helang Jaya	14. Tmn Berjaya
15. Tmn Widuri	16. Tmn Sentosa
17. Penjara Jawi	18. Tmn Panchor Mutiara
19. Jawi Golf Resort	20. Tmn Ilmu
21. Kg. Sungai Baong	22. MRSM Transkrian
23. Kg. Che Aminah	24. Tmn Ilmu Indah
25. Tmn Desa Permai	26. Kg. Sungai Kechil
27. Tmn Pekaka	28. USM Eng. Campus
Class III (low affected area). No. of areas (4)	
1. Tmn Intan Cempaka	2. Kg. Sungai Udang
3. Villa Tanjung Permai	4. Crescentia Park

future housing development project with regards to locational decision on the best or least risked area to houseflies' migration.

In conclusion, GIS technology provides an important tool in the spatial decision-making process with regards to the study of house fly habitat. Analysis on "where do house fly originate" and to "what extent that the house fly hazards can affect the communities" is achievable.

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