Modelling Burglary Susceptibility – An Expert Judgement Approach

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Abstract. Developing a model allow a better understanding of the nature of a complicated phenomenon. With advancement of tools and technology, model development has been applied widely to mimic the phenomena of interest, spatial or non-spatial wise, allowing a guided decision making to be made. In this paper, the phenomena of burglary vulnerability and susceptibility are modelled based on expert opinion input to create a model that imitates the expert profiling of burglary occurrences, which is dependent on individual expert wisdom and experience in handling the burglary investigation. Due to seriousness of burglary crime offences in Malaysia, especially the urban areas, a prediction model is needed to correlates the factor of crime and further estimates the spatial susceptibility to work hand in hand with other government initiatives in reducing crime. Eighteen (18) indicators and 63 sub-indicators has been identified to be significant in defining the susceptibility of burglary. Apart from input of rating and ranking of indicators and sub-indicators obtained from questionnaire distribution to expert in handling burglary, the geospatial based data were also incorporated into the model to add the element of spatial accuracy in susceptibility prediction. The geospatial data includes the distribution of burglary incidence from 2010 – 2016, the census data, the building footprint data and the demarcation area. For the collected questionnaire feedback, the procedure of Analytical Hierarchy Process (AHP) were adapted to determine the weight value considering the rating input of expert from the distributed questionnaire. The input of weight and scoring were applied to the corresponding spatial features and combined with the operation of weighted sum to yield the total burglary susceptibility of a place. The results of the model were validated with the real reported burglary frequency based on True Positive Rate correlation matrix. The model validation finds that the model have a sensitivity of 82% in classifying the burglary susceptibility of the building polygon inside the study area. However this model still requires some improvement as it is still lacking to perform the classification of incidence intensity correctly.

Keyword: Expert Opinion, GIS, Burglary Susceptibility, Vulnerability, Analytical Hierarchy Process

1. Introduction

The factor that leads to burglary offences were identified branching from the factor of socioeconomic, demographic, spatial layout and the physical characteristics of the building itself. For socioeconomic factor, two main causes of unemployment [1]–[4] and income inequality [5]–[12] has found leading the burglary and crimes activity. Meanwhile in terms of demographic, studies by [13], [14] found the correlation between burglary and the homes of minority, meanwhile [15] suggests that the distribution of demographic characteristics may influence the generation of crime hotspot. High concentration area of multi-ethnicity and foreign worker are identified as social component that related to concentration of crime [16]. On top of that, [17] emphasized on the black class isolation as factor of crime whereby migration of educated, working class black families out from the traditional black neighbourhood. The migration causes the instability of economics and positive perspective inside traditional neighbourhood which referred as "ghetto" area formation.

Zooming to a more detailed concept, several studies tend to consider larger scale approach in defining the burglary vulnerability by addressing the factor of spatial placement and the building characteristics with its surrounding. [18] relates the town planning and mass housing concept in Malaysia as segregation of economic which indirectly crime, meanwhile [19] studies the effect of emergence of guarded neighbourhood due to crime and its effectiveness in preventing crime. [20] and [21] finds that gated communities does promote the feeling of safety but it promotes social segregation between different economic statuses which may return gated community as targeted areas. From the research that concerns the urban planning point of view, the studies on street design, permeability, accessibility and its relationship to crime such conducted by [22]; [23] and [24], [25] also highlights the spatial design on the vulnerability towards burglary. On the other hand, some studies also adapting the qualitative data collection by conducting focus group interview on burglary offenders to find the method of target selection and target preference such conducted by [26]–[33]. From the study concerning the target selection, characteristics of physical building and appearance with higher vulnerabilities can be identified which benefit this research in terms of indicator and questionnaire design.

Modelling the burglary susceptibility based on the expert judgment were aiming to bridge the dynamic sides of burglary vulnerability together with the spatial, social and demographic characteristics in a geospatial layout. Previously, the method of expert judgment is widely adapted and integrated in geospatial modelling of risk assessment and site suitability modelling such conducted by [34]–[40].

2. Study Area

The study area of Damansara-Penchala is an area located at the side of the area of Kuala Lumpur City with the total area of 45.17782 km2. There are 226 residential areas of various typology varies from traditional Malay settlement, to land-based and high-rise planned residential development bounded inside this region. Damansara-Penchala is an official strategic zoning demarcated by Kuala Lumpur City Hall (Dewan Bandaraya Kuala Lumpur) for strategic planning and urban development under the Kuala Lumpur Structure Plan 2020 (DBKL, 2004). **Figure 1** shows the study area and its location at the edge of Kuala Lumpur District.

This area are chosen as the study area due to the highest association of burglary incidence and detriment value. **Figure 2** shows the top ten list of number of burglary incidence with the detriment value per residential area in Kuala Lumpur. From the chart, two highest committed offences and loss values are from the residential area in the region of Damansara-Penchala. The detriment value of RM 15,796,027.00 for 270 burglary incidence for residential area of Damansara Height is quite high with the mean of RM 58,503.80 for each offend. Apart from monetary loss, burglary also affecting the social values of the society and in terms of the perception of safe living. The variety of social and demography make up of Damansara-Penchala zone is also another factor of site selection. This area inhibit by 41% of Malay, 23% Chinese, 13% Indian and 18% of foreigner (non-malaysian). In terms of housing typography, this area comprises of various house type which reflects the socioeconomic gaps. Affluence and inequality is one of the reason that attracting the offending of burglary [6], [28]. In this study context,

the affluence level are represented by the type of house which portrayed in form of house design, size and residential area types. Another factor of consideration in site selection is due to its geographical placement between the urban areas of Kuala Lumpur and the highly populated district of Petaling Jaya which causing high commute and mobility which affects the risk of burglary offences, in line with research findings of [27]; [41] and [15] which concern of cognitive space awareness and familiarity which heightens the opportunity to become a burglary target.
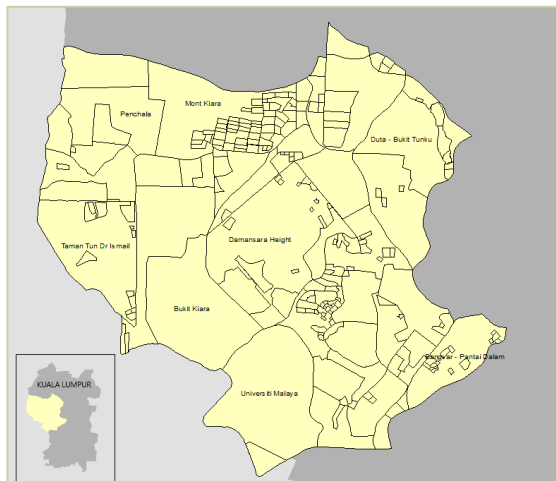

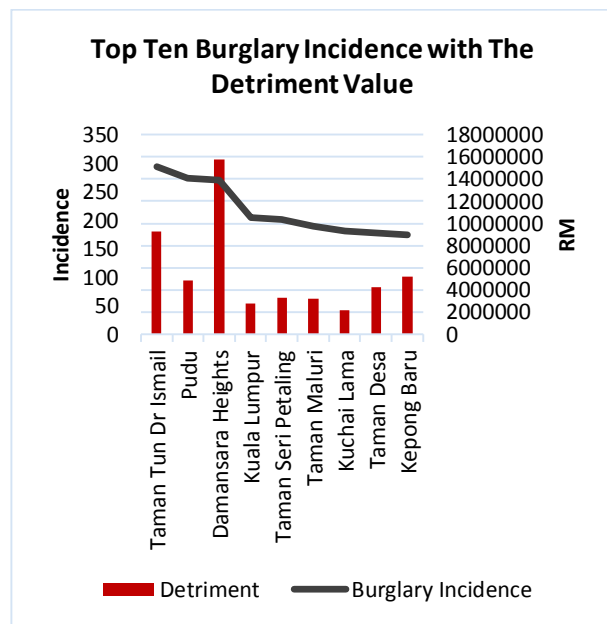**Figure 1**. The study area of Damansara-Penchala and the placement of study area inside of Kuala Lumpur

Figure 2. The top ten burglary incidence and corresponding detriment value according to residential area in Kuala Lumpur

3. Methodology
The section of methodology were divided into several stage, the first one is the data description, which embarks on the data collection method of primary data and the sources and format of secondary data. Following, the indicator development design and reference are discussed. Lastly, the deliberation on the method of model development which covers the AHP for weight value determination and the map production process.

3.1. Data description

The data that has been used to develop the burglary susceptibility model is basically the primary data collected via interviews and questionnaire distribution, meanwhile the secondary data gathered from the government agencies. The primary data collection were done in two phase, the first one is the interview with police officers from Jabatan Pencegahan Jenayah dan Keselamatan Komuniti (JPJKK), Bukit Aman and 6 burglary offenders that also drug user and admitted on committing burglary offences. Since the number of sample obtained from the interview were insufficient to represent the population fairly, this phase of data collection were processed as thematic output by picking up themes that build the preference and clue in target selection for local extent. This deliverables also used in the questionnaire design to collect the relevant information from the expert. The second phase of primary data collection involved the distribution of online and offline questionnaires to sixty (60) police officers that has the experience in handling the burglary investigation. The questionnaire address two parts of rating and

ranking of vulnerability – among the sub-indicators and the overall rating of level of importance throughout the category of indicators which proven to be contributing to burglary vulnerability by previous studies.

For secondary data, the data were gathered from various government agencies, mainly from Sistem Pemantauan Bandar Selamat which under the custodian of Royal Malaysian Police and Urban and Regional Planning Department (Plan Malaysia). Meanwhile other secondary data supple the demographic, social and spatial information to support the model indicator development. **Table 1** summarize the characteristics and the source of the secondary data.

Table 1. The details of secondary data .

No	Data	Format	Source
1	Reported Burglary	Point form, geodatabase	Sistem Pemantauan Bandar Selamat - Malaysian Royal Police and Plan Malaysia
2	Demarcation : Residential Area	Polygon form, geodatabase	Sistem Pemantauan Bandar Selamat - Malaysian Royal Police and Plan Malaysia
3	Census 2010	Polygon form, geodatabase	Department of Statistics Malaysia
4	Building 2013	Polygon form, geodatabase	Kuala Lumpur City Hall (DBKL)
5	Demarcation : Damansara – Penchala Strategic Zone Boundary	Polygon form, geodatabase	Kuala Lumpur City Hall (DBKL)
6	Google Maps and Google Street	Online access	Google ®

3.2. Indicator Development

The structure of the indicators and sub-indicators described in the questionnaire were as depicted in **Figure 3** below. The design of the indicators and sub-indicator structure were inspired by the Papathoma Tsunami Vulnerability Assessment (PTVA) model developed by [37] meanwhile the input of indicator were compiled from various burglary vulnerability studies including [3], [14], [24], [25], [28], [33], [41]-[42].

3.3. Development of Expert Judgement Burglary Susceptibility Model

To develop the model of burglary susceptibility, the data obtained from questionnaire response need to be analyse statistically before assigned as input to produce the map of susceptibility. To calculate overall susceptibility described by 18 indicators and 63 sub-indicators based on judgement of expert respondent, the formula of Relative Vulnerability Index, RVI by [37] were adapted. The formula of RVI are:

$$RVI = \sum\nolimits_{1}^{m}(I_m . S_n) \tag{1}$$

Where
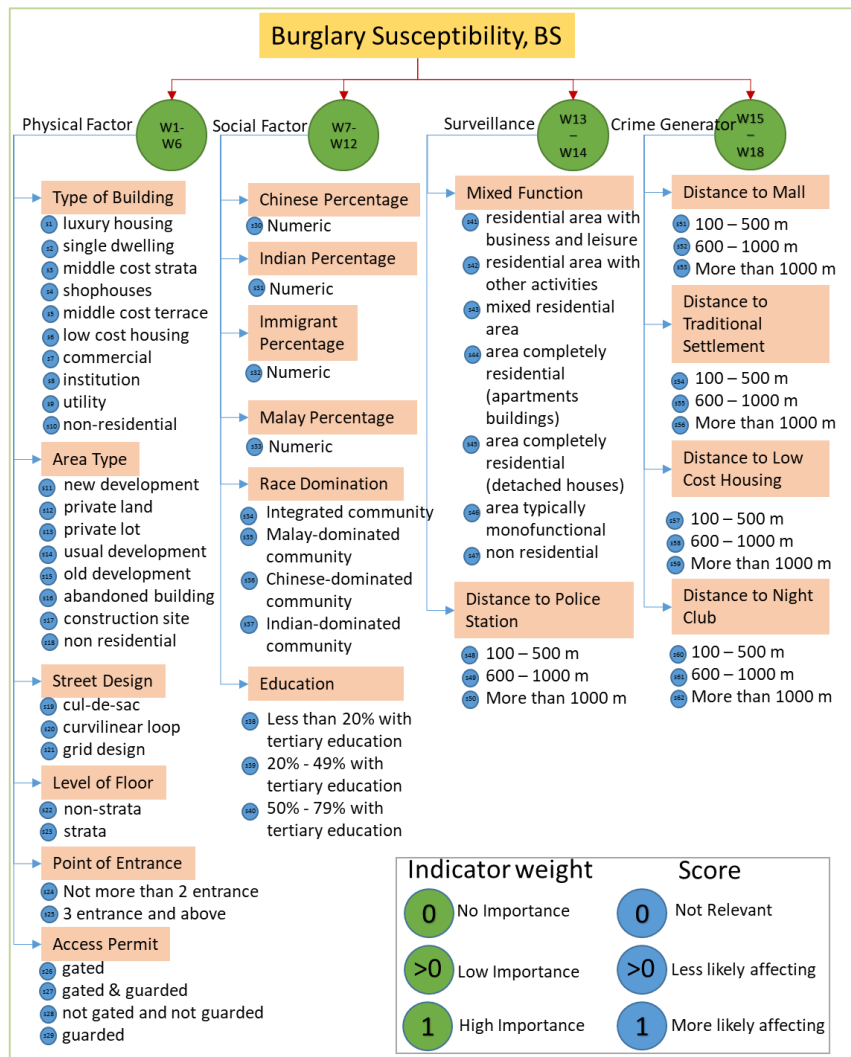|			
	n	=	total raster layer
	I	=	Indicators
	S	=	scores of indicators
	m	=	total number of indicator
	n	=	total number of sub-indicator

Figure 3: Structure of Burglary Susceptibility Assessment Design.

Since the formula in obtaining susceptibility calculation has been identified using RVI, the smaller component of sub-indicator scoring and indicator weight value determination also need to be sorted.

The simpler method of normalized value calculation are adapted in sub-indicator scoring derivation as below:

$$S = \frac{(x - min_x)}{max_x - min_x} \tag{2}$$

Where

x =   the value of individual scoring
$min\ x$ =   the minimum value of overall x values
$max\ x$ =   the maximum value of overall x values

Meanwhile the method of AHP, specifically the pairwise matrix method were adapted for the indicator, I weight derivation. This pairwise matrix requires the arrangement of all the indicator into correlation matrix table and the actual and reciprocal value were assigned based on its importance from one to another (reflecting to the input of real scoring values from expert). The development of the pairwise comparison were carried out with reference to tutorial by [50]. The obtained value of priority

vector from the pairwise matrix steps were validated using the Consistency Index, CI and Consistency Ratio, CR to determine the consistency of the weight value. The Random Consistency Index, RCI for 18 × 18 matrix were referred to RCI Table developed by [51]. According to [52], the priority vector weight is considered as consistent if the obtained CR value is 10% or less. If not, the revision on expert judgement value of pairwise matrix is required. For this research, the weight values obtained from the priority vector values derivation are validated with CR values of 9.3%, thus it is accepted.

The final step in developing the burglary susceptibility model for the study area are to sum and overlay all the respective indicator and sub-indicator values to each spatial location concerns using the formula of RVI. The attributes of spatial were provided by the separate layers raster data according to indicator, which containing the values of sub-indicator scoring respectively. The spatial analysis process of weighted sum were applied to the data to obtained to summation of susceptibility values to its corresponding spatial extent, in this case, the building individuals.

4. Results and Discussion

The deliverables of this model were conveyed in three form which provide the input in burglary susceptibility prediction. The first deliverable are the indicators and sub-indicators which concerns with physical building characteristics, the surveillance element in the building surrounding, the social make-up of the residential areas and its adjacency to identified crime generators point of interest. The second deliverables is the indicators and sub-indicators weight and scoring rank of importance based on the expert judgment and finally, the map which highlight four (4) levels of burglary susceptibility based on its geographical-attributive characteristics of certain place.

4.1. Indicator Weight Value and Sub-Indicator Scoring

The results of weight value derivation from the AHP procedure and sub-indicator scores calculation using normalization method area as tabulated in Table 2 below:

Table 2. The value of weight and sub-indicator from Expert Judgement feedback.

No	Indicator / Weight	Sub Indicator	Score
1	Area Type **0.090286**	new development	0.6875
		private land private lot	0.7188
		usual development	0.7604
		old development	0.8646
		non residential	0.7813
			0.5938
2	Type of Building **0.091953**	low cost housing	0.5750
		middle cost strata	0.5764
		luxury housing	0.5859
		middle cost terrace	0.7695

No	Indicator / Weight	Sub Indicator	Score
		single dwelling (in traditional settlement)	0.7313
		single dwelling (bungalow)	0.6031
		shophouses	0.6111
		institution	0.3047
		office	0.4141
		commercial	0.3500
		shopping mall	0.2125
3	Level of Floor **0.068996**	non-strata	0.9375
		strata	0.6771
4	Point of Entrance **0.079709**	Not more than 2 entrance	0.8438
		3 entrance and above	0.7969

No	Indicator	Category	Value
5	Access Permit **0.092618**	gated gated and guarded not gated and not guarded guarded	0.7656 0.5729 0.8906 0.4844
6	Street Design **0.056512**	cul-de-sac curvilinear loop grid design	0.4375 0.7656 0.6875
7	Indian Percentage **0.062915**	Numeric	0.7031
8	Chinese Percentage **0.036346**	Numeric	0.8854
9	Immigrant Percentage **0.087641**	Numeric	0.4922
10	Malay Percentage **0.049893**	Numeric	0.8646
11	Race Domination **0.084083**	Integrated community Malay-dominated community Chinese-dominated community Indian-dominated community	0.7734 0.7813 0.7188 0.6094
12	Education **0.003179**	50% - 79% with tertiary education	0.6641
13	Distance to Police Station **0.074637**	100m 500m 1000m more than 1000m	0.3646 0.5625 0.6250 0.8125
14	Mixed Function **0.029549**	a) residential area with business and leisure b) residential area with other activities c) mixed residential area d) area completely residential (apartments buildings) e) area completely residential (detached houses) f) area typically monofunctional	0.6146 0.6484 0.5781 0.6406 0.7813 0.8047
15	Distance to Mall **0.009593**	In 1000 meter buffer from Mall	0.4188
16	Distance to Traditional Settlement (Kampung) **0.016141**	Inside Traditional Settlement (Kampung) area	0.7188
17	Distance to Low Cost Housing **0.043147**	Inside Low Cost Housing area	0.6875
18	Distance to Night Club **0.022802**	In 1000 meter buffer from Night Club	0.3290

From the pairwise matrix development for indicator weight value determination, it is found that the factor of access permit or security play the most critical part in determining the susceptibility towards burglary offences in local perspective. The expert also agrees that gated community not necessarily has lower vulnerability towards burglary, which in line with findings of [20], [21]. The second highest indicator in determining the susceptibility towards burglary is Type of Building, followed by Area Type. Both indicator reflects the element of affluence or worthiness to be selected as target, as well as

representing the easiness of entrance in terms of accessibility. Middle cost terrace and usual development were selected as the highest rank of target type to be selected due to its medium level of security and uniform housing layout, which agrees to finding by [53] which stress on housing homogenousity on accessibility rate. This findings on homogenousity and burglary vulnerability are found to be contradicting to finding by [24] which also conduct studies in several selected residential areas in Shah Alam. In terms of demographic features, the experts in majority relates the susceptibility towards burglary with the increased population of immigrant as potential offender. Race domination plays a rather important factor in determining burglary susceptibility with highest values on Malay dominated community, followed by integrated community, Chinese dominated community and lastly, Indian dominated community. Among all indicators, the least important indicator based on expert judgment are found to be adjacency to Mall and Tertiary educated population.

4.2. Expert Judgment Burglary Susceptibility Model and Validation

The operation of spatial analysis of weighted sum using the formula of RVI delivers the output of burglary susceptibility in four (4) levels are mapped as shown in **Figure 4**. To validate the accuracy of the prediction model, the correlation matrix of True Positive, True Negative, False Positive and False Negative over the reported burglary data aggregated as burglary frequency per building to indicate its intensity. This validation method are adapted with reference to [54]–[59] (Table 3). This method used to quantify how reliable the results of a diagnostic test [59]. Sensitivity evaluates on how good the model classifying the positive events, meanwhile specificity estimates the likelihood of the negative events. Accuracy measures how correct a model identifies the positive and the negative events. In this research. the evaluation of correctness of classifying high susceptibility area are described as sensitivity, meanwhile the correctness of classifying non-positive susceptibility area are described as specificity, and the accuracy of overall modelling results are described as accuracy.
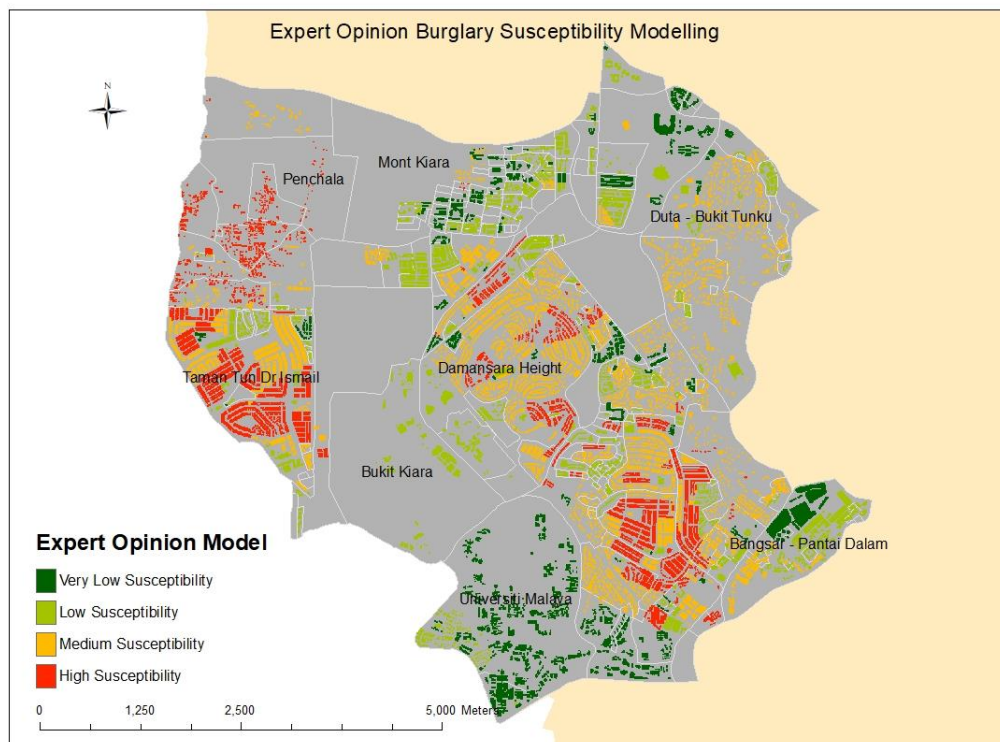

Figure 4. The map of burglary susceptibility based on Expert Judgment data.

The formula on the calculation of sensitivity, specificity and accuracy [59] were given as:

$$Sensitivity = TP/(TP + FN) \tag{3}$$

(Number of true positive assessment)/ (Number of all positive assessment)

$$Specificity = TN/(TN + FP) \tag{4}$$

(Number of true negative assessment)/ (Number of all negative assessment)

$$Accuracy = (TN + TP)/(TN + TP + FN + FP) \tag{5}$$

(Number of correct assessments)/ Number of all assessments)

Table 3. The validation of developed model with burglary frequency distribution.

Susceptibility / Frequency	Very Low	Low	Medium	High
0 (0)	100	177	340	206
1 (1-3)	89	160	304	249
2 (4-6)	7	6	5	0
3 (7-9)	1	1	1	0
No of polygon	197	344	650	455
Sensitivity	88.21%			
Specificity	12.15%			
Accuracy	50.18%			

The validation finds that the expert judgment model has a quite good performance in classifying the presence of burglary susceptibility but lacking in specificity of identifying the location with lower susceptibility towards burglary. In terms of intensity, it is also finds that this model lack of ability in classifying the intensity of higher burglary frequency with high susceptibility label. On overall, this expert judgement model only describes the burglary trends in study area with 50.18% of accuracy. From this numbers, it is shown that this model still requires improvisation in terms of method of data collection and the questionnaire design. The results of model may be improved if the data collection were done with the presence of researcher, as the misunderstanding in addressed questions can be discussed. Furthermore, the expert respondent are from different age group, which may lead to obsolete trending of burglary profiling hence staking the results in average.

5. Conclusion

The aims of modelling the expert judgment in geospatial approach were achieved by combining the input of the features defining the burglary susceptibility in rank of importance by the police officer. This model are believed able to provide a new perspective of modelling the burglary prediction apart from statistical approach. With improved means of data collection, the model performance can be improve to provide the accuracy as reliable as data driven modelling approach.

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