LANDSLIDE HAZARD FACTORS (LHF) BY COMMUNITY PERCEPTION SURVEY IN KOTA KINABALU, SABAH

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ABSTRACT. *This study aims to investigate disaster perception of factors causing landslides for the people of Kota Kinabalu city area, Sabah, Malaysia. Five hundred and seven adult respondent residents from the local government and private agencies exposed to landslide hazard participated in this study using structured questionnaires. Perception of landslide hazard factors (LHF) was assessed by statistical analysis such as Descriptive Analysis, Factor Analysis, Independent Samples T-Tests and Analysis of Variance (ANOVA). Major information in this survey relates to the factors likelihood to cause landslides. Socio-demographic and experiential information of respondents was also collected. Exploratory study on descriptive analysis indicates that the slope gradient factor fell in the highest rank with highest frequency (474) for events causing landslides, followed by water (469), supervision (425), negligence (415), geology (390), design (385) and geomorphology (365). Factor analysis results show that there are two factors that cause landslides: Engineering Geological Characteristics (EGC) and Human Factors (HF). After performing Varimax Rotation Method with Kaiser Normalisation, Factor EGC comprises four items: geology, geomorphology, water and slope gradient; while Factor HF comprises three items: negligence, supervision and design. Independent samples t-test for equality of mean results showed there were no significant mean differences in community perception of EGC or HF for both gender with professions and gender with educational background categories for all respondent items ($p>0.05$). ANOVA results showed there were significant mean differences in community perceptions of EGC among educational background at 10% level of significance ($p<0.1$) but no significant mean differences among other variables such as professions, home location and living area ($p>0.05$). In a different situation, the ANOVA results showed there was significant mean differences in community perceptions of HF among professions at 5% level of significance ($p<0.0.5$) but no significant mean differences among other variables such as educational background, home location and living area ($p>0.05$).*

KEYWORDS: Landslide hazard factors (LHF), community perception survey (CPS), statistical analysis

INTRODUCTION

Landslide hazard often found discussed in newspapers and electronic media. Due to this disaster, the government is forced to bear millions of Malaysian ringgit given compensation to the victims involved and repair ruined infrastructures and utilities. Malaysia has guidelines and acts about land development especially on highland area and slopes. Most guidelines and acts available are more focused to the preliminary processes of the construction activities and land development like housing, building or road on highland area and hilly slopes; and analyse landslide distribution or slope stability analysis study. However, landslide study involves the community perception, awareness and preparedness is still less carried out in Malaysia.

In the last three decades, several studies have been done to investigate on the community perception, awareness and preparedness for geohazard occurrences globally which may be referred in the international project reports, international proceeding conferences or international manuscripts. Most research findings suggest that perception, awareness and preparedness for a natural disaster is associated with a wide range of socio-demographic characteristics of the household, which may play a different role depending on the social and environmental context. Among these characteristics, significant though often low correlations have been reported for age (Schiff, 1977; Lindell & Whitney, 2000; Heller *et al.*, 2005), marital status (Dooley *et al.*, 1992; Russell *et al.*, 1995), presence of children living at home (Turner *et al.*, 1986; Dooley *et al.*, 1992; Edwards, 1993; Russell *et al.*, 1995), income (Edwards, 1993; Russell *et al.*, 1995), education (Edwards, 1993; Russell *et al.*, 1995), home ownership (Turner *et al.*, 1986; Russell *et al.*, 1995; Mulilis *et al.*, 2000) and length of residence at the same location (Dooley *et al.*, 1992; Russell *et al.*, 1995). Along with these variables, some studies have also demonstrated that the level of disaster perception, awareness and preparedness may change as a function of some key personal and psychological factors, including previous disaster experience (Jackson, 1981; Johnston *et al.*, 1999; Norris *et al.*, 1999; Zaleskiewicz *et al.*, 2002; Heller *et al.*, 2005), personality characteristics (Heller *et al.*, 2005), self-efficacy (Mulilis & Lippa, 1990), causal attributions (Baumann & Sims, 1978; Turner *et al.*, 1986; McClure *et al.*, 1999), perceived responsibility for preparedness (Mulilis & Duval, 1997; Lindell & Whitney, 2000; Mulilis *et al.*, 2000) and amount of concern or preoccupation for a future catastrophe (Dooley *et al.*, 1992; Weinstein *et al.*, 2000).

Hence, to carry more comprehensive studies on this research method, Kota Kinabalu area as fast developing capital city of Sabah was chosen as the pioneer research area. Generally, the rapid development since the eighties (80's) had a spill over effect in Kota Kinabalu area where lands were cleared for construction of highways, high-rise buildings, industrial, housing and several other heavy infrastructures. These activities had, besides spurring economic growth, also caused geohazard management issues.

Landslide Hazard Occurrences in the Kota Kinabalu, Sabah, Malaysia

Kota Kinabalu city lies centrally on the western coast of Sabah, Malaysia roughly about longitude E 116^o 02' to E 116^o 09' and latitude N 05^o 55' to N 06^o 01' (Figure 1) and surrounded by the Crocker Ridges have their complex structural geological background may give negative prospect to any land development activity. According to the local research angle, there is some landslide research related was being conducted and published in documented research report, international proceeding or refereed manuscript near with study area such as Muhamad Barzani Gasim & Brunotte (1987), Tongkul (1989), Faisal (1994) and Faisal *et al.* (1997), Golutin & Tating (2001), Webster *et al.* (2001) and Rodeano *et al.(*2006a, 2006b & 2007). Barzani Gasim & Brunotte (1987), Tongkul (1989) and Faisal (1994) discussed of incident description landslide by taking into account the structural geology and general geology inputs. Faisal *et al.* (1997) linked the natural problem on lithological characteristics of the Crocker Formation with the underground water presence that can be influenced on foundation stability design. In the same situation, Golutin & Tating (2001), Webster *et al.* (2001) and Rodeano *et al.* (2007) have studied landslide through the case study approach that has occurred in Kota Kinabalu vicinity involving property damage and loss of lives. While Rodeano *et al.* (2006a and 2006b) described in detail about the useful of engineering geology information and the issue for geohazard problem occurrences in the Kota Kinabalu town area, Sabah, Malaysia. However, all the materials described above are more converging to study landslide by scientific or technical approach and are not through questionnaires on community perception, awareness and preparedness related to the landslide hazard factors (LHF).

If looked into geohistorical angle, there were some case landslide incident has occurred in the study area without recorded or published thereby complete and comprehensive. For example, on 26th December 2001 and 30th June 2006 landslides occurred in the same place at the Lok Bunuq village area which resulted in 10 fatalities and losses amounting to hundred thousands of Malaysian ringgit (Figures 2 & 3). A landslide event involving an embankment slope (causeway) also occurred on 10th October 2006 in the Menggatal-Sepanggar highway area (Karambunai) with tragic impacts on the locals with 2 lives lost (Figures 4 & 5), and some cases of landslide also occurred simultaneously on the same day (June 6, 2010) involving the embankment slope along Shantung Road, Bantayan Road, Bukit Bendera Road, Bukit Padang Road and Minitod Road resulting in interference of the traffic system for a month.

The immediate response was a directive to stay away or vacate residences or buildings with no exemption in the areas hit in this study area. For example, the Shantung-Penampang road settlement area, the Yayasan Sabah College Community lectures building, the Taman Winley area and the MARA University of Technology Malaysia (UiTM) Sabah branch campus (lectures building) all had to be abandoned because their state was found to be unstable and there was a worry that they would be affected in the event of another landslide occurring. This does not include a few current cases where no drastic action was taken or dealt with appropriately by local authorities such as the slope stability problem along the Sepangar-Tuaran highway, Penampang-Inanam road, Kota Kinabalu-Telipok road, Bundusan road area residences, UMS-Sulaman road, Luyang housing area, Bukit Bendera ridge area, Likas ridge area and many more which are still actively used.

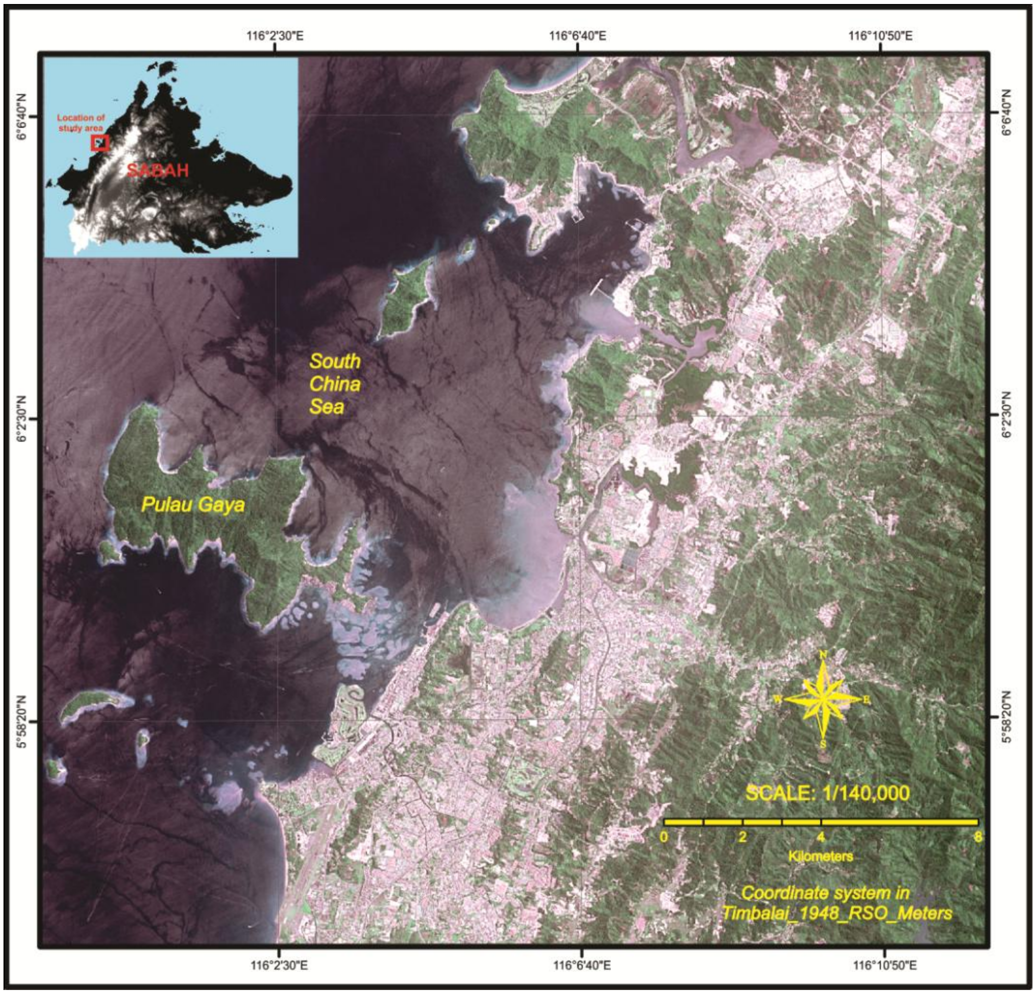

Figure 1. Location map of the study area.

Figure 2. Photo showing the damaged house due to landslide hazard at Lok Bunuq village area (30th June 2006).

Figure 3. Photo showing the former landslide area which flowed from the upper slope at Lok Bunuq village area (26th December 2001).

Figure 4. Photo showing the landslide embankment area has destroyed almost half road in Karambunai Resort junction area which collapsed in 10th October 2006.

Figure 5. Photo showing the shortcrete failure area in slope while waiting to collapse in any time alone because of failure design and less monitoring (10th October 2006).

MATERIALS AND METHODS

Five hundred and seven (507) adult respondent residents from the local government and private agencies exposed to landslide hazard participated in this study using structured questionnaires. Some of the information contained in the survey questionnaires are as follows: 1. Respondent's background (age, gender, number of family members, educational background, employment status, position, experience, type of residence, the location of residence, the period length of stay, estimated budget of accommodation, internal home equipments and vehicle, availability purchase hazard insurance and frequency of road route); 2. General statement (experience on hazard and factors of landslide); and 3. General reaction (monitoring the development of highland, the proposed action against the developer, the parties are to be blame, the proposed hillside development, compliance with the approval of the plan, the concept of the doctrine of universal planning and development factors that cause failure of enforcement highlands).

Statistical Package for Social Science (SPSS) was used to perform statistical analysis on the data collected from the survey forms. The analysis that was performed in this study was Descriptive Analysis, Factor Analysis, Independent samples t-test and ANOVA.

Factor analysis was used to identify respondents' perception on the factors causing landslide. The factor analysis model as stated by Johnson and Wichern (2002) is:

$$\begin{aligned} X_1 - \mu_1 &= \ell_{11}F_1 + \ell_{12}F_2 + \cdots + \ell_{1m}F_m + \varepsilon_1 \\ X_2 - \mu_2 &= \ell_{21}F_1 + \ell_{22}F_2 + \cdots + \ell_{2m}F_m + \varepsilon_2 \\ &\vdots \\ X_p - \mu_p &= \ell_{p1}F_1 + \ell_{p2}F_2 + \cdots + \ell_{pm}F_m + \varepsilon_p \end{aligned} \quad (1)$$

Johnson & Wichern (2002) stated the orthogonal factor model with *m* common factors as follows:

$$\underset{(pX1)}{X} = \underset{(pX1)}{\mu} + \underset{(pXm)}{L}\ \underset{(mXm)}{F} + \underset{(pX1)}{\varepsilon} \quad (2)$$

where,
μ_i = mean of variable *I*, ε_i = *i*th specific factor, F_j = *j*th common factor & ℓ_{ij} = loading of the *i*th variable on the *j*th factor

The communalities are estimated as $\tilde{h}_i^2 = \tilde{\ell}_{i1}^2 + \tilde{\ell}_{i2}^2 + \cdots + \tilde{\ell}_{im}^2$ (Johnson & Wichern, 2002). The principal component factor analysis of the sample covariance matrix S is specified in terms of its eigenvalue-eigenvector pairs $(\hat{\lambda}_1, \hat{e}_1), (\hat{\lambda}_2, \hat{e}_2), \cdots, (\hat{\lambda}_p, \hat{e}_p)$, where $(\hat{\lambda}_1 \geq \hat{\lambda}_2 \geq \cdots \geq \hat{\lambda}_p$. Let $m < p$ is the number of common factors. Then the matrix of estimated factor loadings $\{\tilde{\ell} i_j\}$ is given by

$$\tilde{L} = \left[\sqrt{\hat{\lambda}_1}\hat{e}_1 \vdots \sqrt{\hat{\lambda}_2}\hat{e}_2 \vdots \cdots \vdots \sqrt{\hat{\lambda}_m}\hat{e}_m \right] \text{(Johnson \& Wichern, 2002).} \quad (3)$$

Johnson & Wichern (2002) stated the estimated specific variances are provided by the diagonal elements of the matrix $S - \tilde{L}\tilde{L}'$, so

$$\tilde{\psi} = \begin{bmatrix} \tilde{\psi}_1 & 0 & \cdots & 0 \\ 0 & \tilde{\psi}_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \tilde{\psi}_p \end{bmatrix} \text{with } \hat{\psi}_i = s_{ii} - \sum_{j=1}^{m} \tilde{\ell}_{ij}^2 \quad (4)$$

Foster (1998) stated to compare the scores of two groups of different subjects on one variable, use the independent-samples t test. Berenson *et.al* (2006) stated the pooled-variance t test for the difference between two means is

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{S_p^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \quad (5)$$

$$\text{Where } S_p^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{(n_1 - 1) + (n_2 - 1)} \quad (6)$$

and,
$S_p^2 =$ pooled variance, $\bar{X}_1 =$ mean of the sample taken from population 1, $S_1^2 =$ variance of the sample taken from population 1 $n_1 =$ size of the sample taken from population 1, $\bar{X}_2 =$ mean of the sample taken from population 2, $S_2^2 =$ variance of the sample taken from population 2 & $n_2 =$ size of the sample taken from population 2.

Triola (2005) stated the hypothesis test statistics for two means for independent samples is

$$t = \frac{(\overline{X}_1 - \overline{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\left(\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}\right)}} \tag{7}$$

where,
$\overline{X}_1 =$ mean of the sample taken from population 1, $S_1^2 =$ variance of the sample taken from population 1, $n_1 =$ size of the sample taken from population 1, $\overline{X}_2 =$ mean of the sample taken from population 2, $S_2^2 =$ variance of the sample taken from population 2 & $n_2 =$ size of the sample taken from population 2

Johnson & Kuby (2004) stated Analysis of Variance (ANOVA) is used to test a hypothesis about several populations' means.

RESULT AND DISCUSSION

Descriptive Analysis

Five hundred and seven participants responded to the survey. There were 315 (62.1%) male respondents and 192 (37.9%) female respondents in this study. Apart from that, evaluation from the job categories indicate that about 380 respondents worked in public sectors and 127 respondents worked in private sectors.

Table 1 shows the profile of the respondents. There were 27 respondents with PhD / Master, 118 respondents with degree, 310 respondents with diploma / STPM / certificate level of education and 52 respondents with SPM and below. There were 138 respondents worked as manager and professionals, 342 respondents worked as semi-professional and support staffs and 27 as self-employments. There were 245 respondents lived in housing area, 102 respondents lived in condominium/flat, 69 lived in private lands and 91 lived in village area. There were 102 respondents live along highland, 132 respondents at hilly slopes, 166 respondents live on a filling material and 107 respondents lived nearby coastal or river area.

Table 2 shows the frequencies answering yes for items causing landslide. The results show the slope fell in the highest rank with highest frequency (474) for respondents answering yes for items causing landslide, followed by water (469), supervision (425), ignorance (415), geology (390), design (385) and geomorphology (365).

Table 1. Respondent profile.

Respondent Profile		Frequency	Percent
Gender	Male	315	62.1
	Female	192	37.9
Job categories	Public sector	380	75.0
	Private sector	127	25.0
Educational Background	PhD / Master	27	5.3
	Degree	118	23.3
	Diploma / STPM / Certificate	310	61.1
	SPM and below	52	10.3
Occupations	Management and Professional	138	27.2
	Semi-professional and supporting staffs	342	67.5
	Self-employment	27	5.3
Home location	Housing area	245	48.3
	Condominium / flat	102	20.1
	Private land	69	13.6
	Village area	91	17.9
Living area	Highland	102	20.1
	Hilly slope	132	26.0
	Filling material	166	32.7
	Nearby Coastal or River	107	21.1

Table 2. Frequencies answering yes for items causing landslide.

Items	Frequency
Slope	474
Water	469
Supervision	425
Ignorance	415
Geology	390
Design	385
Geomorphology	365

Table 3. KMO and Bartlett's Test.

KMO and Bartlett's Test		Landslide
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.648
Bartlett's Test of Sphericity	Approx. Chi-Square	299.871
	Significance	0.000

Factor Analysis

Coakes & Sheridan (2008) stated that if Bartlett's test of sphericity is large and significant, and if the Kaiser-Meyer-Olkin measure is greater than 0.6, then factorability is assumed. The Kaiser-Meyer-Olkin and Bartlett's test result in Table 3 shows the Bartlett's test of sphericity is large and significant ($p<0.01$) and KMO is greater than 0.6, then factorability is assumed.

Table 4 below displays the anti-image matrices result. The anti-image correlation matrix is used to assess the the sampling adequacy of each variable. Measures of sampling adequacy are printed on the diagonal. Variables with a measure of sampling accuracy that falls below the acceptable level of 0.5 should be excluded from the analysis. Inspection of the anti-image correlation matrix reveals that all our measures of sampling adequacy are well above the acceptable level of 0.5. Therefore none of the variables will be excluded from the analysis.

Table 4. Anti-image Matrices.

		Geology	Slope Gradient	Waters	Geomorpho -logy	Supervi -sion	Design	Negligence
Anti-image Covariance	Geology	**.886**	.027	-.102	-.231	-.016	-.078	.075
	Slope	.027	**.874**	-.172	-.117	-.161	-.083	.078
	Waters	-.102	-.172	**.893**	-.085	.019	-.090	-.017
	Geomorphology	-.231	-.117	-.085	**.828**	-.023	-.043	-.141
	Supervision	-.016	-.161	.019	-.023	**.872**	-.116	-.164
	Design	-.078	-.083	-.090	-.043	-.116	**.821**	-.226
	Negligence	.075	.078	-.017	-.141	-.164	-.226	**.828**
Anti-image Correlation	Geology	**.586(a)**	.031	-.115	-.270	-.019	-.092	.087
	Slope	.031	**.618(a)**	-.195	-.138	-.184	-.098	.092
	Waters	-.115	-.195	**.701(a)**	-.099	.021	-.105	-.020
	Geomorphology	-.270	-.138	-.099	**.663(a)**	-.028	-.052	-.170
	Supervision	-.019	-.184	.021	-.028	**.683(a)**	-.136	-.193
	Design	-.092	-.098	-.105	-.052	-.136	**.694(a)**	-.274
	Negligence	.087	.092	-.020	-.170	-.193	-.274	**.587(a)**

- *Measures of Sampling Adequacy (MSA)*

Table 5 below displays the total variance explained at two stages for factors causing landslide. At the initial stage, it shows the factors and their associated eigen values, the percentage of variance explained and the cumulative percentages. Two factors were extracted because their eigen values greater than 1. When two factors were extracted, then 45.625 per cent of the variance would be explained.

Table 6 below shows the rotated factor matrix on factors causing landslide. Variable with factor loadings more than 0.45 were chosen in this study because loadings equals to 0.45 is considered average, whereas loadings 0.32 is considered less good (Tabachnick & Fidell, 2001). After performing Varimax Rotation Method with Kaiser Normalization, Factor 1 comprised four items (geology, geomorphology, waters and slope gradient) with factor loadings ranging from 0.691 to 0.487. Factor 2 comprised three items (negligence, supervision and design) with factor loadings ranging from 0.770 to 0.657.

Table 7 below shows the causative factors causing landslide after performing the factor analysis. The results showed that two factors were attributed to landslide. The first factor was Engineering Geological Characteristics (EGC) consists of geology, geomorphology, water and slope gradient. When EGC factor was extracted, then 28.848 per cent of the variance would be explained. The second factor was Human Factors (HF) consisted of negligence, supervision and design. When HF factor was extracted, then 16.777 per cent of the variance would be explained.

Table 5. Total variance explained on factors causing landslide.

Component	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.019	28.848	28.848	2.019	28.848	28.848	1.606	22.946	22.946
2	1.174	16.777	45.625	1.174	16.777	45.625	1.588	22.680	45.625
3	.999	14.268	59.893						
4	.831	11.876	71.769						
5	.738	10.545	82.314						
6	.684	9.770	92.084						
7	.554	7.916	100.000						

- *Extraction Method: Principal Component Analysis*

Table 6. Rotated factor matrix on factors causing landslide.

Factors causing landslide	Component	
	1	2
Geology	.691	
Geomorphology	.642	
Water	.639	
Slope	.487	
Negligence		.770
Supervision		.673
Design		.657

- *Extraction Method: Principal Component Analysis.*
- *Rotation Method: Varimax with Kaiser Normalization.*
- *Rotation converged in 3 iterations*.

Table 7. Factor analysis on factors causing landslide.

Factor analysis for factors causing landslide	Percentage of Variance	Variables
Engineering Geological Characteristics (EGC)	28.848	Geology
		Geomorphology
		Water
		Slope
Human Factors (HF)	16.777	Negligence
		Supervision
		Design

Independent samples t-test

Further analysis using Independent samples t-test was performed on each factors; EGC and HF to test the mean differences on community perceptions between gender and job categories. Table 8 below shows the results of mean differences on community perceptions between gender and job categories for factor on EGC. Levene's test for equality of variance showed equal variances were assumed for gender and job categories ($p>0.05$). The t-test for equality of means results showed there were no significant mean differences on community perceptions on EGC for both gender and job categories ($p>0.05$).

Table 9 below shows the results mean differences on community perceptions between gender and job categories for human factor. Levene's test for equality of variance showed equal variances were assumed for gender and job categories (p>0.05). The t-test for equality of means results showed there were no significant mean differences on community perceptions on human factor for both gender and job categories (p>0.05).

Table 8. Independent samples t-test on EGC.

EGC	Levene's test for equality of variance		t-test for equality of means	
	F	Sig.	t	Sig.
Gender	0.605	0.437	-0.668	0.505
Job categories	0.137	0.711	0.333	0.739

Table 9. Independent samples t-test on HF.

HF	Levene's test for eqaulity of variance		t-test for equality of means	
	F	Sig.	t	Sig.
Gender	0.670	0.413	-0.165	0.869
Job categories	1.478	0.225	0.539	0.590

ANOVA

Further analysis using ANOVA was performed on each factors; EGC and HF to test the mean differences on community perceptions among educational background, professions, home locations and living area. Table 10 below shows the results of mean differences. The ANOVA results showed there was significant mean differences on community perceptions on EGC among educational background at 10% level of significance (p<0.1). The mean difference on community perceptions on EGC was between the degree holders' perceptions and perceptions from respondents with SPM and below. The mean difference was -0.406.

However the ANOVA results showed there were no significant mean differences on community perceptions on EGC among other variables; professions, home locations and living area (p>0.05).

Table 11 below shows the results mean differences on HF among educational background, professions, home locations and living area. The ANOVA results showed there was significant mean differences on community perceptions on HF among professions at 5% level of significance (p<0.0.5). The mean difference on community perceptions was between the Self-employment and semi-professional and support staffs. The mean difference was 0.596.

However the ANOVA results showed there were no significant mean differences on community perceptions on HF among other variables; educational background, home locations and living area (p>0.05).

Table 10. ANOVA on EGC

Variable	F	Sig.
Educational background	2.120	**0.097**
Professions	1.394	0.249
Home locations	1.723	0.161
Living area	1.280	0.281

Table 11. ANOVA on HF

Variable	F	Sig.
Educational background	1.378	0.249
Professions	5.033	**0.007**
Home locations	0.720	0.541
Living area	0.169	0.917

CONCLUSIONS

1. Exploratory study on descriptive analysis indicates that the slope gradient factor fell in the highest rank with highest frequency (474) for respondents answering yes for items causing landslide, followed by waters (469), supervision (425), negligence (415), geology (390), design (385) and geomorphology (365).
2. Factor analysis results showed that there were two factors extracted for the causative factors causing landslide; Engineering Geological Characteristics (EGC) and Human Factor (HF). After performing Varimax Rotation Method with Kaiser Normalization, Factor EGC comprises into four items (geology, geomorphology, waters and slope gradient) while Factor HF comprises of three items (negligence, supervision and design).
3. Independent samples t-test for equality of means results showed there were no significant mean differences on community perception either EGC or HF for both gender with professions or gender with educational background categories for all respondent items ($p>0.05$).
4. ANOVA results showed there was significant mean differences on community perceptions on EGC among educational background at 10% level of significance ($p<0.1$). However the ANOVA results showed there were no significant mean differences on community perceptions on EGC among other variables; professions, home locations and living area ($p>0.05$). In different situation, the ANOVA results showed there was significant mean differences on community perceptions on HF among professions at 5% level of significance (p<0.0.5). However the ANOVA results showed there were no significant mean differences on community perceptions on HF among other variables; educational background, home locations and living area ($p>0.05$).

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