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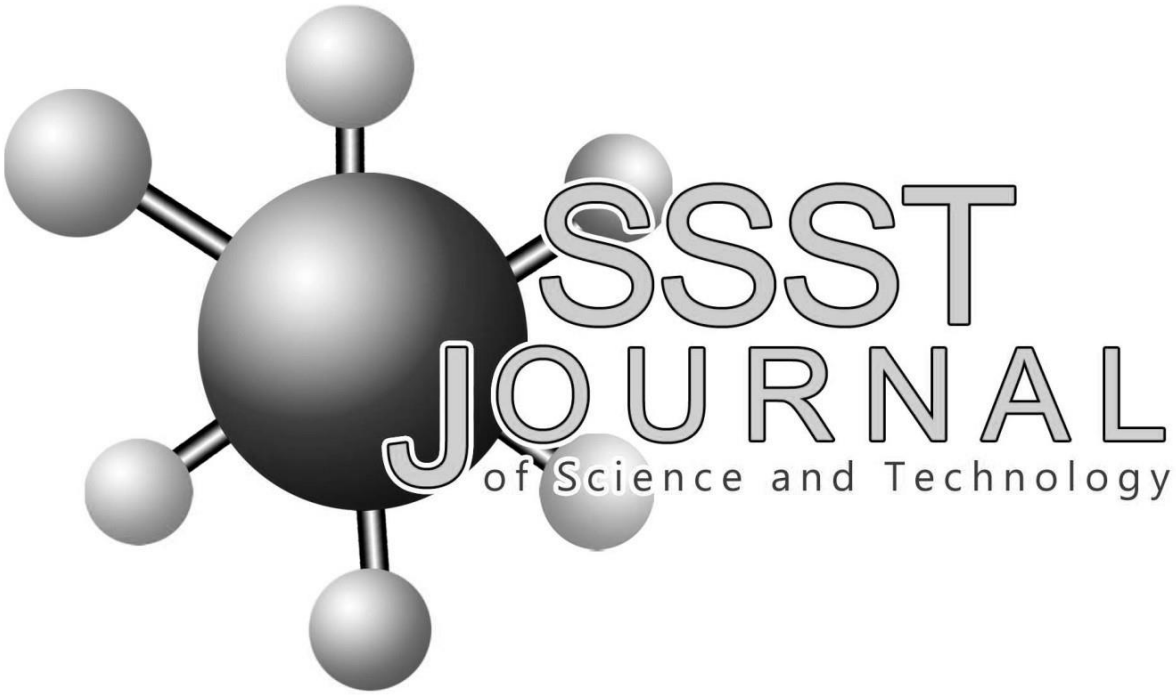

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Instead of:

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• A period should be followed by a single space
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Pseudocalotes khaonanensis (Chan-ard, Cota, Makchai & Laoteow, 2008)

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- Capacity: 36 ml; 1.6 l
- Mass: 3.2 g; 5.1 kg
- Geographic Coordinates: 19° 21' 39.3" N 98° 34' 11.6" E 618 m ASL

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Non-English Language References:

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CONTENTS

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Suan Sunandha Science and Technology Journal, Vol. 2, No.2, July 2015

Mapping Land Cover Dynamics in Nakhon Nayok Province of Thailand

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Abstract: The spatial distribution of land cover information and its changes is very valuable for any planning, management and monitoring at local as well as regional scale. In this paper, multi-temporal Landsat TM/ OLI data were used to classify the land cover of the Nakhon Nayok province in Thailand over the period 2004-2015. The supervised classification maximum likelihood method was implemented to assign probability to land the cover classes considered. The random sampling point method was used for field survey and accuracy assessment. The overall accuracy and kappa coefficient in 2015 were found to be 72% and 0.6626 respectively. The results also indicated that important changes concerned mainly urban (308.46 %), water (-50.46), and agricultural (-12.14) areas, and least changes forest areas (3.17). These results also highlighted that over the last 10 years, urban areas have been characterized by the highest expansion, mainly from the conversion of agricultural land.

Keywords: Remote Sensing, Landsat, Land cover dynamics, change detection

Introduction

Over the past decades, Thailand has experienced many disturbances on its land surface caused by natural and human activities. In particular, anthropogenic impacts mainly in the form of agricultural and urban expansion due increase in population have become an issue of major concern. In order to monitor potential ranges of the impacts of these dynamics on land cover requires accurate mapping and monitoring of land cover changes over long periods.

Remote sensing images can capture the land cover and its changes over larger spatial and temporal scale including remote areas repetitively (Furkuo et al., 2012, Fichera et al., 2012). Satellite images have been used for land cover mapping in various studies (Yuan et al., 2005). The most standard global land cover data is provided by Food and Agriculture Organization (FAO), which is analyzed from several satellite sensors such as the Advanced Very High Resolution Radiometer (AVHHR), Satellite Pour l'Observation de la Terre (SPOT), Medium Resolution Image Spectrometer (MERIS), and Moderate Imaging Spectrometer (MODIS) (Vittek, et al. 2014) with aim to create global land cover database for various global applications.

However, the low spatial resolution of this land cover database causes high uncertainty to observe dynamic on a local scale. Therefore, it is required to analyze with appropriate methods for particular study areas with an acceptable accuracy assessment using field surveys (Hames and Al-Ahmadi, 2008, Lu, et al. 2004). Instead of using high distribution low-resolution data sources on a local scale, Landsat images (moderate resolution) have been used in this study to overcome the sparse information and uncertainty in the classification.

Change detection is an efficient method in order to monitor the interactions and impacts of land cover between human to geography over various periods of time (Fichera1 et al., 2012, Vittek, et al. 2014). This research aims to implement a method to detect land cover change from 2004 to 2015 in the Nakon Nayok province of Thailand. This approach will extract five major types of land cover using remote sensing methods (unsupervised, supervised classification with maximum likelihood method and Image differencing) and field survey data in order to track down the change dynamics over this 10-year period.

MATERIALS AND METHODOLOGY

A. Study Area

Nakhon Nayok province is located in the central part of Thailand at latitude 14.20 degrees and longitude 101.21 degrees. This study focuses on the total area of the Nakhon Nayok province, which has an area of 2122 sq. km (Figure 01). The southern part of the province is the prolongation of Dong Phaya Yen mountain range and northern part is in Sankamphaeng Range, with the elevation 1292 meters. The Khao Yai National Park covers most of the area of this

province, the central part of the province is rather flat which is formed by the Nakhon Nayok River, which is the main river of the province.

B. Landsat data

Clear, Cloud free Landsat TM and Landsat 8OLI images were collected from the United States Geological Survey (USGS) Global Visualization Viewer (GloVis) website (Table1). All images were converted to Universal Transverse Mercator (UTM) projection zone 47. The Landsat 5 TM and Landsat 8 OLI images are acquired in six spectral bands with a spatial resolution of 30 x 30 m (and a TM thermal band at 120 m and OLI band 1,8 ,9,10 and 11 has not been used in this study) and a revisiting period of 16 days.

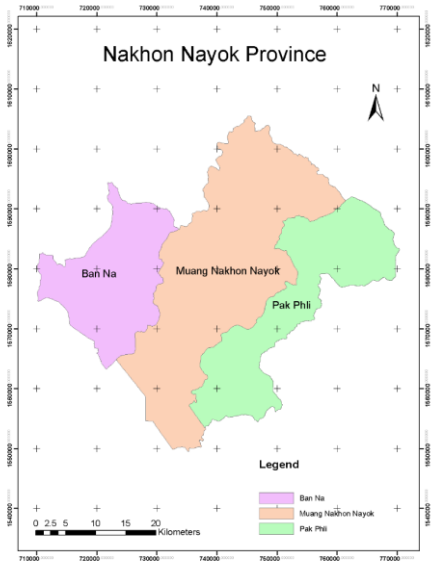

Figure 1: Map of Nakhon Nayok study area

Table 1. Landsat 5 TM and Landsat 8 OLI specifications:

ID	Date of Acquisition	Satellite/ Sensor	Reference system/Path/Row
1	21/11/2004	Landsat 5 TM	WRS -2 /129/50
2	20/01/2015	Landsat 8 OLI	WRS -2 /129/50

C. Methodology

I. Image preprocessing

Based on the selected Landsat imagery over the study area, a series of pre-processing has to be performed prior to the classification and change detection procedure. These pre-processing include the radiometric and atmospheric calibration (Bruce et al., 2004, Rokni et al., 2014). The radiometric correction consisted in changing the 8 Bit digital values of Landsat 5 TM and 16 Bit digital value of Landsat 8 OLI into radiance and reflectance values (Chander et al., 2009, USGS, 2015). The atmospheric correction was performed to remove/ reduce the negative effect caused by the atmosphere (such as scattering absorption by aerosol and water vapors). The Dark Object Subtraction (DOS) method was used for atmospheric correction; it is a simple and widely used image-based method (Chavez, 1988).

II. Training sites

The land cover classification scheme was based on a classification system developed by the Land Development Department (LDD), Thailand. According to LDD land use / cover classification system, the land use and land cover classified as water, bare soil, urban area, agricultural and forest. The unsupervised classifications (ISO data or K-means) were carried out prior to field survey in order to determine the strata for ground truth. The field survey was performed out to collect geolocations information for training and validating landuse/ cover interpretation from Landsat images of 2015. The ground control data were collected using stratified random sampling method (Musa et al., 2003). The target validation points were limited to areas accessible by roads. This constrain was necessary in order to reduce filed survey time. However, collecting ground control points from all those random locations is practically impossible. Therefore, a modification has been made especially areas which are far from the road. In total 23 random ground-control points were collected and the rest was obtained using google earth. The survey was conducted in collaboration with experts from the Royal Forest Department (RFD), Thailand.

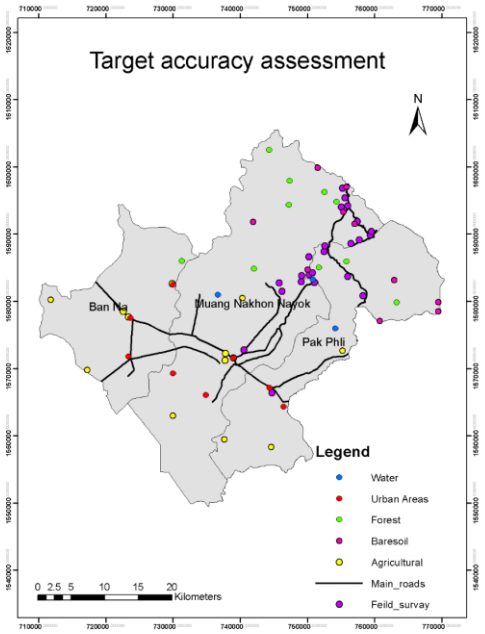

Figure 2. Target accuracy assessment points

III. Land cover classification and change detection

Our classification scheme, with five classes, was based on the land cover and land use classification developed by LDD for interpretation of remote sensor data at various scales and resolutions. A reflective spectral band from 2004 and 2015 was used for classification (Table 01). Combined unsupervised- supervised approach was used for clustering. Two dated Landsat images over Nakhon Nayok regions were

compared using supervised classification technique. In order to obtain automatic image classification, at the locations where ground control points were collected (training data via field survey) same locations were chosen to create areas of interest (AOI). Once training sites were determined using unsupervised classification and geolocations by field survey/AOI, maximum likelihood algorithm was used for performing supervised classification (Bauer et al., 1994). The maximum likelihood algorithm is one of the most widely used algorithms for supervised classification (Wu et al., 2002, McIveret al., 2002, Mengistu et al., 2007 , Reis, 2008).

Three standard criteria were used to assess the accuracy of the supervised classification images: (1) The User accuracy was defined as the proportion of the correctly classified pixels in a class to the total pixels that were classified in that class. It indicates the probability that a classified pixel actually represents that category in reality (Diallo et al., 2009, Rogan, 2002); (2) The overall accuracy was defined as the total number of correctly classified pixels divided by the total number of reference pixels (total number of sample points) (Rogan et al. 2002); and (3) The Kappa coefficient was defined as a statistical measure of accuracy that ranges between 0 and 1. It measures how much better classification is as compared to randomly assign class values to each pixel (Diallo et al., 2009). The Kappa coefficient is the proportion of agreement between observed and predated class from the classifier (Furkuo and Frimpong, 2012).

Results and Discussion

A. Changes in Land cover (2004 -2015)

Figure 3(a) and (b) shows land cover maps in 2004 and 2015. The overall area in each particular land cover class of individual year is shown in Figure 4(a) and (b) as km^2 and a percentage of the distribution. During the periods considered, the agriculture and forestland constituted the most extensive type of land cover in the study area. They accounted for about 48 and 38 % in 2004, and 42 and 39 % in 2015 respectively. This is followed by urban land occupying 3 to 11 % of the total area respectively for the above-mentioned periods.

In 2004 and 2015 however, the forest and urban areas increased to about 1 and 8% of the total area while agricultural and water areas decreased 6 and 3 % respectively. The area of bare land slightly increased in 2015. The average rates of change are summarized in Figure 4 (a) and (b). The area change of water, agricultural, urban, bare soil and forest over the period 2004-2015 was identified to be 60.88, 92.94, -131.26, -3.13, and -19.47 km^2 respectively (the positive values indicate a decrease in area and negative values an increase in the area).

B. Accuracy assessment

Accuracy assessment was performed by using confusion matrix ground truth sampling (Figure 2). Data in Table 2 show that the classification in 2015 has achieved satisfactory accuracies; the obtained overall accuracy, followed by the kappa statistics is 72.72% and 0.6626 respectively. In 2015 the agricultural and urban areas were characterised by the lowest accuracy; this is because some pixels were misclassified as urban areas.

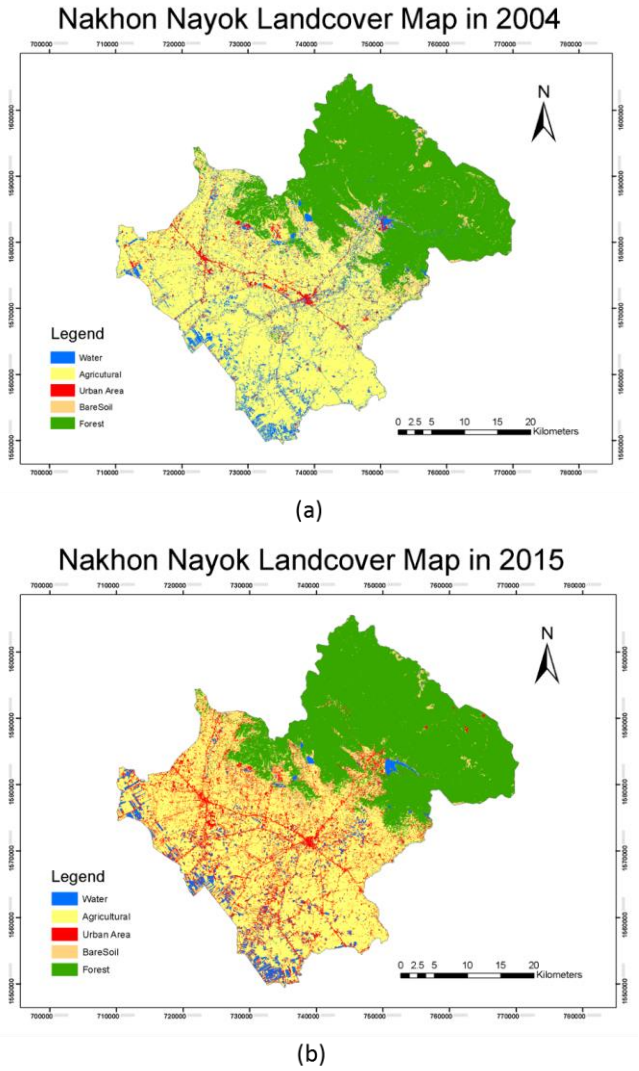

Figure 3. Land cover maps in 2004 (a) and 2015(b)

C. Land cover change from 2004 – 2015 (Discussion)

The accuracies of classification turned out to be better than expected. The good overall accuracies can be explained by the fact that the total number of correctly classified pixels was high. The land cover classes were correctly selected. The precision of the classification might have been different if other land cover types had been classified separately (Shrimp farm, irrigated and non-irrigated agriculture). The lower accuracy results obtained from urban and agricultural areas could be explained by the fact that some agricultural areas were misclassified as urban areas and vice-versa. This indicates that the spectral signature of agricultural and urban areas is quite similar in satellite imagery. However, most of the classes had quit high accuracy scores.

The Landsat TM and OLI satellite based analysis reveals some interesting trends in Nakhon Nayok province as regards

to the land cover developed over the period 2004- 2015. Table 3 shows the loss, gain and net change of each land cover area distribution. It is clear that from 2004 to 2015, urban areas, bare soil and forest areas have been characterized by positive changes (increasing) in area while water and agricultural areas have been the subject of negative changes (reduced). The expansion of urban areas is mainly due to the decrease in agricultural and water areas. Some of the areas covered with agricultural land and water have shifted to urban /building areas. In other words, additional pressures have been placed to expanding urban area and increased the food demand. However, the prime food and water sources (agriculture and water) were lost. A better scenario can be forecast by studying the socio economic condition of the study area. As a result, better government policies can be created in order to sustainable use of existing natural resources and aim to encourage the rural development.

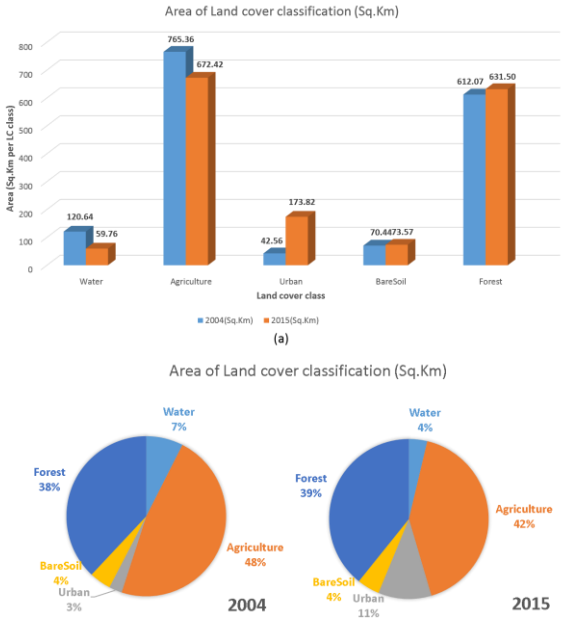

Figure 4. Areas of class distribution in 2004 and 2015 in square kilometers (a) and percentage of the distribution (b)

Table 2. Land cover accuracy assessment

Land cover class	Producers Accuracy (%)	Users Accuracy (%)
Water	100	100
Baresoil	100	90.91
Agricultural	42.86	75
Urban Areas	75	50
Forest	100	90.91
Overall Accuracy = 72.72%		
Kappa Coefficient = 0.6626		

Table 3. Land cover dynamic from 2004 to 2015 (percentage)

Land cover class	Water	Agriculture	Urban	BareSoil	Forest
Water	21.38	4.00	3.90	1.17	0.15
Agriculture	39.95	75.16	30.02	35.90	1.79
Urban	30.49	13.35	62.19	7.97	0.45
BareSoil	3.31	5.81	3.54	27.61	0.68
Forest	4.88	1.69	0.35	27.35	96.93
Class Total	100.00	100.00	100.00	100.00	100.00
Class Changes	78.62	24.84	37.81	72.39	3.07
Image Difference	-50.46	-12.14	308.46	4.44	3.17

Conclusions

The Landsat satellite imagery based change detection analysis has provided an interesting account of the situation in the study area over the period 2004 -2015. Drivers of land cover change were identified to be strongly influenced by changes in agricultural area, which themselves were identified to be influenced by infrastructure and urban development. The results of this study revealed that the conversion of agricultural areas intensified with urban development. The results also indicated that severe changes in land cover occurred in urban (308.46 %), water (-50.46), and agricultural (-12.14) areas. Least changes were observed in forest (3.17) areas. This paper highlights the importance of digital change detection in apprehending the agricultural production situation in Nakhon Nayok province. Further research should be carried out to help better understand about the variations in agricultural and urban areas across the province as well as the conversion and modification mechanisms of the above land cover types.

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Electricity and Water Supply Consumption and Green House Gas Emission at the Office of the Faculty of Science and Technology, Suan Sunandha Rajabhat University

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Abstract: This work was a data collection of electricity and water supply consumption of the Dean's Office of the Faculty of Science and Technology, Suan Sunandha Rajabhat University, Thailand. The greenhouse gas emissions from electricity and water supply consumptions were calculated using the up-to-date emission factor from the Thailand Greenhouse Gas Management Organization (TGO) database. In average, the office consumes 1.045 m^3/d and 87.9 kWh/d of water and electricity, respectively. This is equal to 68.5 Liter per person (11.25 L/m^2) and 4.1 kWh per person (0.6788 kWh /m^2) for the daily water supply and electricity consumptions, respectively. The total daily greenhouse gas emission from both electricity and water supply consumption is 59.01 kg-CO_2 eq. which is mainly came from the electricity consumption (≈ 98%). The average emission based on people and area are 2.566 kg-CO_2 eq per person and 0.422 kg-CO_2/m^2, respectively.

Keywords: Resources management, Electricity, Water supply, Green House Gases Emission

Introduction

Nowadays, global warming is a major problem in the world. This problem is even more intense due to the increase in resources consumption like electricity and water. These consumptions require a lot of natural resources and this results in a higher amount of greenhouse gases (GHGs) emissions. Therefore, it is necessary to collect the data from resources consumption and calculate the emission of greenhouse gases, for proper management of resources. The data can be used as a tool for the decision making process of the resources management and as a database to compare the emissions before and after management.

There were researches conducted to study the resources consumption and calculate the emission of GHGs. Aroonsrimorakot et al. (2013) collected the data and calculated the GHGs emission from the activities of Faculty of Environment and Resource Studies in Mahidol University, Salaya campus in the year 2010. The collected data include the consumption of water supply, electricity , paper usage , diesel , gasohol, chemicals and also the generating of solid waste and wastewater treatment. The results showed that the faculty generated 1,091.85 $MTCO_2e$ (Metric Ton Carbondioxide Equivalent). The major GHGs emission came from the electricity consumption as it accounted to 80% of the total GHGs emisison. Another research by Chalfoun (2014) studied the management of the saving energy from 9 buildings of the University of Arizona. The research focused on the result after the improvement of inefficient windows, installation of external insulation, shading of critical building elements, energy-saving light fixtures, and envelope solar reflectance in summer. The results showed that before starting project all buildings with total area of 1,081,512 ft^2 consumed an annual average 70.2 KBtu/ft^2 (221.59 kWh/m^2) at the cost of $2,186,264 per year. After the improvement, the energy consumption was decreased with the average of 61.42 KBtu/ft^2 (193.76 kWh/m^2) annually. The decrease was calculated by 12.5% and a the reduction of 2915 metric tons of CO_2 equivalent emission. Another research by Aroonsrimorakot (2015) collected the data of resources consumption from several offices that attended the green office program from the period of June 2014 to October 2014 based on the capital average and area average. The results from the research were then used to compare the results of this work.

The faculty of science and technology, Suan Sunandha Rajabhat University is divided into 4 divisions namely: Office of the Dean, Department of Science, Department of Applied Science, and Science Center. The dean's office contains 23 employees (16 officers and 7 administrative staff) with the total area of 140 m^2. The office has attended the Green Office program since 2014 and received the silver medal for the year 2014. The office is continuously improving its green office management by collecting the data of resources consumption like electricity and water supply. The collected data have been used in the study of estimating the GHGs emissions from office. The purpose of this research is to collect and to analyze the data as a decision tool for the improvement of the office's management of resources consumption and GHGs emissions which is a part of Green Office program. The objectives of this work were to calculate the total amount of electricity and water supply consumption and estimate the emission of greenhouse gases as a result of these consumption.The comparison between the data for the year 2014 and 2015 was analyzed using statistics.

Material and Methods

The data of electricity and water supply consumption were manually collected from the period of 29th August 2014 to 30th March 2015. The date of 29th August 2014 (11:00 AM , GMT +7) was set as a reference time and the next time of data collection were subtracted by the data of the reference time.

The dates and time which the datum was collected would be converted to Julian Date (JD) to find the difference of the data between the time of collection. The JD were used to normalize the data to the exactly required time before the statistical comparison.

The reference time (29th August 2014, 11:00 AM GMT +7) was converted to the JD of 2456898.654. At that time, the meter of the water supply and electricity showed the value of 21.038 m^3 and 1369 unit of electricity (kWatt-hour or kWh), respectively. The following week from the reference time, the data were collected at 5th September 2014 (11:15 AM, GMT +7) and this was converted to the JD of 2456905.664. At this time, the meter showed 32.804 m^3 and 2081 kWh for the water supply and electricity, respectively. The difference in the time was 2456905.664 – 2456898.654 = 7.010 day and that week consumed 32.804 – 21.038 = 11.766 m^3 (for the water) and 2081 – 1369 = 712 kWh (for the electricity) and these actual data were plotted in the Fig.1. The data were normalized to the exact 7.000 day in each week for the analysis part (Fig. 2) and the first week gave 11.749 m^3 (for the water) and 710.942 kWh (for the electricity).

The average consumptions rate (per day) were investigated and compared with the data with the existing literature. The GHGs emissions from the consumption of electricity and water supply were calculated by multiplying the consumption with the emission factor from the Thailand Greenhouse gas management Organization (TGO)'s database. The emission factors are 0.6093 kg-CO2 eq / kWh and 0.7043 kg-CO2 eq / m^3 for the consumption of electricity and water supply, respectively (TGO, 2014).

The data from the date 29th Aug to 28th Nov 2014 was selected as the representation of data in 2014 (semester 1/2014) which contains 13 weeks. The date 5th Jan to 30th Mar 2015 was selected as the representation of data in 2015 (semester 2/2014) which contains 12 weeks. The data in December was not included in this analysis due to the end of semester. During semester break, the resources consumption is less than normal period.

The descriptive and inferential statistics of the data were analyzed using SPSS version 20 to compare the weekly data from 2014 – 2015. The following hypothesis were used for calculating both resources consumption and GHGs emisison.

$$H_o : \mu_{2014} = \mu_{2015}$$
$$H_1 : \mu_{2014} \neq \mu_{2015}$$

Results and Discussion

Analysis of cumulative resources' consumption

The results of cumulative consumption of water supply and electricity are shown in Fig. 1

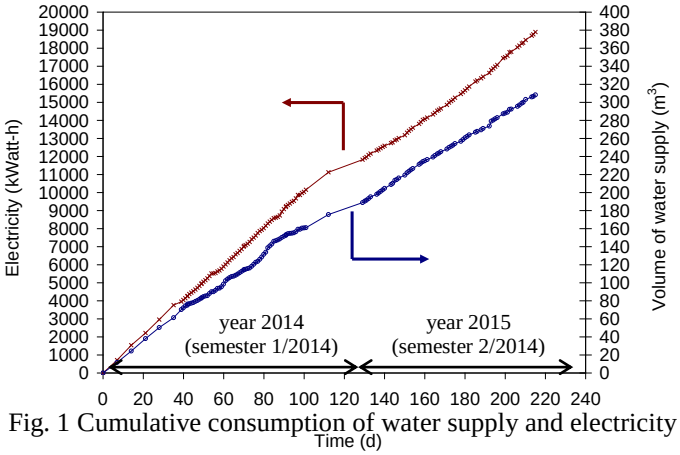

Fig. 1 Cumulative consumption of water supply and electricity

Figure 1 shows that within 213 days of data collection, the water and electric consumption of the Dean's office is 306.6051 m^3 and 18,768.3 kWh, respectively. The mean resource usage of water consumption was calculated as 1.045 m^3 per day. On the other hand, the mean resource usage of electricity was 87.9 kWh per day.

The results in Figure 1 are summarized in Table 1

Table 1. Mean usage of water supply and electricity consumption

Parameter	Water supply	Electricity
average's mean usage	1.575 m^3/d	95.0 kWh/d
maximum of average's mean usage	1.816 m^3/d	109.7 kWh/d
minimum of average's mean usage	1.425 m^3/d	86.6 kWh/d

It can be inferred from the table that the dean's office daily consumes water supply and electricity about 68.5 Liter per person ($1.575 \times 1000 \div 23 = 68.5$ L ca^{-1} d^{-1}) and 4.1 kWh per person ($95.0 \div 23 = 4.1$ kWh ca^{-1} d^{-1}) respectively. In the total area point of view, the office daily consume around 11.25 Liter per square meter ($1.575 \times 1000 \div 140 = 11.25$ L m^{-2} d^{-1}) and 0.6788 kWh per square meter ($95.0 \div 140 = 0.6788$ kWh m^{-2} d^{-1}) for the water supply and electricity, respectively. The result suggests that the resources' consumption of the office of the dean is quite lower than the average consumption in several other offices based on people average however it is quite higher than the average consumption in several other offices based on area average. The comparison of the resources consumption in other several offices are summarized in Table 2.

Analysis of weekly resources' consumption

The data from the Fig. 1 was used to calculate the weekly consumption of the resources. The results of such calculations are shown as Fig. 2.

Table 2. The average daily resources consumption

The office of / Source	Water supply ($L\ ca^{-1}\ d^{-1}$)	Water supply ($L\ m^{-2}\ d^{-1}$)	Electricity ($kWh\ ca^{-1}\ d^{-1}$)	Electricity ($kWh\ m^{-2}\ d^{-1}$)	Reference [1]
Bangchak Petroleum Public Co.,Ltd.	197.69	17.24	4.05	0.354	Aroonsrimorakot, 2015
Bank for Agriculture and Agricultural Cooperatives, Bang Khen Headquarters	110.53	3.77	10.40	0.355	Aroonsrimorakot, 2015
Denso (Thailand) Co., Ltd.	68.45	54.44	0.83	0.658	Aroonsrimorakot, 2015
Denso (Thailand) Co., Ltd., Wellgrow Plant	14.11	2.46	10.43	1.839	Aroonsrimorakot, 2015
Department of Environmental Quality Promotion	92.62	1.52	7.38	0.121	Aroonsrimorakot, 2015
Electricity Generating Authority of Thailand (EGAT)	99.97	5.03	6.63	0.335	Aroonsrimorakot, 2015
Electricity Generating Public Co., Ltd.	222.80	2.61	24.65	0.283	Aroonsrimorakot, 2015
Fuji Xerox (Thailand) Co., Ltd.	No data	No data	6.52	0.744	Aroonsrimorakot, 2015
Honda Automobile (Thailand) Co.,Ltd	105.73	19.89	4.48	0.843	Aroonsrimorakot, 2015
Honda Automobiles - Training Center	208.16	75.43	22.88	8.282	Aroonsrimorakot, 2015
Koh Kha Sub District Municipality	57.07	2.46	2.98	0.131	Aroonsrimorakot, 2015
Mae Fah Luang Foundation	8.54	3.12	0.88	0.326	Aroonsrimorakot, 2015
Mueang Phon Town Municipality	36.97	2.67	0.18	0.013	Aroonsrimorakot, 2015
Office of the dean, Faculty of Science & Tech., SSRU [2]	68.50 (*7/18*) [3]	11.25 (*12/16*)	4.1 (*8/20*)	0.679 (*15/19*)	This work
PEA[4] at Ban Bang Mun Nak District, Phichit Province	145.35	0.66	5.81	0.027	Aroonsrimorakot, 2015
PEA at Buriram Province	69.91	0.48	3.02	0.022	Aroonsrimorakot, 2015
Si Sa Ket Town Municipality	149.84	No data	8.86	No data	Aroonsrimorakot, 2015
Thai Onono Public Co.,Ltd.	94.89	No data	4.28	No data	Aroonsrimorakot, 2015
Toyota Motor Thailand Co.,Ltd. (Ban Pho Plant)	8.79	0.14	1.90	0.030	Aroonsrimorakot, 2015
University of Arizona (focus only 9 buildings) before the implementation of energy saving program	–	–	No data	0.607	Chalfoun, 2014
University of Arizona (focus only 9 buildings) after the implementation of energy saving program	–	–	No data	0.531	Chalfoun, 2014
Water usage of 13 rural communities of northeast Thailand	10 – 90	No data	–	–	Frankel and Shouvanavirakul, 1973
Electricity consumption of Thailand in 2012	–	–	6.53	No data	EPPO [5] , 2013

[1] The data of the resources consumption from Aroonsrimorakot (2015) were collected from the period of June 2014 to October 2014.
[2] Suan Sunandha Rajabhat University
[3] The number in the blanket is the rank of resource consumption saver compared to the offices or the data sources used in the prioritization
e.g. *1/18* mean the office has the lowest resource consumption compared to the other 18 data sources in the same column that used in the prioritization
e.g. *18/18* mean the office has the highest resource consumption compared to the other 18 data sources in the same column that used in the prioritization
[4] Provincial Electricity Authority
[5] The Energy Policy and Planning Office of Thailand

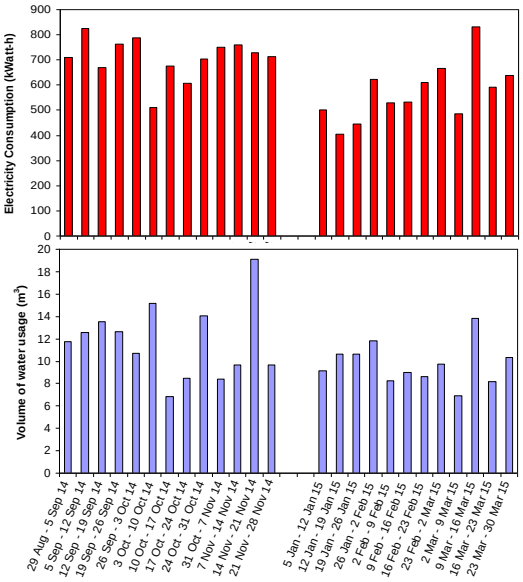

Figure 2. Weekly consumption of water supply and electricity

The inferential statistics were used to analyze the data in Fig. 2 using SPSS version 20 and display in Tables 3 and 4

Table 3. Statistical data of weekly water supply consumption

Parameter		All data	Data of 2014	Data of 2015
Number of week		25	13	12
Average (m^3/week)		10.7836	11.7404	9.7474
SD (m^3/week)		2.8391	3.3054	1.84798
minimum (m^3)		6.8597	6.8597	6.9110
maximum (m^3)		19.1310	19.1310	13.8020
C.I. of 95% (t-Dist) in m^3	lower	9.6117	9.9257	8.8024
	upper	11.9556	13.5620	10.7864

According to Shapiro-Wilk's test of normality, the distribution of two data groups (year 2014 & 2015) in water supply consumption is within the normal curves of normality. It has a confidential interval of 95%. This is because the observed significances are 0.787 and 0.771 for years 2014 and 2015, respectively, which are greater than 0.05. The findings imply that t-test can be used for the testing of hypothesis. The Levene's test was conducted before the analysis of t-test to elucidate the equity of variances. It was found that the groups of data have the same variances (for the C.I. of 95%) with significances of 0.090 which is higher than the reference value (0.05). The two-tailed analysis of t-test was then conducted and found a significance of 0.079 which exceed the reference value (0.05). This inferred that null hypothesis (H_o) is accepted. This could be interpreted that there is no difference between the average of weekly water supply consumption in year 2014 and 2015 ($\mu_{\text{water consumption, 2015}} = \mu_{\text{water consumption, 2014}}$).

Table 4. Statistical data of weekly electricity consumption

Parameter		All data	Data of 2014	Data of 2015
Number of week		25	13	12
Average (kWh/week)		642.6	708.0	571.7
SD (kWh/week)		119.0	81.1	114.8
minimum (kWh)		405.6	511.6	405.6
maximum (kWh)		832.6	824.2	832.6
C.I. of 95% (t-Dist) in kWh	lower	593.4	661.7	510. 6
	upper	691.7	745.6	639.1

It could be implied from the Shapiro-Wilk's test of normality for the electricity consumption that the distribution of the both groups of data (years 2014 and 2015) are within the normal curves with the confidential interval of 95%. This is due to the significances are 0.294 and 0.652 for years 2014 and 2015, respectively, which are greater than 0.05. This finding implies that t-test could be used for the testing of hypothesis. The Levene's test was conducted before the analysis of t-test to elucidate the equity of variances. It was found that both groups of data have the same variances (for the C.I. of 95%) with significances of 0.220 which is higher than the reference value (0.05). The two-tailed analysis of t-test was then performed and found a significance of 0.002 which is lower than the reference value (0.05). This infers that alternative hypothesis (H_1) is accepted which could be interpreted that there is a difference between the average of weekly water supply consumption in year 2014 and 2015. According to the Table 4, it can be noticed that the lower bound of μ_{2014} (661.7 kWh) is higher than the upper bound of μ_{2015} (639.1 kWh). This means that electricity consumption of year 2015 is lower than that of year 2015 ($\mu_{\text{electricity consumption, 2015}} < \mu_{\text{electricity consumption, 2014}}$). The calculated reduction was about 19.25%. The possible reason that affects the decrease of electricity consumption might be due to the campaign of the faculty about the green office program in which the saving electricity consumption was included.

Calculation of Green House Gases emissions

The cumulative of GHGs emissions from the consumption of electricity and water supply were displayed in Fig. 3.

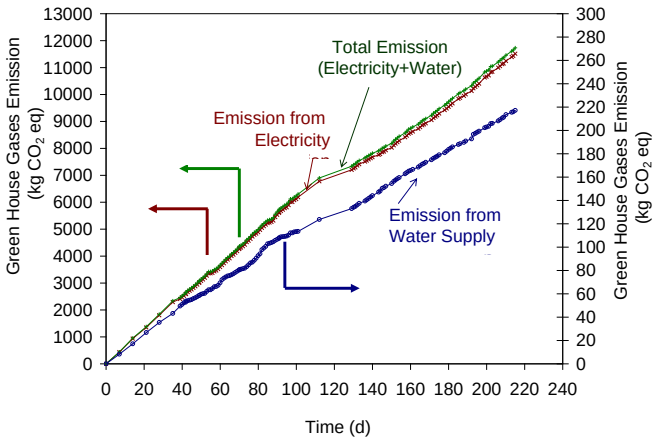

Figure 3. Cumulative Greenhouse gases emissions

During the days of data collection, figure 3 shows that the Office of The Dean emitted an equivalent greenhouse gases of 217.2 kg-CO_2 eq (kilogram of carbon dioxide equivalent) from water supply consumption and 11,514.5 kg-CO_2 eq from electricity consumption. The total emission from both consumptions is 11,731.7 kg-CO_2 eq. Majority of emission came from the electricity consumption which is about 98.1% whilst the water consumption shared the minority emission of 1.9%. This finding was consistent with the previous study of Aroonsrimorakot and co-worker in 2013 that states the GHGs emission mainly came from the electrical consumption.

The mean of the emissions for each day were determined using the slope of the curves. There are 136 data for each type of emissions in the Fig. 1 which were used for determination of the slope. This leads to the mean emissions per day for each type of emissions. The results are summarized in Table 5.

Table 5. Mean of the green house gases emissions in kg-CO_2 eq per day

Parameter	Water supply	Electricity	Total
average's mean emission	1.109 (1.9%)	57.90 (98.1%)	59.01 (100%)
minimum of average's mean emission	1.003	52.74	53.75
maximum of average's mean emission	1.279	66.82	68.04

It could be inferred from the table that each person in the office consume an average of 2.566 kg-CO_2 eq per day and on the basis of area average the office consume 0.422 kg-CO_2 eq per square meter per day.

The comparison of the GHGs emission in several offices is summarized in Table 6. The values of the GHGs average emission in the table were calculated by multiplying the resources consumption rate in Table 2 with the specific emission factor of each resources consumption of TGO (2014) displayed in the section of Material and Methods. The results of the comparison between GHGs emitters gave the same pattern as those of the comparison between resources consumers. When compared to several other offices, the Office of the Dean's GHG emission based on people average is quite low. On the other hand, its GHG emission based on area average is quite high. It is interesting to note that the ranks of GHGs emission saver of the dean's office are the same. However, there are exceptions in the column of area based GHGs emission from the electricity consumption . The rank is lower than that of area based electricity consumption. The possible reason for this is the different emission factors which were applied to the offices in Thai and to the building in the university of Arizona.

Analysis of weekly Green House Gases emissions

The data from the Fig. 3 were selected to calculate the weekly consumption of the resources in the same manner as the section of weekly resources' consumption analysis and the results were displayed as Fig. 4

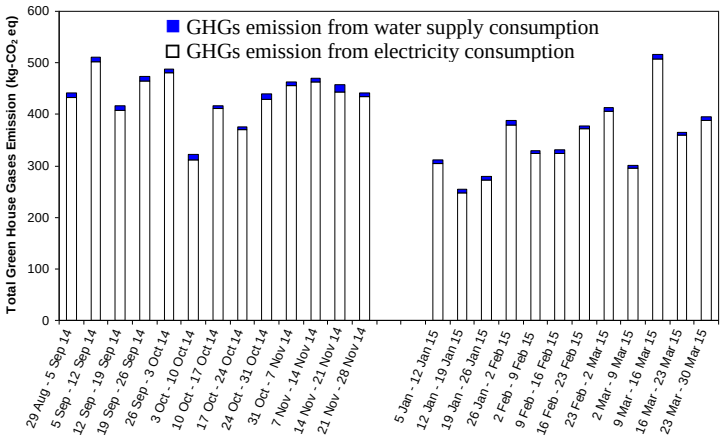

Figure 4. Weekly emissions of greenhouse Gases

The whole stacks represent the total emission while the clear and dark parts of the stacks represent the emission from electricity and water supply consumption, respectively. It could be observed from the figure that the minority emission came from the water supply consumption with the minimum of 1.16% and a maximum of 3.31% and an average of 1.94%.

The analysis of inferential statistics was achieved by the same manner of the previous section. It is interesting to note that the results of the emissions from electricity and water supply consumptions is the same as the previous section in which the emission from the water consumption had an equity between the emission of 2014 and 2015 ($\mu_{\text{water's GHGs 2015}} = \mu_{\text{water's GHGs 2014}}$). The emission from the electrical consumption of 2015 is greater than that of 2014 ($\mu_{\text{electricity's GHGs 2015}} < \mu_{\text{electricity's GHGs 2014}}$). This is because the GHGs emission data were generated from multiplying the emission factor to the data of resources consumption which was no effect in the results of hypotheses testing.

The total emission as a result of the combination effect of electricity and water supply consumptions was analyzed. The statistical data were shown in the Table 7.

Table 7. Statistical data of weekly total green house gases emission

Parameter		All data	Data of 2014	Data of 2015
Number of week		25	13	12
Average (kg-CO_2 eq /week)		369.5	439.6	355.2
SD (kg-CO_2 eq /week)		127.6	49.27	70.66
minimum (kg-CO_2 eq)		254.6	322.4	254.6
maximum (kg-CO_2 eq)		517.0	511.0	517.0
C.I. of 95% (t-Dist) in kg-CO_2 eq	lower	368.9	411.4	316.9
	upper	429.3	463.9	399.9

Table 6. The greenhouse gases emission of each resource consumption.

The office of / Source	Water supply ($kg\text{-}CO_2$ eq ca^{-1} d^{-1})	Water supply ($kg\text{-}CO_2$ eq m^{-2} d^{-1})	Electricity ($kg\text{-}CO_2$ eq ca^{-1} d^{-1})	Electricity ($kg\text{-}CO_2$ eq m^{-2} d^{-1})	Reference [1]
Bangchak Petroleum Public Co.,Ltd.	0.139	0.0121	2.47	0.216	Aroonsrimorakot, 2015
Bank for Agriculture and Agricultural Cooperatives, Bang Khen Headquarters	0.078	0.0027	6.34	0.216	Aroonsrimorakot, 2015
Denso (Thailand) Co., Ltd.	0.048	0.0383	0.50	0.401	Aroonsrimorakot, 2015
Denso (Thailand) Co., Ltd., Wellgrow Plant	0.010	0.0017	6.36	1.120	Aroonsrimorakot, 2015
Department of Environmental Quality Promotion	0.065	0.0011	4.50	0.074	Aroonsrimorakot, 2015
Electricity Generating Authority of Thailand (EGAT)	0.070	0.0035	4.04	0.204	Aroonsrimorakot, 2015
Electricity Generating Public Co., Ltd.	0.157	0.0018	15.02	0.173	Aroonsrimorakot, 2015
Fuji Xerox (Thailand) Co., Ltd.	No data	No data	3.98	0.453	Aroonsrimorakot, 2015
Honda Automobile (Thailand) Co.,Ltd	0.074	0.0140	2.73	0.514	Aroonsrimorakot, 2015
Honda Automobiles - Training Center	0.147	0.0531	13.94	5.046	Aroonsrimorakot, 2015
Koh Kha Sub District Municipality	0.040	0.0017	1.82	0.080	Aroonsrimorakot, 2015
Mae Fah Luang Foundation	0.060	0.0022	0.54	0.198	Aroonsrimorakot, 2015
Mueang Phon Town Municipality	0.026	0.0019	0.11	0.008	Aroonsrimorakot, 2015
Office of the dean, Faculty of Science & Tech., SSRU [2]	0.0482 (*7/18*) [3]	0.0079(*12/16*)	2.50 (*8/20*)	0.414 (*13/19*)	This work
PEA[4] at Ban Bang Mun Nak District, Phichit Province	0.102	0.0005	3.54	0.016	Aroonsrimorakot, 2015
PEA at Buriram Province	0.049	0.0003	1.84	0.013	Aroonsrimorakot, 2015
Si Sa Ket Town Municipality	0.106	No data	5.40	No data	Aroonsrimorakot, 2015
Thai Onono Public Co.,Ltd.	0.067	No data	2.61	No data	Aroonsrimorakot, 2015
Toyota Motor Thailand Co.,Ltd. (Ban Pho Plant)	0.006	0.0001	1.16	0.018	Aroonsrimorakot, 2015
University of Arizona (focus only 9 buildings) before the implementation of energy saving program	–	–	No data	0.633 [5]	Chalfoun, 2014
University of Arizona (focus only 9 buildings) after the implementation of energy saving program	–	–	No data	0.554 [5]	Chalfoun, 2014
Electricity consumption of Thailand in 2012	–	–	3.98	No data	EPPO [6] , 2013

[1] The data of GHGs emissions from Aroonsrimorakot (2015) were not taken directly from that work but they were calculated by multiplying the emission factor from TGO (which are 0.7043 kg-CO_2 eq / m^3 for water supply and 0.6093 kg-CO_2 eq / kWh for electricity) (TGO, 2014) with the resources consumptions data in the literature of Aroonsrimorakot (2015).

[2] Suan Sunandha Rajabhat University

[3] The number in the blanket is the rank of GHGs emissions saver compared to the offices or the data sources used in the prioritization
e.g. *1/18* mean the office has the lowest GHGs emissions compared to the other 18 data sources in the same column that used in the prioritization
e.g. *18/18* mean the office has the highest GHGs emissions compared to the other 18 data sources in the same column that used in the prioritization

[4] Provincial Electricity Authority

[5] These values were calculated based on the emission factor stated in the literature of Chalfoun (2014) (which is 1.043262451 kgCO_2eq / kWh)

[6] The Energy Policy and Planning Office of Thailand

The data in the table were analyzed by inferential statistics by the same manner as the section of weekly resources' consumption analysis

The results suggest that the two groups of the data (2014 and 2015) have a normal distribution which can be further used for t-test analysis. The testing of variances indicates that the two groups of data have the same variance. The testing hypotheses using t-test inferred a difference between the average of weekly water supply consumption in year 2014 and 2015. This means that, the total GHGs emission of 2015 is lesser than that of 2014 ($\mu_{\text{total GHGs 2015}} < \mu_{\text{total GHGs 2014}}$).

This is because the electricity consumption plays a major role in the GHGs emission (approx. 98%), thus reducing electricity consumption resulted in the significant decrease of total GHGs emission.

Conclusions

In this study the resources consumption (electricity and water supply) and their GHGs emission were evaluated. Both descriptive and inferential statistics showed that the all data of resources consumption have a normal distribution and same variance. The water consumption has not been changed in 2014 and 2015. On the other hand, the results of the study showed that electrical consumption had decreased significantly in 2015 compared to the year 2014 and this resulted in the decreasing of total GHGs in 2015. The findings of this study can be as a reference for sustainable management of resources in other organizations, e.g. green office project.

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The Health Effects of Computer Use on Personnel at the Suan Sunandha Rajabhat University

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Abstract: This survey research aimed to find the health effects of computer use on Suan Sunandha Rajabhat University's personnel. A total of 312 samples were selected out of 1401 population by simple random method. Inferential statistics were used throughout the hypothesis testing and data analysis (percentage, mean and standard deviation). The correlation between risk factors and computer-used behavior were calculated by Pearson correlation and Creamer's V coefficient (95% CI). The results indicated that the samples spend 6-10 hours of the workday on the computer. In order to create a good working environment, the organization has provided good computing facilities. The overview of computer-used behavior suggests that the personnel have regular good practice, i.e. 5 - 6 times per week. The research result found that the most of personnel have a regular eyestrain, eye fatigue, sore eyes and irritation symptoms at least 5-6 times per week. In addition, the personnel have regular neck, shoulder, back, waist and wrist pain symptoms at least 3-4 times per week. The result indicated that the computer user's behavior and user's health status related to each other, and were in the same way. In conclusion, the academic staff requires the basic computer usage knowledge in order to avoid future health problems.

Keywords: Health Effects, Health Disorder, Computer-used behavior, Office Syndrome, Computer Syndrome.

Introduction

Nowadays, computer is one of the main tools used in education institutes and other business sectors. On the one hand, the computer use has made life easy, but on the other hand has negative effects on human health. The extent of using a computer can cause injury to body muscles such as eyestrain, neck and shoulder pain, back pain, lumbar pain, finger numbness and locking. This may result in accumulation of injuries that goes unnoticed over a long period. The severity of the symptom depends on the physical condition and self-health care of individual computer users (Manop, 2014).

This research aimed to survey the health effects of computer use on personnel at the Suan Sunandha Rajabhat University. The research question based on the premise that computer use affects the health status of people. The result of this study will be useful to create awareness of the side effects of computer use on the physical health of the user. In addition, to avoid illness, the coordination will require between employees and agency owners to stipulate the correct computer-used behavior (e.g. Computer use, Placement of computer equipment, and Physical exercise during work) (Department of Health Ministry of Public Health, 2014).

Methodology

A. Sampling method:

In this research, a simple random sampling method was used for defining the samples from Suan Sunandha Rajabhat University staff. The samples were composed of 143 academic instructors and 169 academic supporting staff. These samples were calculated using the formula defined in Yamane, 1973.

B. Data Tools:

The questionnaire consists of four factors:

1) Bio-social factor (table 1).
2) The leading factor: Includes computer use knowledge (table 3) and attitude (table 4).
3) The contributing factor: Includes computer equipment (table 5) and working environment (table 6).
4) The reinforcing factor: Include advice from experts or social media (table 7).

In addition, the questionnaire also consists of the computer-used behavior (table 8) and the health status of computer user (table 2).

C. Data Collection:

The data collection was achieved using following four steps

1) Contact the head of department and request data collection
2) Describe the objective of the research and questionnaire

3) Distribution and follow up of the questionnaire
4) Checking the integrity of the answers.

If any questionnaires were found missing, then new random sample were selected.

D. Data Analysis:

The data were analyzed using a computer software package SPSS. Statistics were used (frequency distribution, percentage, mean and standard deviation) to analyze data and the relationship between, 1) The risk factors and computer-used behavior, 2) The health status of computer user and computer-used behavior by Pearson correlation and Cramer's V coefficient. (Figure 1)

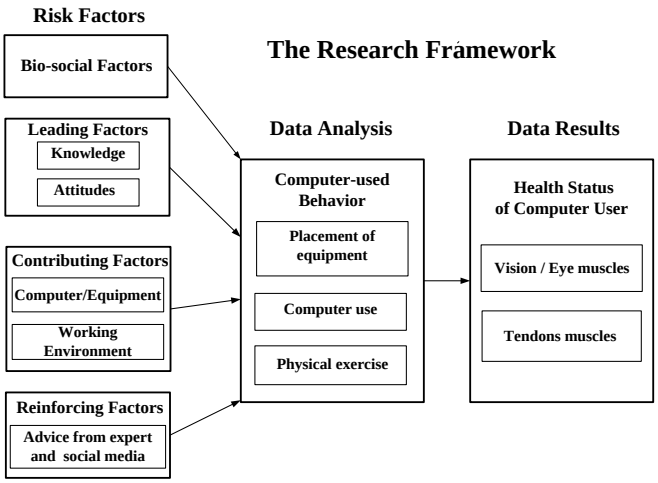

Fig.1. The Research Framework for data analysis

E. Quality Control:

The quality control has been tested using following two steps:

1) In order to establish the content validity, the three experts were then asked to evaluate the index of consistency (IOC). If IOC was less than 0.005, then the questions were adjusted to the experts advice.

2) In order to establish the reliability, we have chosen 39 people (samples) from the Ministry of Education with similar working life style. The reliability has been determined using Cronbach's alpha-coefficient; the obtained reliability value was 0.9297.

Results

After complete analysis the obtained results are as follows:

1) The Bio-social factor of the samples showed in table 1.

Table 1. The Bio-social Factors

Number	Category	Frequency	Percentage
1	Gender		
	Male	141	45.2
	Female	171	54.8
2	Age		
	< = 30 years	174	55.6
	> 31 years	138	44.4
3	Education Level		
	Bachelor	178	57.2
	Master	118	37.9
	Doctoral	16	4.9
4	Position		
	Instructor	169	54.2
	Supporter	143	45.8
5	Starting used age		
	> 12 years	67	21.5
	13-20 years	185	59.3
	21-30 years	47	15.1
	31-40 years	7	2.2
	41-50 years	6	1.9
6	Used Hours		
	< 2 hrs / day	16	5.2
	3-5 hrs / day	120	38.6
	6-10 hrs / day	141	45.2
	11-15 hrs / day	25	8.1
	> 15 hrs / day	10	2.9

2) The SPSS 17 software were used to analyze the collected response from 312 samples. The demographic information showed that the most of the samples had the health related computer syndrome (computer vision syndrome, carpal tunnel syndrome, and musculoskeletal disorders).

Specific considerations showed that the samples have vision sickness and tendon muscles 5-6 times per week and 3-4 times per week respectively (Table 2).

Table 2. Health status of computer user

Health Status	Level of Symptoms		
	$\bar{X}$	S.D.	Results
1. Vision	3.47	0.7544	5-6 times per week
2. Tendon Muscles	3.37	0.7721	3-4 times per week
Overview	3.410	0.7065	5-6 times per week

3) The leading factors showed that the 64.1 percent of the samples have high level of knowledge in computer usage.

Specific considerations showed that the most of samples have high level of knowledge for practice in computer use as well as the health impact of excessive computer use (Table 3).

Table 3. Level of computer use knowledge

Knowledge Type	Level of Opinion		
	low	moderate	high
1.Practice in computer use	19.3%	10.9%	79.8%
2.Health impacts from excessive computer use	15.1%	19.2%	65.7%
Overview	4.5%	31.4%	64.1%

4) The samples had a very high positive attitudes towards computer usage.

Specific considerations of computer use attitudes showed that the samples have high awareness of computer use as well as the knowledge of avoiding the health impacts from excessive computer use (Table 4).

Table 4. Level of computer use attitudes

Attitudes Type	Level of Opinion		
	$\bar{x}$	S.D.	Results
1. Creating best practice in computer use	4.21	0.5399	highest
2. Avoiding health impacts from excessive computer use	4.08	0.5713	high
Overview	4.14	0.5114	high

5) The contributing factor showed that the overview of providing computer equipment was at a high level (Table 5).

Table 5. The contributing factor: Computer Equipment

Factors	Level of Opinion		
	$\bar{x}$	S.D.	Results
Ergonomic equipment	3.74	0.8049	high
Connection of equipment	3.81	0.9234	high
Internet Connection	3.72	0.8423	high
LCD/LED Screen	3.85	0.8071	high
Adjustable Monitor	3.77	0.8892	high
Light-Protect Equipment	3.67	1.0101	high
Standard Keyboard	3.85	0.8796	high
Comfortable Mouse	3.88	0.8413	high
Mouse Pad	3.41	1.2049	moderate
Cradle Document	3.32	1.2282	moderate
Overview	3.66	0.645	high

Specific considerations showed that every factor was at a high level. First, quantity of work, followed by temperature & light, and place of work (Table 6).

Table 6. The contributing factors: Work environment

Work Environment	Level of Opinion		
	$\bar{x}$	S.D.	Results
1. Quantity of work	3.91	0.6877	high
2. Place of work	3.66	0.6450	high
3. Temperature and Light	3.78	0.6387	high
Overview	3.75	0.5349	high

6) The reinforcing factor is nothing but the advice of computer use from experts or social media. In the overview, the samples were guided for computer use about twice a month.

Specific considerations showed that receiving information via internet is the first ,other media (newspaper, radio & TV) second , and from colleagues last priority (Table 7).

Table 7. The reinforcing factors: Advice for computer use

Advice from expert and social media	Level of Guide		
	$\bar{x}$	S.D.	Results
1. Families	3.12	1.1479	2 times a month
2. Colleagues	3.33	0.9989	2 times a month
3. Doctors	2.63	1.227	2 times a month
4. Newspaper, TV & Radio	3.35	1.0274	2 times a month
5. Internet	3.36	1.0277	2 times a month
Overview	3.21	0.7919	2 times a month

7) An overview of computer-used behavior showed that the samples practiced computer use 5-6 times per week.

Specific considerations showed that samples give high priority to the placement of computer equipment, second priority for computer use and last priority for the physical exercise during the operation period (Table 8).

Table 8. Computer-used behavior

Behavior Type	Level of Practice		
	$\bar{x}$	S.D.	Results
1. Placement of Equipment	3.88	0.6734	5-6 times/week
2. Practice of computer use	3.75	0.6088	5-6 times/week
3. Physical exercise during work	3.47	0.7838	5-6 times/week
Overview	3.72	0.5643	5-6 times/week

8) The relationship between any risk factors and computer-used behavior showed that the knowledge, starting age and computer use hours per day related to computer-used behavior in a low level of relation and the same way. ($r = 0.120, 0.216, 0.168$, and p-value= 0.034, 0.000, 0.010)

The computer usage attitude, used computer equipment,

working environment and the advice from experts or social media related to the computer-used behavior in a moderate level of relation and the same way. (r = 0.411, 0.475 , 0.580, 0.439, and p-value = . 0.000, 0.000, 0.000, 0.000) (Table 9)

Table 9. Relation between risk factors and computer-used behavior

Risk Factors / Behavior	Correlation Analysis		
	r	p-value	Level of Correlation
1. Knowledge	0.120*	0.034	low & same way
2. Attitudes	0.411**	0.000	moderate & same way
3. Computer Equipment	0.475**	0.000	moderate & same way
4. Work Environment	0.580**	0.000	moderate & same way
5. Advice from Sources	0.439**	0.000	moderate & same way
6. Starting Age	0.216**	0.000	low & same way
7. Hour of use	0.168**	0.010	low & same way

** Sig. Level .01
* Sig. Level .05

9) The relationship between health status of computer user and computer-used behavior showed that the health-side effect of vision and tendon muscles related to computer-used behavior in a low level of relation and the same way. (r = .212, .225, .181, and p-value = .000, .000, .000) (Table 10)

Table 10. Relation between computer user's health status and behavior

Side Effect	Level of Correlation		
	r	p-value	Results
1. Vision	0.225**	0.000	low & same way
2. Tendon Muscles	0.181**	0.000	low & same way
Overview	0.212**	0.000	low & same way

** Sig. Level .01

These results can conclude as follows:

1. Computer use can cause vision syndrome and tendon muscles to staff. The staff often have headache, eye muscles, neck / shoulder, wrist / finger, back, and waist pain 3-4 times per week, The effect of computer use is more on vision than tendon muscles.

2. The most of the staff started using a computer at the age of 13-20, so the injuries are accumulating continuously. The daily computer use of personnel is 6-10 hours, so the prolong use of a computer may lead to future disorder or computer related health issues.

3. The most staff possesses good knowledge and attitude of computer use. The staff had a high level of satisfaction in their workplace's computer equipment and working environment .

4. The major factors related to the staff's health behaviour are the working environment, the computer equipment, the advice from an expert and social media, and the computer usage attitude.

5. The minor factors related to the staff's health behavior are the starting age of computer use, duration of computer use, and computer usage knowledge.

6. The computer use have significant side effect (vision and tendon muscles) on staff's health behavior.

The results are according to the hypothesis of this research.

Discussions

From research question: Does prolonged computer use have impact on computer users? How much duration of computer use can affect computer users? The answers are listed in Table 11.

Table 11. The results of computer usage's side effect researches

Author,Year & Country	Population & hours work / day	Symptom	Suggestion
This study (2015) **Thailand**	312 Academic staff (6-10 hrs.)	Eye strain Muscle pain	Share computer manual Adjust to best practice Break & exercise
Anusit (2015) **Thailand**	Judiciary staff	Stress Disorder Eye strain Muscle pain	Use ergonomic work chair Break & exercise
Akinbinu et al. (2013) **Nigeria**	100 Security & Exchange staff (6-8 hrs.)	CVS	Regular break Blinking/Checking Eyes Use glare screen
Zheng et al. (2007) **China**	3 Clinical cases (5-8 hrs.)	Eye strain Neck/Back pain Headache	Adjust Screen & Light Warm eyelid massage Adjust sitting position
Ellahi et al. (2011) **Pakistan**	120 employees & students (> 4 hrs.)	MD* Stress disorders CVS, CTS**	Safe & Comfortable Computer Workplace Provide Job Training

* MD = Musculoskeletal disorders ***CTS = Carpal Tunnel Syndrome
** CVS = Computer Vision Syndrome

Table 11 shows the comparison of current research results with similar research in other parts of the world. The eyestrain is very commonly syndrome in every career around the world. The duration of prolonged computer usage is more than four hours per day. The most suggestions are daily supplementary break and physical exercise, which can minimize the risk of computer syndrome.

Conclusions

From this research, there seems to be a connection between health problems from computer use, especially on health conditions in terms of vision and tendon muscles. From many

researchers have found that working for a long time with limited motion, fixed focal distance vision, and formed muscle tension incessantly are the main cause of computer syndrome, which is composite of Eyestrain, Pain syndromes, Local inflammations & Compression syndromes (Sudoa, 2015).

The Health and Safety Regulation 1992 (4) of United Kingdom suggests that "Should provide workers a break before their body have severe fatigue, not waiting until body shows signs of fatigue then having a break for recovery". Therefore, we should use these finding and suggestion to reduce some risk of the health effects from computer usage. The organization should create "Workplace Wellness" for good health behavior of their employees, and the computer users should provide the appropriate break time for relaxing and reducing illness.

The suggestion of this research as follows:

1. The entity should provide a manual detailing the correct method in computer use for the employees and train them in ways to use ergonomic methods. Consequently, computer users should adjust their behavior, posture and work patterns in a proper way during their working hours to reduce illness. The suggestion is corresponding to Zheng Yan and Ellahi in table 11 (Zheng Yan, 2007; Ellahi, 2011).

2. The entity should define time for a break and make a campaign to exercise in every two working hours; it means to relax body muscles. The suggestion is corresponding to Anusit & Akinbinu in table 11(Anusit, 2015; Akinbinu, 2013).

For reducing eyestrain, previous studies had an additional suggestion to adjust the light of the computer screen and warm eyelid massage (Zheng et al., 2007), besides checking eyes regularly (Akinbinu, 2013).

The suggestion for the next research as follow:

1.To study the developing potential risk to staff who use computer in their work.

2. To promote personnel participation with the university by studying their health effects from computer use and behaviour, with consideration of the body, mind, and society.

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Assessment of Human's Attitude Towards Natural Resource Conservation in Protected Area in Thailand

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Abstract: Attitude of residing people towards a protected forest area was evaluated for sustainable use of natural resources and forest conservation in the Phu Kao–PhuPhan Kham National Park in Thailand. Their economic and social conditions were assessed in three villages of Phukao, NongBua Lamphu Province. Data were collected from 348 households (66.5%) heads or the representatives in the villages with the questionnaire. The questionnaire consisted of three parts: (i) general economic and social information (ii) social grouping and participation and (iii) attitude toward participation in conserving natural resources and tourism management in this area. To evaluate their attitude, the collected data were divided into four categories: (i) level 4 equilibrium/nature (ii) level 3 warning (iii) level 2 risk (iv) level 1 crisis for forest conservation in the protected area. Overall, their attitude towards natural resource conservation, the social grouping and the community participation was very low. However, the attitude towards ecotourism is very high. We suggest that forest conservation will be maintained by more progress of ecotourism in this area.

Keywords: Human Altitude, Natural Resources, Sustainable Management, National park, conservation

Introduction

Increasing of urbanization and population growth are important factors in the increasing of food demands (Rosegrant & Cline, 2003). For this reason, agricultural activities have been wildly spread. Forest clearing for cultivation and changing in agricultural practices; such as intensification techniques, irrigation canal, grazing, residual management and drainage all affect the natural environment system. Additionally, the modernized agricultural techniques, such as mold broad plow, motorized tractors, hybrid cultivars, inorganic fertilizers and pesticides, can cause severe effects on biodiversity in forests(Mackenzie et al, 2012; Olupot et al, 2009). Besides, in tropical forests, even in protected area have been partially disturbed by the anthropogenic intrusion (Ellis et al, 2010; Fashing et al, 2004). Conservation policies tend to move the communities out by applying law enforcement. Nevertheless, many local people continue to harvest forest products from protected areas by boundary encroachment and poaching. The rapid expansion of existing community in protected areas can cause anthropogenic forest fragmentation and forest resources harvesting for livelihood needs can also impacted forest structure and soil erosion (Pimentel et al, 1995). Even small human settlements in rural areas can exert an ecological impact on a much larger area, according to Andrew Hansen, Director of the Landscape Biodiversity Lab at Montana State University in Bozeman, USA (Hunter, 2007). "The effect of rural homes on native species population dynamics can be felt tens to hundreds of kilometers away".

To reduce the effect of environmental degradation is an important issue for natural forest conservation. However, Thailand government is not yet fully successful to conserve the protected forests in national parks. The local communities are still residing in the protected area in Phu kao – Phu PhanKham National park in Thailand. The people in the national park are highly dependent on forest ecosystem for its diverse and abundant natural, wildlife, land, food and water resources. The importance of these resources has caused indigenous people to diverse way of managing them sustainably. Attitude of residing people in the national park towards forest conservation is critical

for reducing the effect of forest degradation. Attitudes toward the staff of protected area and the perceptions of management practices also affect the attitude of residing people (Allendorf, 2007; Takon et al, 2013). For example, conflicts with park rangers due to resource extraction, too strict rules on forest resources use and rude behavior, such as harassment by park rangers, generate negative attitudes for local people toward the protected areas (Allendorf, 2007; Takon et al, 2013).

We have examined the attitude towards forest conservation of the people residing within this protected area (Fig. 1).

Materials and Methods/ Methodology

Study Area

This study was carried out at the Phu Koa area (PK), a part of Phu Kao -Phu Phan Kham National Park located in its upper northeastern plateau. It is comprised of 318.36 square kilometer located between latitudes 16° 44' - 17° 2' N and longitudes 102° 25'- 102°43'E in the Nong Bua Lam Phu Province, lying between the south of UdonThani Province and the north of KhonKaen Province, Thailand. PK Mountain Range consists of two parallel lines of mountains. The outer line is steeper and higher ranging from 446.6 to 580.0 m above the sea level (asl), while the inner line is lower with 313.3 m to 380.00 m asl. There are nine peaks in this range, namely Phu Fang, Phu KhumPun, Phu Han, Phu KoMo, Phu Chan, Phu Phro, Phu Luak, Phu Wat and Phu Moei. Phu Moei (580 m asl) is the highest peak among them. In PK, three village communities have been established in its central plain of PK, DongBak, WangMon and ChaiMongkala villages. Three communities existence in the central of this protected area are spread more quickly within last 20 years.

These communities spread very quickly within the last 20 years causing the severe forest fragmentation and degradation over the plain (Fig. 2).

The Royal Thai Forestry Department (RFD) had tried to expel the village inhabitants from this protected forest. There had been several times of conflicts between the RFD and the village inhabitants. However, the RFD was not fully successful for expelling the inhabitants. After these disputes, the RFD had announced the boundary lines for these communities so that the forest beyond the boundaries is protected from human developments. To stop the severely degradation of this area, the protected forest was designated as the 50th national park of Thailand in September 20, 1985.

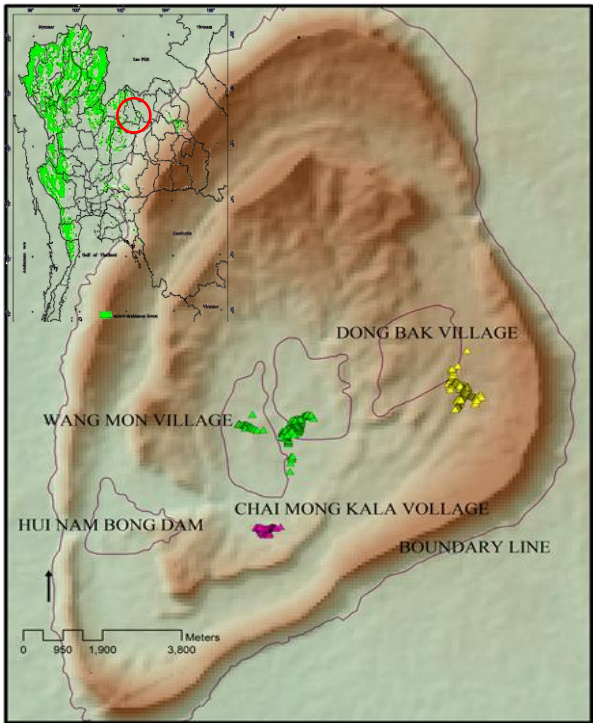

Figure 1. Study area and the boundary line between communities and forest area in PK. Green pink and yellow show the location of each household in three villages by GPS.
Source: The digital figure of land use in the study site is from the Land Development Department in Thailand, and the map of Thailand is from the Wildlife and Plant Conservation Department of the National Parks in Thailand , 2011.

Figure 2. The severe forest fragmentation and degradation of cassava and rubber.

Data Collection and Analysis

The data were collected from communities, aerial photographs, documents provided by government offices and field survey. We organized community meetings (Fig. 3). The aerial photographs were used to distinguish the agricultural and residential areas. The documents were provided by the Agriculture Office of NongBua LamPhu and KhokMuang Subdistrict Administration Organization, Non Sung District, NongBua LamPhu Province. A field survey was carried out to locate the geographical coordinates of every household with GPS Garmin 60Csx, Garmin, Olathe, KS, USA. From the GPS data, a map illustrated the locations was drawn with the help of Geographical Information System (ArcGIS 10.2.2, Environmental Systems Research Institute, Redlands, CA. USA) as shown in Fig. 1.

Figure 3. Communities participation and questionnaire survey in August 2014.

Three legally-settled villages in the PK were used in this study. The data were collected from 543 household heads or representatives of the three villages through meetings supported by the Office of Phu Kao-Phu PhanKham National Park and KhokMuang Subdistrict Administration Organization, NonSung District, NongBua LamPhu Province. However, only 348 household heads or 66.5% of the total could attend the meetings because some of them worked in another province or due to other reasons. During the meetings, a questionnaire was distributed for them to fill out.

The questionnaire had three parts (1) general economic and social information, (2) analysis of social grouping and participation and (3) analysis of attitude towards participation in conserving natural resources and tourism management in the area. The data were assessed according to the criteria shown in Table 1.

Table 1. Assessment Criteria for Attitudes towards Participation in Conserving Natural Resources and Tourism Management.

Index	Reason
Behavior of forest utilization	
	-Community reliance on forest reduces natural resources, affecting management of natural resources and watershed.
(1) little pass	
(2) much not pass	
Role in conserving natural resources in the area	
	- Cooperation between the government sector and communities can lead to sustainable management.
(1) community's responsibility pass	
(2) government's responsibility not pass	
Participation in tourism management in the area	
	- Both the government sector's insight into and agreement to the management reduce conflicts of management in the protected area.
(1) required pass	
(2) not required not pass	
Attitudes towards area management	
	- Community awareness that conservation is its responsibility enables the community to protect and manage natural resources in the area.
(1) good awareness pass	
(2) little awareness not pass	

The scores obtained from the criteria were totaled and compared with those in Table 2.

Table 2. Scores Indicating States of Area

State	Total score	State score
Balance/Nature	91-100	4
Warning	71- 91	3
Risk	51- 70	2
Crisis	<51	1

According to Table 3, the scores revealing the state were compared with the scores of the state of the environment systems divided into four levels:

(1) Nature – high diversity. Each component is abundant and functions normally.

(2) Warning –disturbance to component and/or function with fast recovery

(3) Risk – disturbance on component and/or function with longer period recovery and/or displacement of some components

(4) Crisis – disturbance to endangered and/or extinction species component also inactive or without function

Results and Discussions

Economy and social aspects

Presently, there are 215 households with 901 residents in WangMon village, 85 households with 335 residents in Chai Mongkol village, and 223 households with 830 residents in DongBak village, with the total of 523 households with 2,066 residents. The aerial photographs show the land use for residential and agriculture classification as shown in Table 3.

Table 3. Data about Economic and Social Aspects

The Basic data		*%*
Description		
Number of household	523	100.0
Number of respondents	348	66.5
Education	*Elementary*	83.1
Migration	*Other provinces*	55.1
	Congenital here	44.5
Resident period	31 to 40 years	85.7
Number of people in household	1-5 people	69.5
Occupation	*Farming*	74.7
Household income	*100,000-200,000* (baht/month)	86.5
Debt	*yes*	88.8
savings account	*no*	72.4

Source: The data from field survey, 2014.

The area of 10,000 rai (1,600 ha) in PK is set aside for residential and agriculture and 3,677 rai (588.3 ha) for the construction of Huay Nam Bong Reservoir, a royal initiative project. Of the agricultural area, cassava is grown most, covering an area of 3,720 rai (595.2 ha). The sampled total population in the 3 villages is 348 villagers. Among the household heads, male is 56.9 % and female is 43.1 %. Most of them (household heads) are 41-50 years old (26.7 %), followed by those aged over 61 years old (23.0 %) and 20-30 years old (7.2 %). They practice Buddhism, and almost all of them (98.7%) do not want to relocate from the villages. For education, 83.1 % of them (household heads) finished elementary school and 3.7% of them did not receive any formal education.

Most residents (74.7%) grow field crops, followed by those who raise garden crops (12.1%). Only a few of them are civil servants, merchants or unemployed. For their economic conditions, most of them (72.4%) do not have savings, 27.6% have savings and 88.8% have debt. According to the interview, most of them obtain vehicles for rice field, chemical fertilizers and pesticides, while using loan.

Social grouping and community participation

Afforestation takes place regularly in this area, because of severe economic conditions. 72.1% of them have participated in forestry, such as acceleration of tree growth, while 27.9% have not yet participated.

The residents reside in the protected area or the boundary area, while some of them are rangers in the park. The rangers engage in the protection of forests and wildlife as a government official or in other agencies. However, almost all farmers do not participate in such activity. 61.5 % of all households have not yet participated in such training or meetings with government officials or private agencies, while 38.5% have participated in such training or meetings.

Lam Huay Bong is a major stream in PK, and they use water for drinking and for feeding the agricultural areas. 54.9 % of all households have participated in the campaign to protect this stream, while 45.1% have not yet participated in such activity.

Attitudes towards Participation in Conserving Natural Resources and Tourism Management

The forests in PK are a major food source for the residents in NonSung District and its environs. Both local residents and outsiders have used and collected forest products. As a result of forest used for a long time, forest degradation continues and forest products runs out. The abundance of valuable trees, such as *Payung* or Siamese Rosewood (*Dalbergia cochinchinensis*), decreases, because of illegal logging.74.7%of residents think that forest conservation is the rangers' responsibility while 62.4 % of agree that the government does not have enough budget for forest management. However, 18.4 % consider that the residents should furthermore participate in activities for conserving natural resources, and12.9 % believe that forest conservation is the responsibility of the residents.

The division between the national park and the community area will help to solve the issue of encroachment. More lectures will be presented to solve the conflict between rangers and residents and

to encourage co-existence between forest nature and communities. Although 41.1 % of residents agree with such division, 58.9% are not agree with the division.

PK has a high potential for eco-tourism, since many footprints of herbivore dinosaurs and a-million-year shellfish has been found. The Department of Geology, Ministry of Natural Resources and Environment make a plan to set up a museum in the community, displaying these exhibits. There are also natural sights for tourists. During the past two years, eco-tourism in this area has been flourished. 80.2 % of residents agree with the statement that this area should be promoted as a tourist attraction, and 62.4 % agree with the statement that a group should be set up to manage the tourism. 75.9 % think the needs of guide training for local young adolescent.

The natural resources in PK forests have been dwindling, because of the rapid growth of the communities during the past 20 years. 42.8 % of residents think that the shortage of land area for farming is the most important issue, and 84.9 % think that its the lack of water. 89.7 % feel that water for daily use is not enough especially during the dry season, and 61.8 % feel that water source in this area is in run-down.

Forest fires usually break out in the drought-deciduous forest during the dry season. In the present, forest arson is common to collect forest products. 46.6 % of residents think that forest fire is a serious problem in this area.

Attitudes towards community participation in conserving natural resources

We summarize the attitude of local people in relation to conservation of natural forest resources from the four aspects, as follows.

1) Behavior of forest utilization: 82.8 % (288 households) in the three villages take wood out of the protected forest area to make firewood and charcoal. Bamboo shoots, mushrooms, herbs, vegetables, and animals are also taken out. Only 17.2% of households do not collect forest products.
2) Role in conserving natural resources: 87.1 % (303 households) think that the conservation of natural resources is the responsibility of government, while 12.3% think that it is the responsibility of the community.
3) Participation in tourism management: 62.4 % (217households) desire tourism management. This will be a social potential in this area.
4) Attitude towards area management: 205 households (58.9 %) do not agree with the boundary dividing between the forest area and the residential area.

As a result, the criteria in attitude of local people are still low, except for 3) tourism management. Overall, the total score in their attitudes is 24.1, indicating that the attitude towards natural resource conservation, social grouping and community participation is still in the lowest level (crisis) in Table 3.

Conclusions

To conserve the natural forest and forest resources, the boundary lines between human areas and protected forests have been set in the national park. However, we are not yet successful in conserving the protected forests. Using a large amount of fertilizers and pesticides may induce irreversible disturbance to the natural habitats. Degradation of forest structure and function may cause soil erosion in this area. As agricultural land is degraded and abandon, more forests are cut and converted to newly agricultural land (Myers et al, 2000; Pimentel et al, 1995). Because the PK area is exposed to such great danger, the evaluation of the attitude of the resident is needed for forest conservation. Our results suggest that the importance of forest conservation need to be more instilled not only to adult generation but also the young generation, for sustainable use of forest resources and ecological service. Nevertheless, the attitude towards ecotourism is very high in the study area. Thus, we suggest that forest conservation must be potentially maintained and promote progress of eco-tourism in this area.

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Improving existing landslide hazard zonation map in KMC area, Sri Lanka

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Abstract: In Sri Lanka, presently used landslide hazard zonation (LHZ) map which was developed by National Building and Research Organization (NBRO) is based entirely on geological, geomorphological and hydrological factors. As development expands into unstable hill slope areas under the pressures of increasing population and urbanization, human activities such as deforestation or excavation of slopes for road cuts and building sites, etc., have become important triggers for landslide occurrence. The present study was undertaken in highly urbanized Kandy Municipal Council (KMC) area in Sri Lanka. Main objective of the study was to validate the existing LHZ map with current active landslides and the improvement of the LHZ map for further use for management purposes. Validation of the existing LHZ map shows lowest percentage of landslide occurrence in the landslides most likely to occur zone and highest in the landslides are to be expected zone. To evaluate this situation building density and transport lines were used. The relationship between building density and landslide occurrence was 97.1% and the relationship between distance from transport lines and landslide occurrence was 88.3% till 50 m. An improved LHZ map was developed including the effect of building density and distance from transport lines using frequency ratio method and improved LHZ map has an accuracy of 98.5%.

Keywords: Buildings, Hazards, Map, Landslide, Roads

Introduction

Landslide status in Sri Lanka

Landslides, as one of the major natural hazards, account each year for enormous property damage in terms of both direct and indirect costs. Landslides are defined as the movement of a mass of rock, debris or earth down a slope (Cruden, 1991). Most of the time landslides are aggravated by human activities as geological features hardly change with time compared to human activities. In Sri Lanka landslides have become a frequent major natural hazard in terms of both space and time. As a result landslides are attracting increasing attention in recent times. Landslides occur mainly in the hill country surrounded by mountain ranges. In the case of occurrences of landslides in Sri Lanka, ten major districts have been identified as Landslide prone areas. Those are Badulla, Nuwara-Eliya, Rathnapura, Kegalle, Kandy, Matale, Matara, Galle, Hambanthota and Kalutara. Over 12,500 km^2 of landslide prone areas are spread over these ten districts. It is about 20% of the total land area and is occupied by 30% of the total population of the country. Therefore, occurrence of frequent landslides and slope failures could be considered as the most significant natural disaster in Sri Lanka.

According to National Building Research Organization (NBRO) reports, torrential rain in November / December 2010 and January 2011 has caused 675 cases in six districts where a number of slope failures resulted in loss of lives and property.

Existing LHZ map

NBRO has created LHZ maps for most vulnerable areas for landslides in Sri Lanka. It is used to predict the zones that are susceptible for sliding during the rainy season incorporating rainfall intensity and duration**.** Here landslide hazard analysis focuses mainly on the spatial zoning of the hazard based on geomorphologic and hydrologic factors but not human induced features such as overloading slopes by new constructions associated with development programs, vibrations from heavy traffic and excavation or displacement of rocks etc. LHZ map was developed considering Slope angle, Overburden, Land use, Landforms, Geology and Hydrology. Under geology rock type, dip angle and direction, deviation angle, presence of faults, folds, joints were considered. Soil thickness was considered in overburden. Relative relief, drainage density, Basin area, Basin shape and proximity to water bodies were considered under hydrology. Shape and roughness was taken into account in landform. The basic data on these aspects has been gathered in 1995 from field surveys as well as from desk studies. This existing LHZ map is classified into five hazard zones as, Landslides not likely to occur, Modest level of landslide hazard exists, Landslides are to be expected, Landslides most likely to occur and not mapped area. The existing landslide hazard zonation map consider only the geomorphologic and hydrologic factors that are responsible for the landslide occurrence. But human pressure on earth also induces landslides. Validation refers to comparing predictions of a method with a real-world data set, for assessing its accuracy or predictive power (Begueria, 2006).

Motivation

The current situation of increase in landslide occurrence in the hill country, especially in highly urbanized areas not only endangers future sustainable living, but also puts the existing built environment at extreme risk. For more than two decades settlements in this area have experienced the catastrophe of landslides. In the past, Kandy did not suffer many landslides compared to other hilly areas of Sri lanka (such as Nuware eliya, Badulla, Hali-ela and Ratnapura) which experienced multitudes of continuous and serious landslide problems over so many years during rainny seasons. Latter stages of 2010 and beginning of 2011 in Sri Lanka, particularly Kandy experience a dramatic increase in landslide incidents and caused damage to infrastructure and human lives. Field surveys shows that most of these landslides occurred on cut slopes or on embankments alongside roads and highways in mountainous areas. Some of these landslides occurred near high-rise apartments and in residential areas, causing great threat to many people. So a logical reason for increased incidents would be due to the high pressure imposed by rapid urbanization. Landslides have been a common phenomenon in Kandy district and KMC area is more prone to landslides as human intervention has been taken place to the maximum in this area. Therefore recognition of landslide prone areas is becoming increasingly important in land use decisions. Zonation maps based on landslide studies resulting in hilly areas are an essential requirement nowadays for the development activities in many countries. This is because occurrence of landslides is a serious constraint to economic development, particularly in developing countries like Sri Lanka. The aim of this study is to identify anthropogenic causative factors responsible for the increased landslide incidents in the KMC area that could be used to improve the existing LHZ map. In order to achieve that, following objectives were chosen as to validate the existing landslide hazard zonation map by using active landslides in the study area, assess the effect of building density, distance from transport lines for the recurring incidence of landslides in this area and develop an improved landslide hazard zonation map including building density and distance to transport lines using frequency ratio method.

Methodology

Study area and data collection

Kandy Municipal Council (KMC) area was selected as the study area (Figure 01) which consists three divisional secretariat divisions. Those are Gangawatekorale with 42 GN divisions, Pathadumbara with 2 GN divisions and Harispaththuwa with 1 GN division.

The 1:10000 digital maps of building footprint and transport lines in Kandy municipal council area developed in 2010 (54-13, 54-14, 14-18, 14-19, 54-23, and 54 - 24: 1: 10 000 Map tiles named by Survey Department) were obtained from the Survey Department, Colombo, Sri Lanka and the presently used 1: 10 000 digital LHZ map (existing map) developed in 1995 was obtained from NBRO.

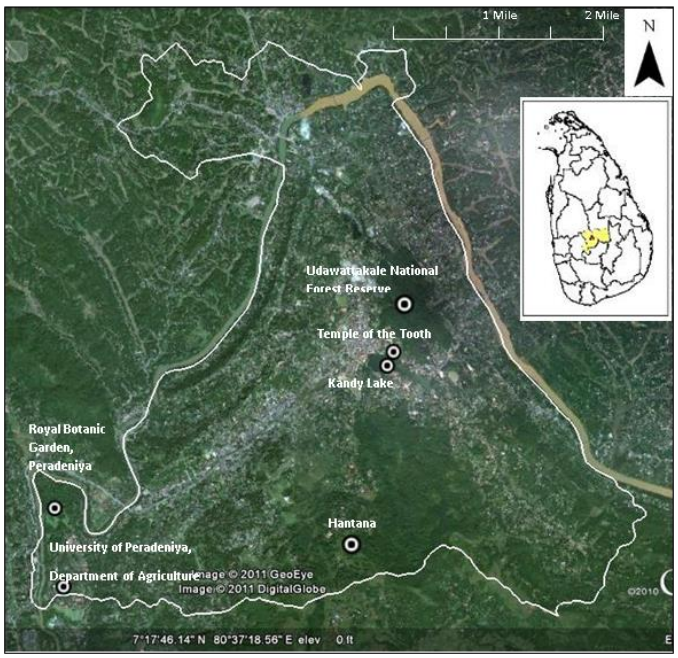

Figure 1. Study area

Locations of active landslide areas were identified from satellite images/Google earth software (2011–February), NBRO reports/field book and historic memory of neighborhood. The active landslide areas were marked on 1:10 000 scale base maps (Air Base Map Projection- Survey department) and GPS points were also taken at the site. The existing LHZ map has been classified into five hazard zones as, Landslides not likely to occur, Moderate level of landslide hazard exists, Landslides are to be expected, Landslides are most likely to occur and not mapped area (Figure 02).

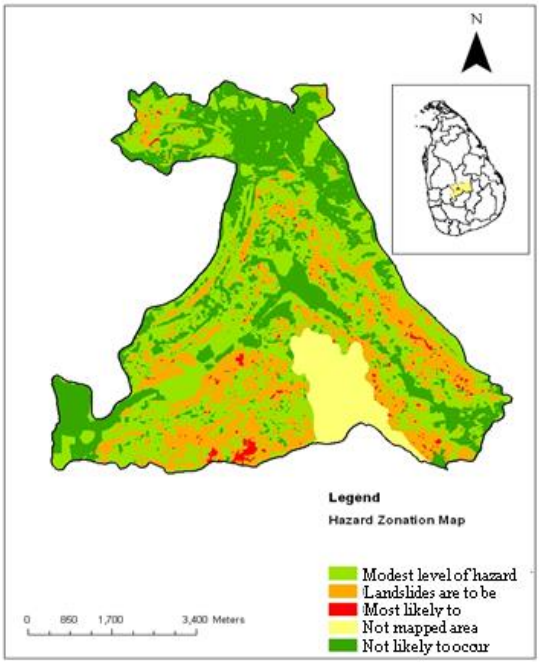

Figure 2. Existing LHZ map

Validation of existing LHZ map

Figure 03 shows the consecutive steps which were performed to validate the existing LHZ map. Using this data taken at each site, active landslide areas were digitized to develop the active landslide distribution map in 1: 10000 scale. The scale which was used here was same as in existing LHZ map. Validation of LHZ map was performed by comparing the known landslide location data with the landslide hazard map. The main step was data collection and construction of a spatial database. A key assumption of this approach is that the potential occurrence of landslides will be comparable with the actual distribution of landslides. Active Landslide distribution map (with 10m buffer) was used to validate the existing LHZ map. The landslide distribution map was superimposed on the existing LHZ map in GIS environment as Sarkar *et al* was done in, 2007.

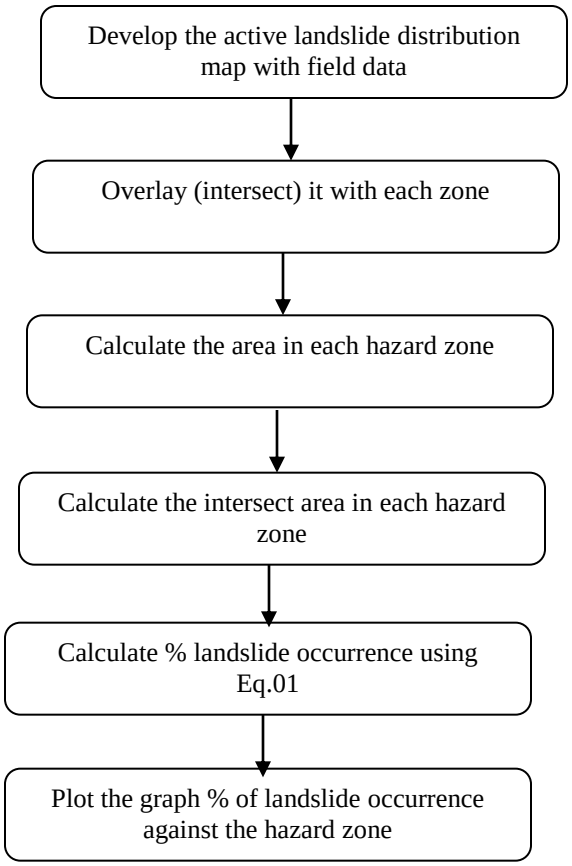

Figure 3. Validating procedure of existing LHZ map

Then calculated the intersect areas of each hazard zone and active landslide distribution to calculate the affected area under each hazard class (Eq.01). Percentage occurrence of landsides related to each hazard class was calculated and the graph of percentage landslide occurrence against the hazard zone was plotted.

Equation 01

$$Percentage\ Landslide\ Occurrence = \frac{Area\ that\ have been\ affected\ by\ landslides\ in\ the\ relevent\ hazard\ class}{Total\ area\ in\ the\ relevent\ hazard\ class} \times 100$$

Assess the effect of building density and distance from transport lines

The effect of building density and proximity to transport lines on occurrence of landslides was evaluated using the active landslide distribution map, building density map and transport lines map. Building density polygon map was classified into equal interval of five density classes. Building density classes were ranked as the highest rank (4) to the highest density class and lowest rank (0) to the lowest density class. Then calculated the total area under each density class and landslide affected areas in those density classes. Six zones were seperated as 0-10 meter, 10-20 meter, 20-30 meter, 30-40 meter, 40-50 meter, 50-60 meter from major transport lines. Then the area of these zones and the active landslide areas in each of these zones were calculated to get the percentage occurrence of landslides with proximity to major transport lines. The relationship between the causative factors and landslide occurance should be a positive linear relationship. Data on building density, proximity to major transport lines and percentage occurrence of landslides were used in linear regression analysis to get the relationship between these two criteria and occurance of landslides (Begueria, 2006).

Development of Improved LHZ map

Results of validating the existing LHZ map shows active landslides in the study area does not comply with the existing landslide hazard zones. So as the results show building density and distance from transport lines have a strong effect on landslide occurrence LHZ map.

Frequency Ratio value (Eq.02) for each factor's range was evaluated by the ratio of the area where landslides occurred (landslide-occurrence ratio) to the total study area for a given factor's attribute (area ratio) (Lee and Pradhan, 2006). The improved new hazard zonation map was classified according to expert knowledge (Gokceoglu and Aksoy, 1996; Van Westen *et al*., 1997; Binaghi *et al*., 1998; Barredol *et al*., 2000; David and Paul, 2000; Saha *et al*., 2002; Lan *et al*., 2004; Oztekin and Topal, 2005) into four zones (Barredol *et al*., 2000) as most hazardous, moderately hazardous, landslides not likely to happen and safe zone.
The improved LHZ map was also validated using the same method as for the existing LHZ map using active Landslide distribution map.

Equation 02

$$Frequency\ Ratio = \frac{Area\ of\ landslide\ with\ characteristic\ /\ Total\ landslide\ area}{Total\ area\ with\ characteristic\ /\ Total\ area}$$

Figure 04 shows the methodology of development of improved LHZ map.

Percentage occurrence of landsides related to each hazard class was calculated by using Equation 01 and was plotted the percentage landslide occurrence against the hazard zone. R^2 value of the linear regression was also considered in evaluating the prediction power of landslides.Units of Measurement: All measurements should follow the International System of Units (SI)

Results and Discussions

Validation of existing LHZ map

Table 01 represents the percentage landslide occurrence values. According to the results of validation of landslide hazard zonation map, the lowest percentage of landslide occurrence is in the landslides most likely to occur zone. Highest percentage of landslide occurrence is in the landslides are to be expected zone and the percentage of landslide occurrence has gradually decreased from Modest level of landslide hazard exists zone to landslides not likely to occur zones. The not mapped area also has a 0.34 of landslide occurrence percentage. As the landslides most likely to occur zone represents the highest hazard zone and it does not show the highest percentage of landslide occurrence. Figure 05 shows that highest hazard zone has the lowest percentage of landslide occurrence. Percentage landslide occurrence in other zones which represent fewer hazards has relatively high occurrence of landslides. This results show that the existing landslide hazard zonation map should be updated according to the present situation.

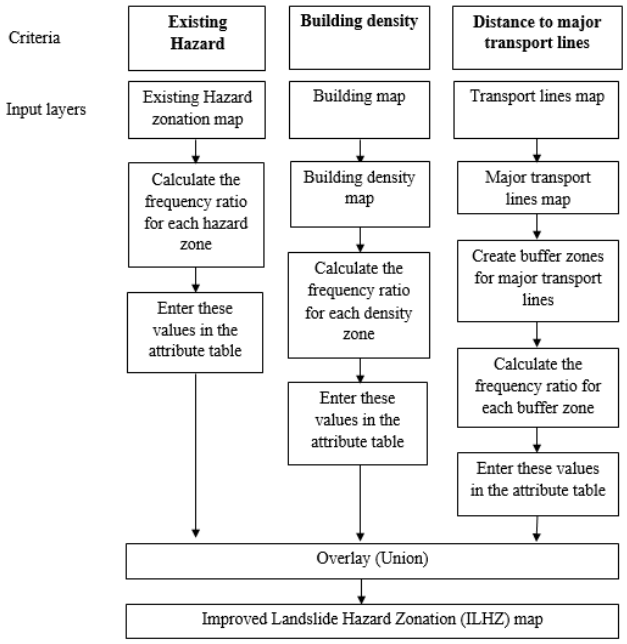

Figure 4. Flow diagram of development of ILHZ map in GIS

Table 1. Percentage landslide occurrence values

Hazard class	Area of Hazard (m^2)	Area of Landslide (m^2)	% landslide occurrence
Not mapped	3205883	11115	0.34
Landslides not likely to occur	11938243	23540	0.19
Modest level of landslide hazard exists	17267278	62104	0.36
Landslides are to be expected	9554851	48154	0.5
Landslides most likely to occur	461988	676	0.14

Assess the effect of building density and distance from transport lines

Table 02 shows with the increase in building density percentage landslide occurrence increases except for highest density class. It is because the highest building density is found in flat lands where landslides did not occur. The occurrence of landslides in most likely to occur area is the lowest because of the high degree of hazard identified at the early stages. As a result protective/mitigation measures have been implemented in these areas. Human settlements or development activities carried out is minimal due to the identification of high degree of hazard from landslides. So further sliding is under control in these human untouched areas, but the other areas have become more prone to landslides due to lack of attention given to protective measures and rapid development in those areas. As a result earlier safe areas now has been converted to vulnerable areas most probably due to high pressure imposed on earth by inappropriate human activities carried out in hilly areas. Table 03 shows percentage landslide occurrence decreases with the increased distance up to 50 meters from transport lines.

Table 2. Percentage landslide occurrence values in each building density class

Density	Area(m^2)	Landslide area(m^2)	Percentage (%)
0(lowest)	14034510	8641	0.061
1	12871084	8836	0.068
2	11257049	8560	0.076
3	3503700	3255	0.09
4(highest)	761900	0	0

Table 3. Percentage landslide occurrence values in each buffer zone

Distance from transport lines(m)	Active landslide area(m^2)	Total area(m^2)	% landslide occurrence
10	1405	2162530	0.064
20	1395	1993630	0.070
30	737	1855710	0.039
40	325	1721400	0.018
50	215	1591480	0.013
60	219	1490790	0.015
70	325	1428320	0.022

Development of Improved LHZ map

The improved landslide zonation map created based on frequency ratio method, integrating the effect of building density and major transport lines to the existing landslide hazard zonation map (Fig.04). Figure 05 shows that the percentage landslide occurrences in improved landslide zonation map have gradually increased from safe zone to landslides most likely to occur zone. This graph clearly shows that the percentage landslide occurrence has gradually increased as the hazard increases in the zones with highest percentage of landslide occurrence in landslides most likely to occur zone and lowest percentage of landslide occurrence in landslides are not likely to occur zone.

This study shows that the hilly urban areas where building density is moderately high, the landslide risk are high. It is because the slope properties have been modified due to over-urbanization, excessive earth works, natural drain blockages etc. Including the effect of building density and proximity to major transport constructions into the hazard zonation map will make the map more accurate as this study shows there is a significant relationship between those two factors and landslide occurrence in sloppy areas. In the existing hazard zonation map only 1.8 % of total land area was considered as most likely to occur, but after eleven years with the rapid development and human intervention it has increased to 16.6% of the total land area. This identification is very important because, unless proper corrective measures are taken, progressive slipping of earth will continue to take place. Landslides can become aggravated with time because the hill slopes has the potential to slide down when weakened by the absorption of rain water and from other human activities , such as cutting of slopes, denuding of slopes from vegetation and failing to provide adequate drainage conditions.

Regression analysis shows the prediction power of the improved landslide hazard zonation map is 98.5%.

Conclusions

Existing landslide hazard zonation (LHZ) map shows it should be revised according to the present situation. Population pressures and increasing urbanization in the KMC has influenced the increased landslide occurrences. Integrating the effect of building density and proximity to transport lines to the present landslide hazard zonation map increases the prediction power of landslide hazard zonation map. In the improved landslide hazard zonation map Landslides most likely to occur zone has been expanded and the Landslides not likely to occur zone has been shrunken. Improved LHZ map has an accuracy of 98.5%.

Recommendations

A maintained landslide inventory in landslide prone areas including location of the landslide, extent affected, damage caused etc. is important to update and validate the Land Slide hazard (LHZ) maps.

Improved LHZ map can be used to alert both the public and the authorities to the real danger posed by potential future landslides in KMC area or in particular, to highlight the threat posed to private dwellings and other buildings such as schools that lie on the path of potential landslides endangering life and property.

People do need protection for their lives, their dwellings,other infrastructure and access roads. If proper regulations governing hillside development work are not established and enforced, the landslide problem in Kandy will continue to get worse during prolonged rainy periods, resulting in enormous threats to life and property in Kandy.

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