MONITORING URBAN ENVIRONMENTAL SUSTAINABILITY GREENING CAMPUS USING GEOSPATIAL TECHNOLOGY

PARVIZ GHOJOGH NEJAD

UNIVERSITI TEKNOLOGI MALAYSIA

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PARVIZ GHOJOGH NEJAD

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DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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ABSTRACT

Sustainability is a paradigm which introduces the proper techniques to decrease the harmful effects of human activities, which lead to pollution. Environmental sustainability is at the heart of universities, and the University of Indonesia has introduced a globally accepted sustainability assessment tool called Green metric. This research is focused on Universiti Teknologi Malaysia (UTM) in Johor, which is moving toward achieving environmental sustainability. The physical development of the campus and the increase in its population and transportation have brought about environmental issues like air and noise pollution. In the assessment of land use and transportation sustainability level, it was found that campus physical development is closely related to transportation and is not considered in the Green Metric defining criteria, thus, making it necessary to highlight this issue. As such, the main objective of this study was to develop an approach to address the importance and relationship of urban form and transportation in achieving environmental sustainability. Furthermore, by applying geospatial technology, the indicators could be analyzed and recommended in the Green Metric as an assessment tool, allowing other universities to evaluate their sustainability level. The initial approach used remote sensing data, Worldview 2, and quick birds. Preprocessing included using Dark Pixel, converting the raw digital number value to radiance factor, combining the spectral and spatial resolution attributes of Panchromatic and Multi-Spectral imagery to achieve 0.5 resolution, and using the Gram Schmidt techniques. Next, step-by-step processing actions were applied to the same images using object base classifiers, rule base classifiers and pixel base classifiers, such as maximum like hood and support vector machine, finally, ground truth, result and accuracy assessment were carried out for land cover mapping. Then, Shannon entropy model estimation was calculated to track built-area development, The second approach used interpolation processing techniques. The stages involved were data representing, exploring information, fitting an interpolation model, performing diagnostics, model comparison, and cross-validation using Kriging and Inverse Distance Weight (IDW). The findings of the study area were heterogeneous and complex due to the nature of the urban environment, creating misclassification of the pixels or undesirable information and details. Rule and object classifiers were used to address this issue, and the image object rule base classifier showed 80% overall accuracy, which outperformed the pixel base classified at only 64%. Thus, they are successful techniques for quality and quantity purposes. The estimates found from the Shannon entropy model showed that UTM had become the dividing line between compact and disbursed development, mostly at the T and U zones in the cluster area. Noise, air and traffic pollution in UTM showed medium and high levels, which exceeded the National Ambient Air Quality Standard and noise level threshold. The output for IDW showed good accuracy for nitrogen dioxide and noise pollution levels except for carbon dioxide, which recorded 2.542182 value. Kriging showed good accuracy when the data series was bigger, and a variogram could be calculated. This study has shown that land development and types of traffic movement can be significant parameters for reaching sustainability which was not initially included in the green metrics indicators. As such, multiple type of scenarios related to traffic and land development can be introduced to be helpful for further detection.

ABSTRAK

Kelestarian adalah paradigma yang memperkenalkan teknik yang betul untuk mengurangkan kesan berbahaya daripada aktiviti manusia, yang membawa kepada pencemaran. Kelestarian alam sekitar berada di tengah-tengah universiti, dan Universiti Indonesia telah memperkenalkan alat penilaian kemampanan yang diterima secara global yang dipanggil metrik hijau. Penyelidikan ini tertumpu kepada Universiti Teknologi Malaysia (UTM) di Johor, yang sedang menuju ke arah mencapai kelestarian alam sekitar. Pembangunan fizikal kampus dan pertambahan penduduk serta pengangkutan telah membawa isu alam sekitar seperti pencemaran udara dan bunyi. Dalam penilaian penggunaan tanah dan tahap kemampanan pengangkutan, didapati pembangunan fizikal kampus berkait rapat dengan pengangkutan dan tidak diambil kira dalam kriteria penentuan metrik hijau, menyebabkan isu ini perlu diketengahkan. Oleh yang demikian, objektif utama kajian ini adalah untuk membangunkan pendekatan untuk menangani kepentingan dan hubungan bentuk bandar dan pengangkutan dalam mencapai kelestarian alam sekitar. Tambahan pula, dengan menggunakan teknologi geospatial, penunjuk boleh dianalisis dan disyorkan dalam metrik hijau sebagai alat penilaian, membolehkan universiti lain menilai tahap kemampanan mereka. Pendekatan awal menggunakan data penderiaan jauh, Worldview 2, dan quick birds. Prapemprosesan termasuk menggunakan Piksel Gelap, menukar nilai nombor digital mentah kepada faktor sinaran, menggabungkan atribut resolusi spektrum dan ruang bagi imejan pankromatik dan Multi Spectral untuk mencapai resolusi 0.5, dan menggunakan teknik Gram Schmidt. Seterusnya, tindakan pemprosesan langkah demi langkah telah digunakan pada imej yang sanna menggunakan pengelas asas objek, pengelas asas peraturan dan pengelas asas piksel, contohnya maksimum seperti hud dan mesin vektor sokongan, dan akhimya, kebenaran tanah, keputusan dan penilaian ketepatan telah dijalankan untuk pemetaan tutupan tanah. Kemudian, anggaran model entropi Shannon dikira untuk mengesan pembangunan kawasan binaan. Pendekatan kedua menggunakan teknik pemprosesan interpolasi. Peringkat yang terlibat ialah mewakili data, meneroka maklumat, memasang model interpolasi, melakukan diagnostik, perbandingan model, dan pengesahan silang menggunakan Kriging dan Inverse Distance Weight (IDW). Penemuan kawasan kajian adalah heterogen dan kompleks kerana sifat persekitaran bandar, mewujudkan salah klasifikasi piksel atau maklumat dan butiran yang tidak diingini. Pengelas peraturan dan objek telah digunakan untuk menangani isu ini, dan pengelas asas peraturan objek imej menunjukkan ketepatan keseluruhan 80% mengatasi pengelas asas piksel pada hanya 64%. Oleh itu, ia adalah teknik yang berjaya untuk tujuan kualiti dan kuarititi. Anggaran yang ditemui daripada model entropi Shannon menunjukkan bahawa UTM telah menjadi garis pemisah antara pembangunan padat dan disbursed, kebanyakannya di zon T dan U di kawasan kluster. Pencemaran bunyi, udara dan lalu lintas di UTM menunjukkan tahap sederhana dan tinggi, yang melebihi Standard Kualiti Udara Ambien Kebangsaan dan ambang tahap kebisingan. Output untuk IDW menunjukkan ketepatan yang baik untuk nitrogen dioksida dan tahap pencemaran bunyi kecuali karbon dioksida, yang mencatatkan nilai 2.542182. Kriging menunjukkan ketepatan yang baik apabila siri data lebih besar, dan variogram boleh dikira. Kajian ini telah menunjukkan bahawa pembangunan tanah dan jenis pergerakan trafik boleh menjadi parameter penting untuk mencapai kemampanan yang pada mulanya tidak dimasukkan dalam penunjuk metrik hijau. Oleh itu, pelbagai jenis senario yang berkaitan dengan lalu lintas dan eniban nan tanah boleh diperkenalkan untuk membantu pengesanan selanjut.

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LIST OF ABBREVIATIONS

3D	-	Three-dimension
AI	-	Artificial Intelligent
ANN	-	Artificial Neural Network
API	-	Atmospherically Pollutants Index
ATC	-	Automatic Tube Counts
DB	-	Decibel
DK	-	Disjunctive Kriging
DN	-	Digital Number
DOE	-	Department of the Environment
EMS	-	Environmental Management System
EPA	-	Environmental Protection Agency
GIS	-	Geographical Information System
GPS	-	Global Position System
GS	-	Gram Schmidt
GVS	-	Green Vegetation Space
HWUM	-	Heriot-Watt University Malaysia
IDW	-	Inverse Distance Weighting
IK	-	Indicator Kriging
IO	-	Image Object
ISA	-	Impervious Surface Area
LOS	-	Level of the Sustainability
LULC	-	Land Use and Land Cover
MAAQG	-	Malaysia's Environmental Air Quality Guidelines
ML	-	Multilayer
MLP	-	Multi-layer-perceptron
NDVI	-	Normalize Different Vegetation Index
NDWI	-	Normalize Difference Water Index
OK	-	Ordinary Kriging
PDCA	-	Plan-Do-Check-Act
PK	-	Probability Kriging

PSZ	-	Library of Sultan Zanariah (*Perpustakaan Sultan Zanariah*)
QOL	-	Quality of Life
RBF	-	Radial Basis Function
RMK-9	-	Ninth Malaysia Plan (*Rancangan Malaysia Ke-9*)
RS	-	Remote Sensing
SIM	-	Spatial Interpolation Methods
SK	-	Simple Kriging
SVM	-	Support Vector Machine
TDM	-	Transportation Demand Management
UCTS	-	University College of Technology Sarawak
UI-GMR	-	UI Green Metric Global University Rank
UK	-	Universal Kriging
UM	-	Universiti Malaya
UTM	-	Universiti Teknologi Malaysia
VOC	-	Volatile Organic Compound

LIST OF SYMBOLS

D	-	Target destination
ME	-	Mean Error
RMSE	-	Root Mean Square Error

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Sustainability is at the heart of the university's for a more sustainable university, it is necessary to study the advanced plans and initiatives relevant, From the between plans, actions to trending and making the university sustainable the initial stage is creating a green campus with the friendly environment, Green Campus it is a concept, which is part of various fields. For example, ecological construction on campus, energy conservation, programs directed by students towards the creation of the ecological campus, and many others There were several ideas and frameworks in literature founded which propose campus sustainability (Alshuwaikhat and Abubakar, 2008; Beringer, 2007: Ng *et al.*, 2013; McMillin and Dyball, 2009; Newman, 2012; Velazquez *et al.*, 2006; Weenen, 2000; Zhao and Zou, 2015, Rimvydas Labanauskis; Samuelsson and park, 2017; Nagendra et al 2018; Abdullah Alomar1,2021).

All these proposed frameworks have tried the answer queries about ways a university campus could for better management to achieve development that contains sustainability and which types of the principle and rule must be followed. However, there are many ways to develop sustainability at Campus University that depend on university strategies. Universities to achieve sustainability in their university environments (Zuhairuse *et al.*, 2009; Weenen, 2000; Weiland, 2006; Becker, 2007; Figueiro and Raufflet, 2015; Bizerril., 2018; U NESCO,2020).

For reaching these goal universities from all over the world tried to introduce different criteria and the threshold for the level of sustainability can help them to make universities greener, by the luck. The University of Indonesia sustainability assessment tool called Green metric is Globally accepted ranking provided a chance to every university to evaluate the level of sustainability to achieve the targeted goal which is

the greening campus, by the responding to the defined questionnaire related to green campus criteria which are focused on the six major groups containing setting and infrastructure, climate change and energy, waste minimizing, water consuming, transportation, eco-friendly education, to the evaluation of the university sustainability.

This research considers the transportation and the environmental aspect, air and noise pollution related to traffic, and land development within the Universiti Teknologi Malaysia (UTM) Johor campus, Transportation can be a cause of major parts of environmental problems. Nowadays the use of energy in transportation has increased. Forty years ago, total energy use in transportation was between 15% and 20%, but today energy utilization is around 35% and it is still increasing. Transportation is the biggest cause of greenhouse gases in the world, and it was addressed by the 1997 Kyoto services (Chapman, 2007).

It is a very obvious and known form of land development with transportation has direct relation means if urban development in the compact form energy consume less than the urban development in the disparate form because people can reach easily to the target and facility in the short distance it means urban form effective in the energy use for transportation and global warming (Liu and Shen, 2011) In the study carried out by the Newman and Kenworthy (1999) it is represented there is a significant relationship between urban density and energy consumes for the transportation shown Figure 1.1. The more density, the less the energy used for each person, the more energy used for the less density urban appearing with more using of the private transport opposite to this, more density it became suitable for non-motor transport, public transport, and green traffic.

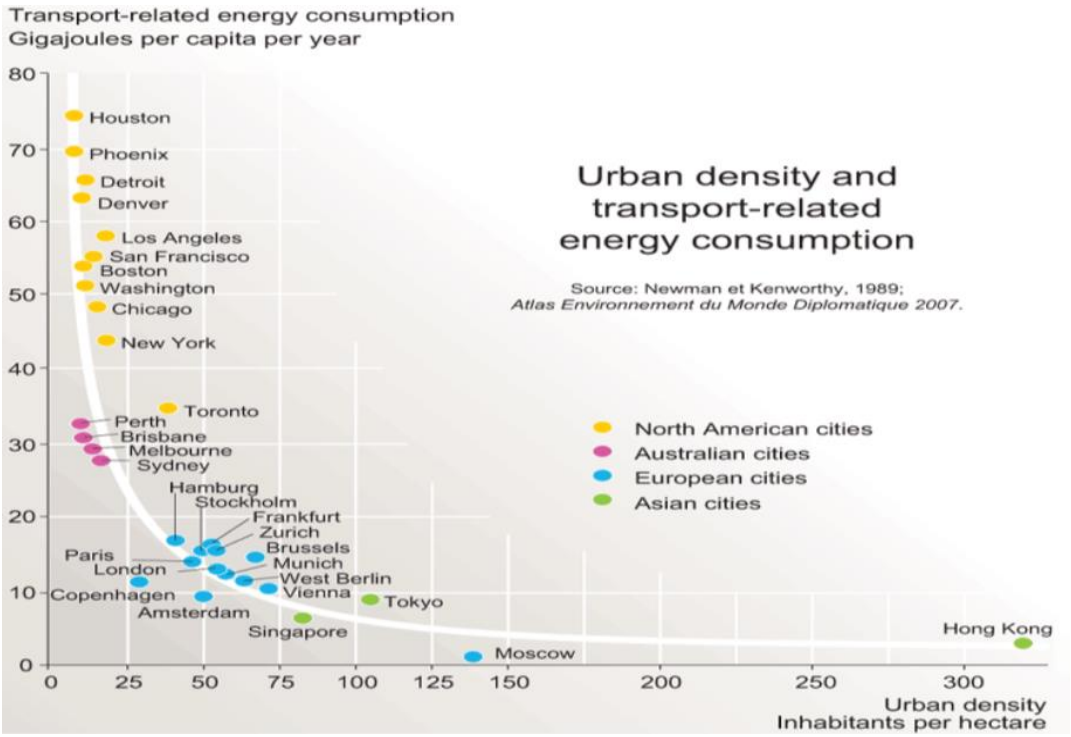

Figure 1.1 Energy usage related to transportation and urban density development (Newman and Kenworthey, 1999).

For the universities, also it is accepted the idea that urban form design and transport have close relation and able to extremely influence the way university feels also, Land use desperation, forming the transport model split type and the travel behavior some investigation was done by the previous researcher it shows parameters like the urban form and particularly the location of the people's settlement show very significant role in the choosing travel mode and travel attitude (Pinjari *et al.*, 2011; Puntambekar, 2011; De Vo et al., 2018; Humphreys & Ahern,2019; Roel Faber and Raimbard Merkies, 2021).

Accordingly, transport type and its modes which it includes transport capacity, fuel consumption, passenger, and transport sizes are the effective parameters for the total emission and greenhouse gas to the environment (Transportation, Maritime and Road Amenity, 2011).

Transportation pollution with a different type of transport shown in Figure 1.2 is seen non-motor transport or Green traffic, which includes transportation like walking and cycling and transportation, which not containing non-renewable energy

with less harm to the environment can have zero-emission to the environment, opposite it motor transport and private car have high emission.

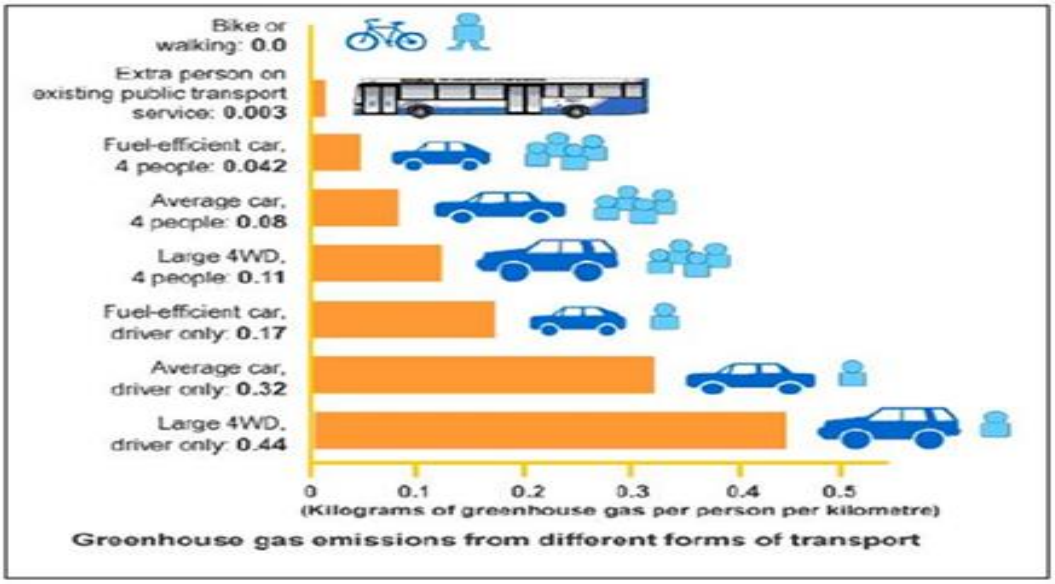

Figure 1.2 Transportation pollution with a different type of transportation (Maritime and Road Amenity, 2011).

An increasing number of vehicles and are related to unplanned land development, causing to create significant traffic pollution. Therefore, there is consensus that motion needs to be taken to limit the environmental influences of transport.

This study examines how Geographical Information System (GIS), Remote Sensing (RS) must be applied as a tool to assist achieve sustainable campus improvement with the consideration of the environmental part of sustainability, it is identifying planning problems affecting the performance of the university campus about sustainability and global warming.

This investigation not only is useful to make a theoretical principle for a comprehensive determination and understanding of urban environmental sustainability, at the same time represents the integration of different methods and data from different sources for the measurement and great analysis, especially to create a spatiotemporal view.

1.2 Problem Statement

Traffic pollution is a serious problem regarding environmental protection, with the increasing number of vehicles and the continuous development of technology. Transport issues derive the main from the imbalance between the capabilities or provide of transport services and the demand of individuals, the daily journey of people to and from the campus. Motorized transport is one of the highest impacts that an academic institution can put on the environment. Traffic jams, travel delays, and travelers' discontent are all the results of this imbalance.

UTM campus also has always been filled with vehicles, mainly automobile vehicles, and private buses. Motorized vehicles such as buses, automobiles, and motorcycles are an essential requirement at present for UTM staff and students to become an important means of transportation to facilitate their movement on campus. This led to one of the problems faced by all UTM citizens to come to work and college. This situation occurs when all the people who wish to enter the UTM enter at the same time.

These are amid environmental issues like air and noise pollution. Therefore, finding an accurate way to assess and measure comparative sustainability levels of existing and future developments of transportation has become an important issue.

Since the UI Green Metric, Global University Rank (UI-GMR) was introduced as the assessment tool and it is a recognized standard guideline for constructing a green university, so able to help universities to sustain their activities and policies, evaluation based on the selected indicators from the commonly used assessment tools.

To understand and predict the impact of urban transportation infrastructure and land use design on human exposure to traffic-related pollutants with a focus on compacts development, it makes necessary to do more study and research about the urban form with transportation behavior and it is a negative impact on society, especially the relationship between an urban form with the transportation and outcome pollutions is still became an ongoing challenge and there is a lack in comprehensive

research on the relationship between physical character and transportation allocated for universities.

And to address issues of concern, we reviewed indicators defined in the Green metric assessment its parts, include transportation and infrastructure categories which is related to transportation and land development of the greening campus, they were as selected case study for this research and we found compactness and distance from center parts of campus to reach availability facility which has a significant effect for a mode of the transportation choice is an undefined indicator in Green metric assessment categories in the Green campus evaluations, which can be count as the significant criteria.

Because for solving and decreasing traffic pollution the compactness rule and Green traffic can be one of the options for controlling traffic pollution and trending transportation to sustainable transport. When there is potential for people inside the campus to use green traffic like the walkability and connectivity to reach the destination, following the To Toor (2004) 1 to 2 km is an accepted distance walking, and 1 to 5 km distance is moral to cycling (Kong *et al.*, 2009).

It poses a problem if the impacts of integrated land use and transport policies to reduce the travel demand and the weak aspects in planning the physical development of the campus that led to the lack of creating an environment should be ignored. Which offers an environment conducive to learning and living (Shuhana *et al.*, 2007).

This study is to investigate the relevant problem and environmental effect of allowed automobiles, which is used in the UTM campus. Studies happened for analyzing the existing relationships among the university campus urban forms, physical development, type of land development, and traffic pollution by integrating remote sensing and GIS techniques.

In the first issue, the effort will be prepared in this study to map out the situation for the land cover of UTM, Johor Baharu, Malaysia. According to the Schovengerdt (2007) statement in creating a base and thematic maps able to represent

the proper distribution of the detectable objects in the earth; with the advantage to provide valuable information explaining to introducing for a selected area, more than just as an informative description and data used are Advanced Land Observation Satellite high resolution which includes two satellite images Quick Bird and World View 2. However, high-resolution data is good for land cover mapping because it shows more details for feature extraction and classification, but it is not sufficient to automatically cause high accuracy in classification since heterogeneously and being complex is the nature of the urban environment.

What matters most in this regard is the accuracy, speed, and quality of land-use maps. So, it needs to apply the excellent technique for classification, but at present, it is not possible to state which classifier is best for all situations as the characteristics of each image and the circumstances for each study vary so greatly, and there is no general unity related to great classification techniques to introduced for all time, type of the application and kind of the data to use is affecting the performance of the classification techniques (Ming, 2000). Many researchers could not find the best performance for any unique classification which is consuming specific data sets (Hand, 1986). As some researchers stated, due to altitudinal structure, and a variety in Land Use can Land Cover (LULC) classes in each study area, a unique guideline for choosing the best classification method cannot be applied to all areas (Xie *et al.*, 2010; Schulz *et al.*, 2010; Zhou *et al.*, 2018).

According to the data source, such as imagery, and geographic characteristics of the area under analysis, developing, adapting, and applying different approaches. Feature extraction methods, make the feature extraction process to be more challenging (Freire *et al.*, 2010). Improvement in remote sensing techniques in spatial or spectral resolution strengthens their applicability for urban environmental study, and to the assessment between different types of classifier, it made compulsory to identify the best performance for any classifier, which is more applicable high speed.

Then for the second issue by using GIS to map and estimate traffic pollution, with the implementation interpolation model and spatial data analysis Tools, For every mapping technique multiple parameters can be effective factors for the assessment and

realizing the final result of the mapping they have included density of sampling, type of spatial distribution to sample, sample collecting, surface form, data adjustment, data ordinariness, grid dimension, and determination, as well as the different method in how they combine and relate (Li and Heap, 2011). Therefore, this study tried to identify the great Spatial Interpolation Methods (SIM) for mapping a traffic data set for pollution parameters of air and noise it is hard because different SIM is proper to the different data types (Chiu *et al.*, 2009). An investigation like this research can help to full fill this gap for the campus sustainability assessment which is the relation of the transportation and compactness not mentioned in the Green Metric.

1.3 Research Gap

1) Sustainable campus initiative is an ongoing effort and needs for a professional and systematic environmental management approach

2) A Green campus study has different steps, data collection to find out the status of the campus, then finding the problematic area and reason are Finally, proposing the way that can solve the issues,

To achieve the sustainable development case study selected from the integration of parameters and techniques for evaluation is a quite challenging topic

3) Spatially highlighting the weakness of the Green metric indicator for measuring pollution of the transportation with current usage of defined indicator not discussed with the previous researcher.

1.4 Research Questions

1) How geospatial technology can be a useful tool for the assessment of sustainable transportation in the Greening campus?

2) What are the best classification techniques for land cover mapping of the study area?

3) How sustainable and compact campus planning can assist in achieving green traffic with implanting modern technology?

1.5 Aim and Objectives of Research

The aim of these research is to address the environmental issues through efficient use of geospatial technologies and focusing on the assessment procedure of sustainability where quantitative or qualitative value measures of the paradigm are developed for the situations will assist to meet legitimate sustainability targets, especially in the universities and colleges, and these researches examine how Geographical Information Systems (GIS), Remote Sensing (RS) can be used as tools to help achieve sustainable urban development with a focus on the environmental aspect of sustainability.

Therefore as the main objective of this work geospatial techniques implemented to represent significant relation between transportation with land development, compactness, and distance, which is not, considered in the Green metric defined indicator questioner to the evaluation level of the campus sustainability. For achieving this goal following processes were done:

1) To evaluate the accuracy of two kriging and IDW (Inverse Distance Weighting) interpolation methods for the prediction of the two selected indicator noise and air values in the study area. Compare pollution maps created with the regulatory standards provided by the Environmental Impact Assessment Methodologies and create a 3D model from the same pollution data.

2) To compare the image object-based to the pixel-based techniques using a parametric and non-paramedic classifier, to define the best classification

techniques for the land cover mapping of the study area with comparable accuracy between different types of the classifiers.

3) To implement the Shannon entropy model to the tracking land development from the different dates of the high-resolution satellite images.

1.6 Scope of Study

The scope of this study is integrating GIS and remote sensing technology to design an assessment tool for the evaluation of the campus transport sustainability its effects from compactness and distance from the central part of the campus to the achievement of the scope, these assessments are carried out in the three phases using measured secondary data on environmental, traffic air and noise pollution data, the classification of the ground coverage from the Quick Bird image acquired in 2006, World View 2 2015, acquired, of satellite images, and then Shannon entropy model paid to evaluate the type of the campus development and its relation to mode of transport on UTM campus.

First, understanding the forms and levels of pollution in the urban environment is significantly incredible, therefore, obtaining data with accuracy and measure able data collection is the initial requirement for the evaluation of the quality of the urban environment. This is possible to happen by settling to operate a specific number of stations for the observation and monitoring placed in a different place of the view (Allegrini and Costabile, 2002). This can be because the price of creating and implementing normal observance systems is very high; the utilization of analytical instruments is long, costly, and might seldom be applied for a period of observance within the field, though these will give help correct analysis (Hadjimitsis *et al.*, 2012).

Creating a pollution map with a GIS base which is, applying interpolation techniques, IDW and kriging are useful within the assessment of urban pollution. It demonstrates; however, the type of integrated urban model may be extended to handle the mapping of traffic pollution with the implementation of the interpolation models

and special knowledge analysis. This mixture of the characteristics of land use and the transport network of the model is connected to the contribution of traffic pollution that opens the doors to the analysis of the environmental impacts of the various styles of land use policies and transport.

Secondly, due to the high development of land within the campus. Monitoring changes in the LULC and analyzing the consequences of these changes are urgently needed to provide information to policymakers in support of sustainable development. The classification method does design according to user requirements, this spatial resolution from choosing remote sensing data, unity by earlier literature, image processing, also possible classification algorithms, and even present restrictions. That method needs to do instructive, complete also divisible (Jensen, 1996; Landgrebe, 2003).

Finally, after using high-resolution satellite image it is suitable for urban feature classification Shannon entropy model be applied it can make possible to track the land-use change during the several years and these changes happened, according to urban environmental sustainability or not then result can be useful for future decision making to planning, it is identifying planning problems affecting the performance of the university campus concerning sustainability and world warming. Furthermore, the software used for data processing includes PCI Geomatics, ENVI, ERDAS Imagine, ArcGIS, cognition software, Microsoft Office. The area of study may be useful to formulate and implement environmental strategies and action plans on campus, for which a new environmental management tool is applied that provide stronger institutions, better structures and equipment, and incentives for better institutional performance.

1.7 Significance of Study

The main goal for this work is to represent the environmental issue, according to on systematically studying campus sustainability from the two types of view, it including theoretical and experimental, as significant a part of the urban environment,

the urban traffic parameter is one amongst the key factors that cause pollution of the urban environment, for this reason, analysis on transport, educational activity and sustainability has raised within this last decade. When the transport plan becomes developed impotently in some earlier century also should give the idea of new realism, the concept must be understood this modal analysis on each lead about transportation planning, too. Accordingly, these opinions about the symbol should grow stronger and further important. Therefore, sustainable transport policies within the university should regularly measure their results because the result of less pollution is one of the most characteristics of sustainable developments, So the utilization of the standards outlined by the Environmental Protection Agency (EPA) is often a major measuring tool to measure or monitor future emissions or contamination and interpolation of the model for the prediction of various pollution parameters in numerous zones of UTM will set objectives to sustainable the university.

This case has caused the development tends to prepare the contaminations once understanding the behavior of the pollutions, and this study able to give the environmental pollution information for case studies on the UTM campus. Besides that future patterns of land use and coverage, must be understood in a very series of special, temporal scales to tell apart and predict the behavior and impacts of native land use in the different environmental aspects and the analysis of the land use map within the past is very important and necessary to predict changes in land use which will occur within the future. This research focuses on UTM for the ecological campus using a geospatial approach as the significant part, it is not just gives an academic source to properly understanding the campus sustainability, but at the same time provide arrangements of multiple methods with information source to measurable and differentiated analysis, mostly to sustainable transport view.

1.8 Thesis Structure

This thesis contains following five chapters which are listed below:

Chapter 1; the first chapter of the study starts with a general introduction that represents a brief overview of the outlines of this work such as the background of the Study, Problem Statement, Research Gap, Research Questions, objectives of Research, Scope of Study, Significance of Study, Research Aim.

Chapter 2; Literature Review that includes the scientific review of previous works carried out in the different fields which are relevant research issues, such as urban environmental sustainability and components, sustainable campus and availability approaches, UI Green Metric, geospatial technology, land cover mapping towards change detection, classification, urban density and Shannon entropy estimation, sustainable transport and Model Split, traffic pollution, GIS interpolation techniques IDW (Inverse Distance Weighting) and Kriging, and other related issues were discussed.

Chapter 3; Methodology sets the geographic circumstance of the study and introduces the datasets that should be used for the research purpose, the material and techniques implemented, the research methodology by Presenting research data collection and research method, data source and interpolation, data source and classification, segmentation, spectral of band ratio, rule-based classification, accuracy assessment, and built-up compactness classification model.

Chapter 4; Analysis of the result represents how much the appropriate methodology is successful in reaching desired output. Results, analysis and presentation of data, and findings were produced, discussed and Presented in this chapter 4, by producing figures and tables for the data source interpolation, data source and classification

Chapter 5; Conclusions and Recommendation illuminate the research with a brief discussion of study, suggest future research and final conclusion drawn from the work.

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Appendix A

LIST OF PUBLICATIONS

1) Idi, B. Y., & **Nejad, P. G.**, (2013). Fusion of RADARSAT-2 and IKONOS Images for Land Cover Mapping: Performance Analysis. *Applied Remote Sensing Journal*, 3(1), 18-24.

2) **Nejad, P. G.**, Ahmad, A., & Zen, I. S. (2018). Approach to Environmental Sustainability and Green Campus at Universiti Teknologi Malaysia: A Review. *Environment and Ecology Research*, 6(3), 203-209.

3) **Nejad, P. G.**, Ahmad, A., & Zen, I. S. (in press). Assessment of The Interpolation Techniques on Traffic Noise Pollution Mapping for the Campus Environment Sustainability. *International Journal of Built Environment & Sustainability*. 6(3), 203-209.