

**Developing GIS - Based Road Mapping
Network for Responding Terrorist
Activities**

Upul Krishantha Marambage

M.Sc.

2014

**Developing GIS - Based Road Mapping Network for Responding
Terrorist Activities**

By

Upul Krishantha Marambage

**Thesis submitted to the University of Sri Jayewardenepura for the
award of the Degree of Master of Science in Geographic
Information Systems & Remote Sensing on 15th June 2014.**

Declaration of the Candidate

The work described in this thesis was carried out by me under the supervision of Dr. (Ven.) Pinnawala Sangasumana Thero and Mr. Pabhath Malavige. And a report on this has not been submitted in whole or in part to any university or any other institution for another Degree/Diploma.


.....
U.K. Marambage

25/07/2014
.....
Date

DECLARATION OF THE SUPERVISORS

We certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the University for the purpose of evaluation.

Certified by:

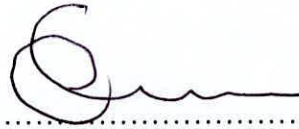
Supervisors:



.....
Dr. (Rev) Pinanawala Sangasumana
Head/Senior Lecturer
Department of Geography
University of Sri Jayewardenepura
Nugegoda
Sri Lanka.

..... 26/07/2014

Date



.....
Mr. Prabhath Malavige
Head / GIS/ Premises Section,
Sri Lanka Ports Authority
Colombo
Sri Lanka.

..... 27/07/2014

Date

Ven. Dr. Pinnawala Sangasumana
Head /Department of Geography
University of Sri Jayewardenepura
Gangodawila, Nugegoda,
Sri Lanka.

Table of Contents

Table of Contents	i
List of Tables.....	iv
List of Figures	v
List of Abbreviations.....	vii
Acknowledgement.....	ix
Abstract.....	xi
1 INTRODUCTION	1
1.1 Background of the Study	1
1.2 Research Problem.....	7
1.3 Significance of the Study.....	11
1.4 Objectives	15
1.4.1 Main objective.....	15
1.4.2 Specific objectives.....	15
1.5 Limitations of the Study	16
2 LITERATURE REVIEW.....	17
2.1 Some Other Countries and the Sri Lankan Experience of Terrorist Attacks.....	17
2.2 Identified New Finding for GIS Applications on Emergency Management and Network Analysis	27
3 METHODOLOGY	33
3.1 Primary Survey	33
3.1.1 Study Area.....	33
3.1.2 Social Background and Physical Condition.....	35
3.1.3 Economical and Cultural Situation.....	46
3.1.4 Project Initiation (Geographically and Tactically Importance of the Area).....	50
3.1.5 Incident Wise.....	53

3.1.6	Population Density.....	54
3.1.7	Terrorist Activity Wise	56
3.2	Sampling.....	56
3.2.1	Nature of Incidents	57
3.2.2	Sample Data Acquisition of Arrests, Recoveries and Vulnerable Locations.....	57
3.2.3	Total Incidents Data.....	58
3.3	Data Collection and Manipulation	60
3.3.1	Secondary Data.....	61
3.3.2	Primary Data.....	63
3.4	Data Analytical Technique	66
3.4.1	Data Collection	68
3.4.2	Spatial Referencing.....	71
3.4.3	Coordinate Systems and Projections.....	72
3.4.4	Getting Terrorist Activity Data into a GIS.....	73
3.4.5	Digitization.....	74
3.4.6	Road Network Generalization	74
3.4.7	Test Topography Rules	75
3.4.8	Network Analyst.....	75
3.4.9	Network index Calculation.....	76
3.4.10	Building.....	77
3.4.11	Results and Conclusion.....	77
4	RESULTS AND DISCUSSION	78
4.1	GIS Based Strategic Road Network Analysis	78
4.1.1	Shortest Path Analysis	79
4.1.2	Road Barriers.....	82
4.2	Buffer Analysis	85
4.2.1	Buffer Analysis for Attacks, Suicide Attacks and Explosions.....	85

4.2.2 Buffer analysis of incidents Vs vulnerable locations and security installations	87
4.2.3 Buffer Analysis of Important Locations, Incidents and Security Installations	90
4.3 Network Service Area	94
4.3.1 Service Areas from Security Installations to Vulnerable Locations.....	94
4.3.2 Service Areas from Incident to Security Installations and Important Locations.....	97
4.4 Hotspot Analysis	100
4.5 Applicability of Road Network Analysis on Responding Terrorist Activities.....	103
5 CONCLUSION AND RECOMMENDATIONS	106
5.1 Conclusion	106
5.2 Recommendations	107
References.....	110

List of Tables

Table 3.1: Population Density of the Study Area.....	35
Table 3.2: List of Less Sanitation Facility According to the Area.....	45
Table 3.3: Incident and Land use Type	51
Table 3.4: Spatial Classification with Land Use Type on Threat Assessment	52
Table 3.5: Population Density in 29 GND.....	55
Table 3.6: Census Types of Terrorist Attacks in the Police Areas	58
Table 3.7: Collected Spatial and Non-Spatial Data Dataset with its Format.....	68
Table 3.8: Parameter – WGS 84 & Sri Lanka 200,000 Coordinate System.....	72

List of Figures

Figure 2.1: Public Support of Terrorism and Insurgency Model (PSOT)	21
Figure 3.1: Study area: 29 GNDs in Colombo Divisional Secretariat Division.....	34
Figure 3.2: Total Population Density Shows at the Study Area.....	38
Figure 3.3: Family Composition of Study Area	39
Figure 3.4: Education Level within 29 GNDs of the Study Area.....	41
Figure 3.5: Living Condition with House Ownership and Roof Condition at the Study Area	43
Figure 3.6: Electricity Distribution Pattern at the Study Area	44
Figure 3.7: Odd Job Category at the Study Area.....	47
Figure 3.8: Religious Status of the Research Area.....	49
Figure 3.9: Incidents and Arrests by Police Area Wise	59
Figure 3.10: Way of Data Collection and Manipulation Process.....	65
Figure 3.11: Data Analytical Technique Mechanism	67
Figure 4.1: Shortest paths from security installations to vulnerable locations for responding any emergency, (Source: Google Maps & Survey Dept. 1:10,000 Digital Topographic Map).....	80
Figure 4.2: Sample Area of Shortest Paths from Security Installations to Vulnerable Locations for Responding any Emergency.....	81
Figure 4.3: Most Suitable Locations for Implement Road Barriers within 400 m – 500 m Distance.....	83
Figure 4.4: Sample area of most suitable locations for implement road barriers within 400 m - 500 m distance, (Source: Survey Dept. 1:10,000 Digital Topographic Map)	84
Figure 4.5: Buffer zone Vs attacks, suicide attacks and explosions happened since 1985,.....	86
Figure 4.6: Sample buffer zone Vs Attacks, Suicide Attacks and Explosions in Fort Area, (Source: Google Earth Map).....	87

Figure 4.7: Buffer Zone Compare with Incidents, Vulnerable Locations and Security Installations, (Source: Survey Dept. 1:10,000 Digital Topographic Map).....	88
Figure 4.8: Sample buffer zone compare with incidents, vulnerable locations and security installations	89
Figure 4.9: Buffer zone compare with important locations, incidents and security installations, (Source: 1:10000 digital topographic map of Survey Department, Sri Lanka GeoEye I - resolution 0.5m.)	91
Figure 4.10: Buffer zone compare with important locations, incidents and security installations in the Fort area	93
Figure 4.11: Service areas from security installations to vulnerable locations, (Source:1:10000 digital topographic map of Survey Department, Sri Lanka GeoEye -I resolution 0.5m.)	95
Figure 4.12: Sample service areas from incident to security installations to vulnerable locations	96
Figure 4.13: Service Areas from Incident to Security Installations and Important Locations	98
Figure 4.14: Sample Service Areas from Incident to Security Installations and Important Locations	99
Figure 4.15: Hotspot Analysis on incident intensity of incidents	101
Figure 4.16: Hotspot Analysis of Model Building on per Incident.....	102

List of Abbreviations

3D	-	Three Dimension
AQAP	-	Al Qa`ida in the Arabian Peninsula
AQIM	-	Al Qaeda in the Islamic Maghreb
CAD	-	Computer-Aided Design
CAD	-	Computer-aided Design
CASA	-	Center of Advanced Spatial Analysis
CHAP	-	Common Humanitarian Action Plan
CIA	-	Central Intelligence Agency
CPP	-	Communist Party of the Philippines
DHS	-	Department of Homeland Security
DMI	-	Directorate of Military Intelligence
DNI	-	Directorate of Navy Intelligence
DoD	-	Department of Defense
DRC	-	Democratic Republic of the Congo
DSD	-	Divisional Secretarial Division
ERT	-	Emergency Rapid Troops
ETIM	-	East Turkestan Islamic Movement
EU	-	European Union
FBI	-	Federal Bureau of Investigation
FIS	-	Islamic Salvation Front
GDP	-	Global Gross Domestic Product
GIA	-	Armed Islamic Group
GIS	-	Geographic Information System
GND	-	Grama Niladari Division
GPS	-	Global Positioning System
GTD	-	Global Terrorism Database
GTI	-	Global Terrorism Index

HAMAS	-	Harakat al-Muqawamah al-Islamiyya
HR	-	High Risk
HSZ	-	High Security Zone
ICM	-	Institute for Conflict Management
IDMC	-	Displacement Monitoring Centre
IDP	-	Internal Displace People
IED	-	Improvise Explosive Devise
IPKF	-	Indian Peace Keeping Force
LeT	-	Lashkar - e -Toiba
LR	-	Low Risk
LTTE	-	Liberation Tigers of Tamil Eelam
MoD	-	Ministry of Defence
NPA	-	New People's Army
NRL	-	Naval Research Laboratory
PAD	-	Police Administrative Division
PHQ	-	Police Headquarters
PKK	-	Kurdistan Worker's Party
PLO	-	Palestine Liberation Organization
SATP	-	South Asia Terrorism Portal
SF	-	Security Forces
SFB	-	Security Forces Base
SIS	-	State Intelligence Service
UN	-	United Nations
UNWTO	-	Nations World Tourism Organization
VHR	-	Very High Risk

Acknowledgement

I would like to express my gratitude to all those who gave me their support and encouragement to complete this thesis.

I am deeply indebted to my supervisors Rev. Dr. Pinnawala Sangasumana, Senior Lecturer & Head of the Department, Department of Geography, University of Sri Jayewardenepura of Sri Lanka and Mr. Prabhath Malavige, Head of GIS / Premises Section, Sri Lanka Ports Authority for their great encouragements, enthusiastic support and advices, whose help, patience, kindness, enthusiastic support, stimulating suggestions and encouragement helped me in all the time of research and writing of this thesis.

I am grateful to lecturing panel of the M.Sc. Programme for their valuable comments and encouragements during my research project. I would like to acknowledge the guidance given by Professor C.K.M. Deheragoda, Department of Geography, Professor R.M.K. Ratnayake and Mr. B.A.S.C. Kumara (Lecturer) Department of the Geography at the University of Sri Jayewardenepura, Dr. Ranjith Premasiri, Senior Lecturer, Department of Earth Resources Engineering, University of Moratuwa during my research. Also I extend many thanks to all of them in the revision of my work which helped me to improve many aspects of my work at last but not least and thank the Department of Geography at the University of Sri Jayewardenepura for enabling me to complete this research in a peaceful academic environment while enriching my professional experience immeasurably.

My special recognition to the Deputy Inspector General of Police and Director of State Intelligence Service Mr. Chandra Nimal Wakista, he gives guidance and encouragement during the entire period of my studies and delivers wonderful unquestionable support for fulfill my wish.

I wish to thank government officials of the 29 GN divisions with surrounding areas of Colombo North, for their persistent and generous help and highly encouraging guidance

to meet the objectives of this research work. I wish to thank the respondents who took part in the questionnaire survey for providing necessary information and their valuable assistance.

My heartfelt gratitude goes to Nalaka, Vasana, Dilhari and Madushanka of my M.Sc. colleagues and staff of the Faculty of Teaching the M.Sc. Degree in GIS & Remote Sensing at the University of Sri Jayewardenepura for their great support indispensable and continuous encouragement rendered to me in making this research thesis a reality.

The will power to succeed not only in this work but also in all the challenges that I face, comes from my beloved wife, Niroshini, my children Vethmi and Rivisha as well as my loving father and mother. I thank them all for their love, sacrifice, enthusiasm, tolerance and support given to me consistently which was the most immeasurable strength to triumph in my life.

Developing GIS - Based Road Mapping Network for Responding Terrorist Activities

Upul Krishantha Marambage

ABSTRACT

Sri Lanka has suffered the curse of terrorism for last three decades with the intent to cause maximum destruction to life and property. Northern and Eastern provinces were demanded by the LTTE terrorist whereas Colombo was a major vulnerable location and LTTE had frequently carried out attacks against civilians target, key politicians, government officials, military installations and economic and commercial targets. The end of the brutal war lasting almost three decade, that may get as an opportunity to develop and implement a GIS - based road mapping network analysis system for responding terrorist activities and analyze variables that can be interrelated between the national security and terrorist activities. Therefore the main purpose of this study was to completely exhaust all terrorist activities. Acquiring accurate information with key statistical data in particular areas terrorist activities can be monitored to prevent and minimize human losses as well as doing emergency management before and after terrorism strikes. There were 29 GND areas of Colombo north selected for the analysis. The techniques of Network and Hotspots analysis were employed to the study. Shortest path to any particular vulnerable location from security installation was analyzed. About 97 vulnerable locations were identified as some low rate lodgers, pharmacies, scrape iron shops, small saloons and some business premises. Only 30 security installations are in the area. Analysis shows that minimum distance from security installation to a vulnerable location is 0.8 km and maximum distance is 2.4 km. Average responding time from any adversary action varies from 3 to 5 Minutes. Junctions that are ranged from 400 m to 500 m distance from all vulnerable locations in the study area was identified as suitable road blocking points. Six GNDs Sammanthranapura, Mattakkuliya, Modara, Madmpitiya, Aluthmawatha and Lunupokuna were identified as major potential areas for terrorist activities. Pattah and its suburb are the most vulnerable locations for terrorism activities as per the hotspot analysis.

Key Words: GIS, Terrorist attacks, Network analysis, Buffer analysis