

GIS Mechanism For Terrain Trafficability

KWGIM Kalugamuwa[#], KA Dinusha, and KUJ Sandamali

General Sir John Kotelawala Defence University Southern Campus, Sri Lanka

[#] <34-sursc-5309@kdu.ac.lk>

Abstract: Geographic Information Systems(GIS) could be identified as a leading application mechanism that grows beyond in each and every aspect of the world. The GIS applications in decision making in the military field was gradually increasing in nowadays. This study oriented to compare the application of GIS in foreign armies and find a suitable GIS application for Sri Lanka Army. The design of this research was accomplished in three stages as reviewing the existing GIS application of foreign armies, and developing the terrain trafficability model using model builder application of GIS. Therefore by reviewing existing applications of other armies in foreign countries clearly identified some of the applicable GIS applications for Sri Lanka. And then by using questionnaire survey including Sri Lankan army officers figure out the appropriate application for the country. As the results of the questionnaire survey, it has found terrain trafficability analysis method is the most suitable method for the country. Then Kalutara district was selected as the study area and land use, soil, elevation, used as raw data. In present, the Sri Lankan army doing terrain analysis using the Intelligence Preparation of the Battlefield(IPB). Terrain overlay is the part of IPB which identify go, no go, slow go areas of the terrain. This research focused on the identification of GIS mechanism for this manual process using GIS accurately compared to the manual process. Therefore suggest utilizing this analysis in the future for the terrain analysis in Sri Lanka Army.

Keywords: GIS, Trafficability, IPB

Introduction

The ability to negotiate varied kinds of terrain is crucial for army land-based operations. During offensive ground operations, the commander and staff has to identify which routes to take as

part of the advance and attack. While the commanders at the respective stages consider the strategic, operational and tactical situations the engineer officer has to determine the trafficability/negotiability of the terrain throughout the theatre of operations. The Sri Lankan military is far behind in using digital technology in comparison to defense forces of other countries. Sri Lankan army doing the terrain analysis using the Intelligence Preparation of the Battlefield (IPB). Terrain overlay is the part of IPB which identify go, no go, slow go areas of the terrain. This research focused on the identification of GIS mechanism for this manual process.

The aim is to identify an appropriate mechanism for Sri Lanka army through the examination of the use of GIS in foreign armies. The researches are limited in Sri Lanka focusing the military terrain trafficability. Modern military operations are highly dependent on mechanized vehicles and these vehicles are in turn only efficient on terrain which able to move with less obstacles.

Scope of this study is to identify an appropriate GIS mechanism for the terrain trafficability of the battlefield for the Sri Lanka Army. Although there are various kind of applications of GIS in the military field, this research was only focus to the analysis of the terrain trafficability. Military means combination of tri forces, but in this research it has been limited only for Army. This study will helpful in future for the commanders when taking decisions on geospatial data with new technology.

Experimental Design

When designing the research, three stages were identified and the existing GIS applications of foreign armies were examined as the first stage. I accustomed review research papers, journals

and websites that is that the secondary knowledge supply to urge the specified information. The journals, research papers and specific web sites were used as sources to find the current mechanisms in forming armies. Secondary knowledge has been taken on existing researches, therefore information terribly correct.

As the second step of my research design, identification of suitability of GIS mechanism for Sri Lanka army was carried out. Because it cannot be notice as higher than secondary knowledge. Questionnaire survey has been done among officers in Sri Lanka Army. Actually it has been distributed form by taking a minimum of one officer from every of the regiment to cover the entire army. Further it has used GIS specialists to gather knowledge of this survey.

GIS Applications Identified In Foreign Armies

USA is the most powerful country within the military sector. They used the highest standard of technological equipment and technology for their operations. According to Warren and Bagley(1992), US Army has adopted a standardized land condition and trend analysis approach to the land management that comes with the use of a geographic information system and satellite imagery. In Esri.com(2020), describe that the USA army use the GIS technology in their military decision-making processes.

According to Fleming, Steven & Jordan, Thomas & Madden, Marguerite & Usery, E. & Welch, R.. (2009) business geographic system (GIS) software system for the military-specific applications is presently being developed and utilized with digital databases to produce custom-made digital maps of variable scale, content and symbolization personal to distinctive demands of military force. Department of Défence, model GIS models for military tasks in ocean, land associate degraded air conditions were made of many informational collections of an investigation territory at United States United States Marines Base Camp Lejeune, North geographical area.

According to Roy A. Welch, (2004) unclassified, commercial remote sensing data in the form of images assimilated from airplanes, unmanned aerial vehicles (UAVs) and satellites are regularly being employed to populate coastal zone databases. GIS are also being worked to integrate and analyse geographic information for military operational purposes.

UK military has high asset of man power, air power, land forces, naval forces, natural resources and so on. According to the website Ieeexplore.ieee.org (2020) over the past few years, the Naval Oceanographic Office (NAVOCEANO) has led the way. in the development of this pioneering technology. According to Dykes, James & Hancock, T.E.. (2002) GIS methodology is principally well suitable for collecting, organizing, storing, analysing, and distributing geological, oceanographic, meteorological, and even space data. As users at NAVOCEANO have come to know how GIS tools could vastly improve operations, certain capabilities for giving out and distributing relevant METOC (meteorological and oceanographic)information have evolved.

According to Petrovski and Toshesvki (2016) capabilities that use in UK for GIS are following: Command and management, Defence mapping organizations, Base operations and facility management, Force protection and security, Military engineering, Mine clearance and drawing, Mission coming up with, Terrain analysis etc.

Thailand is a south Asian country which faced for many wars within the history. According to Anon (2020), Khotcharit (2004) applied GIS tools to make a CCM (Country College of Morris) map in Kanchanaburi Province in western Thailand, using the weight-linear-combination technique. The considered data were surface slope, soil, vegetation, transport, obstacle, rainfall, and built-up area.

According to the Geospatial World (2020), Specific GIS functionalities which are of importance from the point of view of battlefield surveillance are Data fusion, Demonstration of

Considering about the African countries Nigeria has the biggest armed force. According Francis Fajemirokun, O. Adewale & Timothy Idowu et.al (2006) GIS as a tool is used by police personnel to line up effectively for emergency response, make sure mitigation urgencies, analyse past events, and predict future events. GIS can likewise be applied to induce basic data to crisis responders upon report or whereas foe course to an event to help strategic composing and response.

Questionnaire Survey

Applicability of GIS mechanism for military and required variables for terrain trafficability model were identified through the questionnaire survey among the selected military officers. The study sample consisted 45 officers including 2 officers from Engineering Service Corp and Corps of Engineers, one officer from each an every regiment of Sri Lanka Army, 5 KDU Lectures, 5 Officers from Centre of Research and Development, 5 officers from Defence Ministry of Intelligence and 2 Other GIS expertise. From this 45 sample 41 had been respond to the Questionnaire.

C.Terrain Trafficability Model

Beginning from the research problem number of steps were followed according to the research methodology. The methodology flow chart of the research is given as Figure

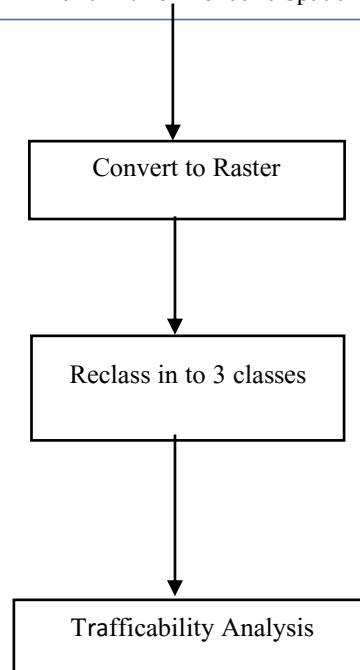
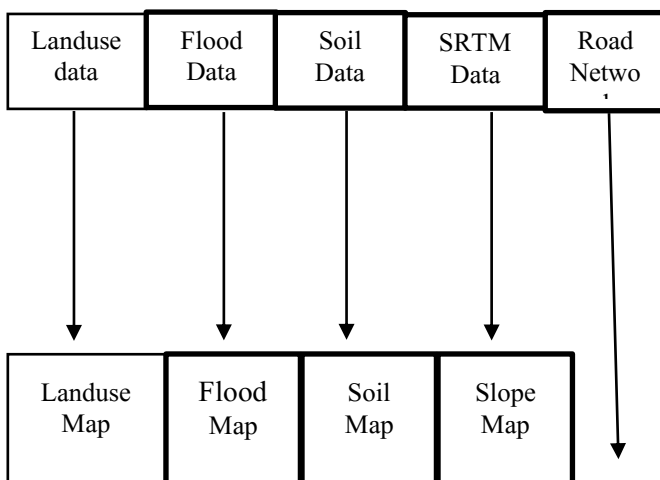


Figure 1 : Methodology flow chart of terrain trafficability model

Source : Created by researcher(2020)

Question	Answers	Percentages
1. Are you familiar with GIS?	Yes	80%
	No	20%
2. Software related to GIS use at present	Arc GIS	45.7%
	QGIS	37.1%
	Arc GIS & QGIS both	5.8%
	Arc GIS & GRASS GIS	2.9%
	No	2.9%
3. Extent of the GIS use in their applications	Highly	12.8%
	Moderately	56.4%
	Never use	30.8%
4. Qualification regarding GIS	By the experience	45%
	BSc	17.5%
	Master's	12.5%
	Post graduate courses	5%
5. Applications currently use in GIS technology	Nothing	17.9%
	Map digitizing and Overlay	7.1%
	Intelligence planning in Battlefield	7.1%
	QGIS mapping	3.6%
	Environment Related Analysis	3.6%
	Teaching	3.6%
	Analysis tools	3.6%
	QGIS	3.6%
	Plan works in Land Surveying	3.6%
	Nothing	3.6%
Currently not using	3.6%	
Arc GIS, WebGIS	3.6%	



D.Data Collection

From the given institutes below used to collect the data for the model.

- a. Surveyor Department:
 - 1:50 000 land use map
 - Hydrological data of Kalutara District
 - Road Network of Kalutara District
- b. Agricultural Department
 - Soil data

Figure 3 : Percentages of Responses

Flood data

d. USGS :

1)SRTM data

Collected data from the various kinds of institution have to categorized according to the given below considering their basic characteristics.

Data	Tafficability		
	Go	Slow go	No go
Slope	Low elevation	Moderate elevation	High elevation
Flood data	No risk flood	Moderate risk flood	Vulnerable flood
Soil data	Dry	Moist	Wet
Land use type	Sparse vegetation Grass land	Moderate dense vegetation, cultivated land and marshy land	Built up area, dense vegetation and thick jungle
Obstacle layer	Military locations	Culvert points	Minefields and Streamlines
Road Network	Main, minor road	Track road	

Figure 2 : Terrain Trafficability criteria table

Source: Aticle " Intelligence Preparation in Battlefield"

RESULT

By the literature review, it was identified the foreign applications of GIS in their armed forces. The results of the questionnaire survey as the given below. As per in the questionnaire survey able to find the applications of GIS in the Sri Lanka Army can be apply in future.

	Question is not clear, but I used GIS	3.6%
	To make direction, access	3.6%
	Not having technical items	3.6%
	Software applications	3.6%
6. Barriers going to face applying GIS technology for their applications	Lack of GIS expertise	36.8%
	Lack of availability Of data	15.4%
	Lack of Licensed software	10.8%
	Lack of resources	10.8%
	All mentioned reasons	10.3%
	Lack of skillful workers	7.7%
	Less practical knowledge	2.0%
7. Applications of Sri Lanka Army that GIS technology can be apply	Terrain Trafficability Analysis	45.3%
	Intelligence and Operations Systems	30.8%
	All mentioned applications	5%
	Logistic Information System	2.5%
	Proximity analysis	2.5%
	Multiple, Terrain, Warehouse Management	2.5%
	Any Application	2.5%
	No application	2.5%

Source : Results of the Questionnaire survey

As per the results it was found that terrain trafficability is the most suitable application in GIS

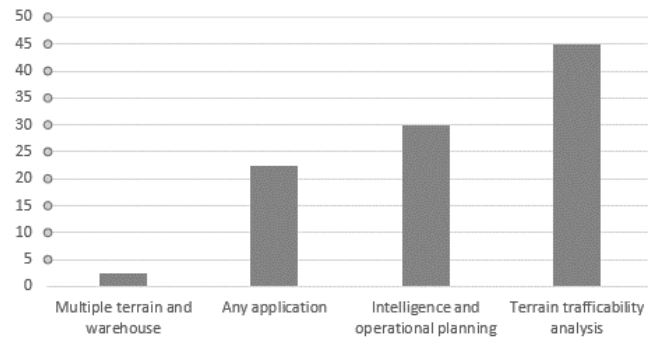


Figure 4 : Suitable application in GIS for Army

Source : Results of the Questionnaire survey

Classified Maps

Above collected data has been classified as per the criteras of the above table.

Land Use Map

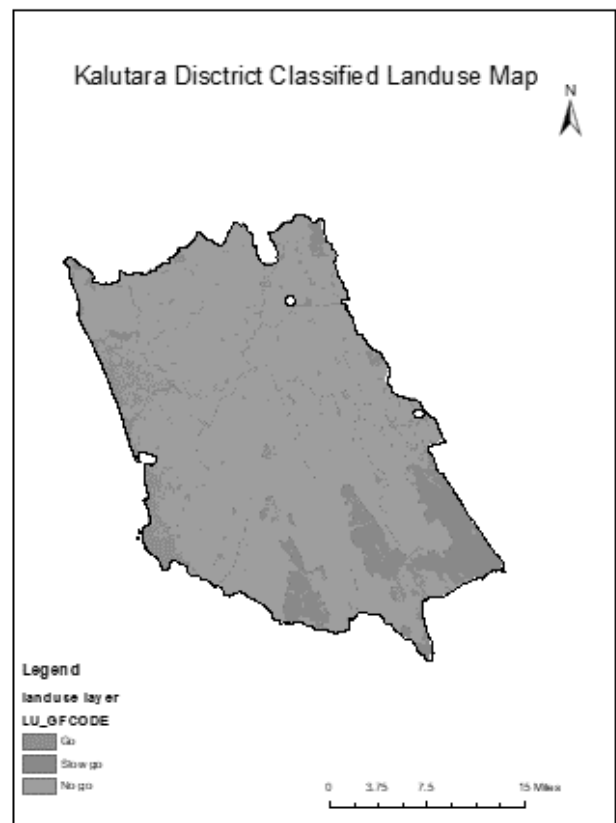


Figure 5 : Classified landuse map of Kalutara District

Source: Constructed by Researcher (2020) in ArcGIS

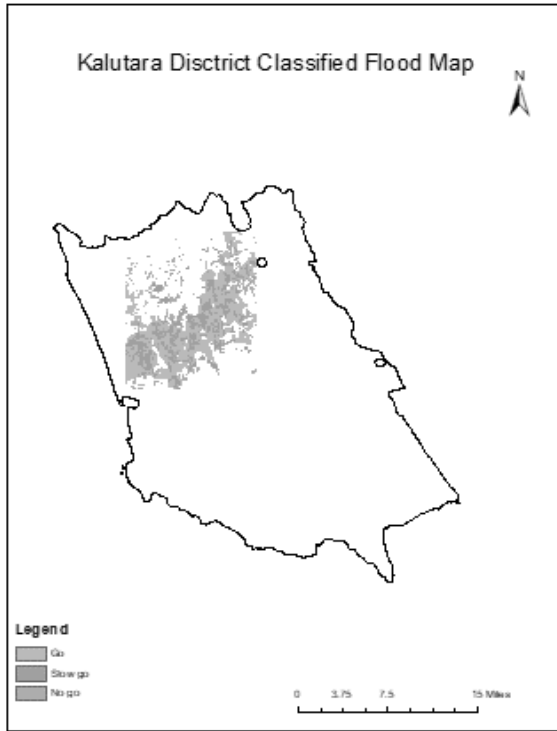


Figure 6: Classified flood map of Kalutara district

Source : Constructed by Researcher (2020) in ArcGIS

Slope Map

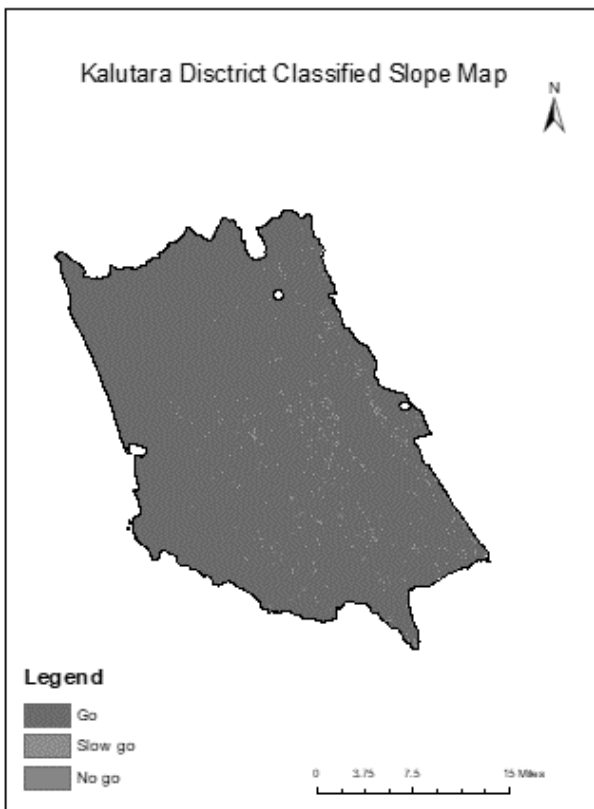


Figure 7 : Slope map of Kalutara District

According to above classified raster maps I have completed the final output of this study. It is the map shown the areas of GO, SLOW GO and NO GO areas of the teerain in Kalutara district

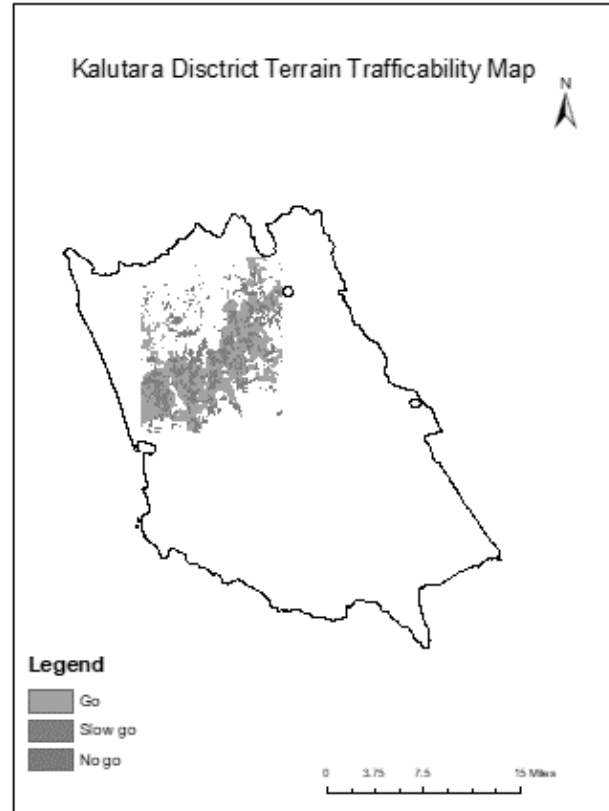


Figure 8: Terrain Trafficability map

Source : Constructed by Researcher (2020) in ArcGIS

Discussion and conclusion

GIS is a worldwide spatial technology use in most of the applications deal with terrain. Army is the ground force of military who fights in land against to the enemies. So, informations about the terrain is much important for the armed forces.

In this research first find out what are the applications of foreign armies on GIS. It has been found that GIS applications of foreign armies by referring the research paper articles in many other countries.

Questionnaire survey through google forms has been conducted to identify what are the present applications of GIS in Sri Lanka army and for what kind of applications we can apply GIS in future. It has been find out terrain trafficability

According to the above requirement terrain
traffability map has been created in ArcGIS
software. It can be clearly show areas which can
be identify to the solider as go, no go and slow
go. Eventhough it has been done through the IPB
process manually this method is more efficient
and very accurate.

But when we going to implement this kind of
model to the military purposes, officers who
involve with decision making procedures based
on geospatial data should have sufficient
knowledge on GIS.

References

Warren, S. and Bagley, C. (1992). SPOT imagery and GIS in
support of military land management. *Geocarto
International*, 7(1), pp.35-43.

Geospatial World. (2020). A GIS Assisted Knowledge-Based
Approach for Military Operations - Geospatial World.
[online] Available at:
[https://www.geospatialworld.net/article/a-gis-assisted-
knowledge-based-approach-for-military-operations/](https://www.geospatialworld.net/article/a-gis-assisted-knowledge-based-approach-for-military-operations/)
[Accessed 30 Jan. 2020].

Docplayer.net. (2020). GIS (geographic information
systems) in ccis (command & control systems) - pdf Free
Download. [online] Available at:
[https://docplayer.net/19289708-Gis-geographic-
information-systems-in-ccis-command-control-
systems.html](https://docplayer.net/19289708-Gis-geographic-information-systems-in-ccis-command-control-systems.html) [Accessed 30 Jan. 2020].

SOFREP. (2020). GIS and NOCS: Italy's Law Enforcement
Counterterrorism Units | SOFREP. [online] Available at:
<https://sofrep.com/news/gis-nocs-italys-law->

Esri.com. (2020). [online] Available at:
[https://www.esri.com/library/brochures/pdfs/gis-in-
defense.pdf](https://www.esri.com/library/brochures/pdfs/gis-in-defense.pdf) [Accessed 30 Jan. 2020].

Ieeexplore.ieee.org. (2020). Brokering meteorological and
oceanographic information in support of military
operations using GIS technology - IEEE Conference
Publication. [online] Available at:
<https://ieeexplore.ieee.org/document/1192122/>
[Accessed 30 Jan. 2020].

Geospatial World. (2020). The Importance of GIS in
Battlefield Surveillance - Geospatial World. [online]
Available at:
[https://www.geospatialworld.net/article/the-
importance-of-gis-in-battlefield-surveillance/](https://www.geospatialworld.net/article/the-importance-of-gis-in-battlefield-surveillance/) [Accessed
30 Jan. 2020].

Acknowledgment

Sincere gratitude forward to Mrs. KA Dinusha and
Mrs. KUJ Sandamai who were the supervised
this research work and all the institutions given me
required data of this research Survey Department,
Agricultural Department etc.

Author Biography/IES



KWGIM kalugamuwa is Lady
Officer cadet in General Sir John
Kotelawela Defence University
Southern Campus. She is
following Bsc. (Hons) Surveying
Science degree in this university.