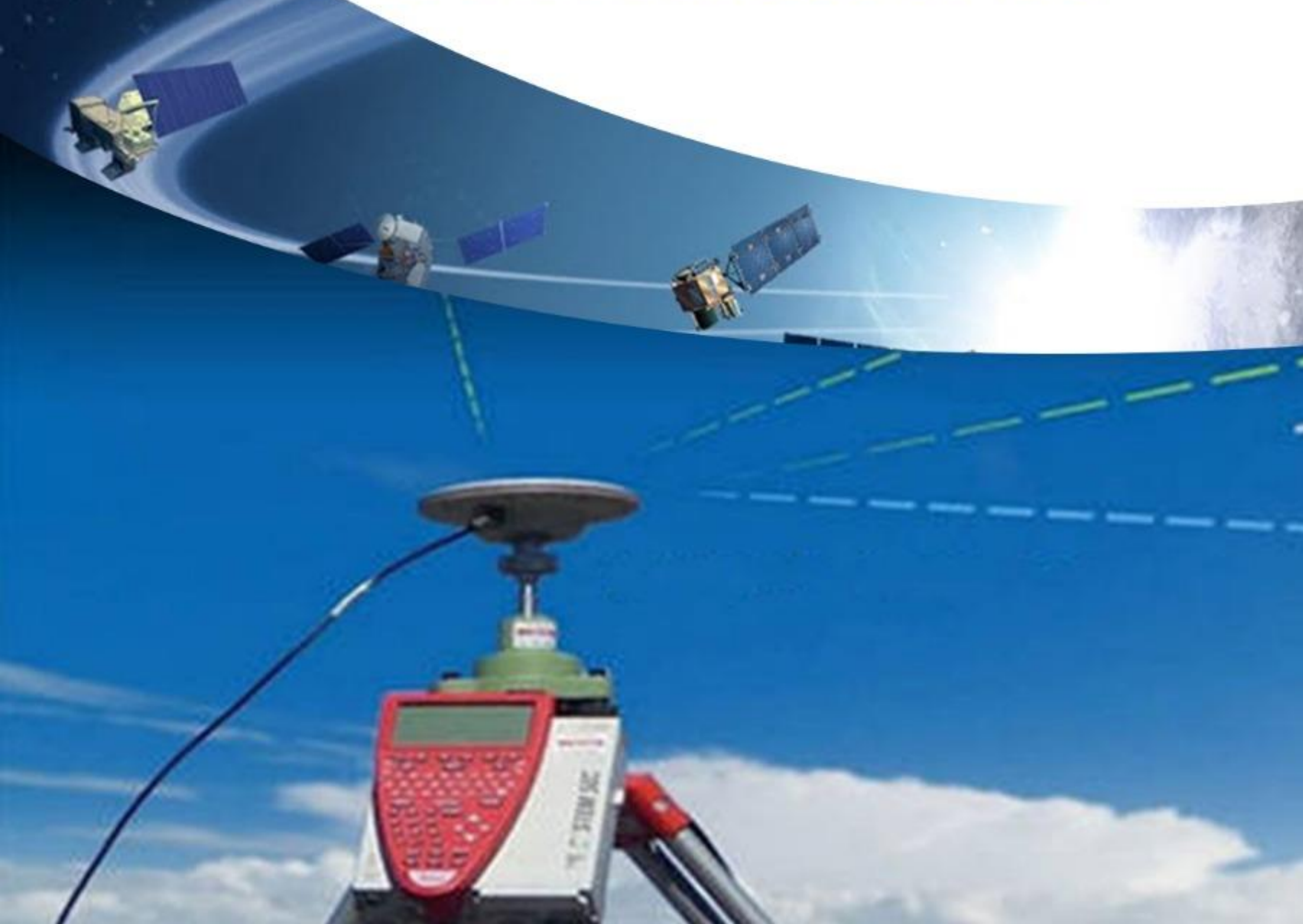
Edition - (1) - 2021-1

JOURNAL OF INSTITUTE OF SURVEYING AND MAPPING DIYATALAWA



JOURNAL OF
INSTITUTE OF SURVEYING AND MAPPING,
DIYATALAWA

Edition (1) - 2021

ABOUT JOURNAL

Journal of Institute of Surveying and Mapping, Diyatalawa which is published annually by the editorial board of Institute of Surveying and Mapping, Diyatalawa, Sri Lanka. The vision of this journal is to offer an academic platform to researchers to publish their researches related to geo-informatics, surveying and mapping in a high quality at national and international level. It proposes to encourage doing research on particular discipline which is very much useful to today's world and also it is designed to be read by academics, professionals, students, reflective practitioners, and those seeking an update on current experience and future prospects in relation to contemporary technology and education themes in surveying professions.

PUBLISHER:

Journal Editorial Board,

Institute of Surveying and Mapping,

Diyatalawa,

Sri Lanka.

057-2229002 & 057-2229004

E-mail: jismdeditor@gmail.com

Web: www.ism.ac.lk

Message from Chief Editor

Being the 17th Director of the institute of Surveying & Mapping and having ranked with the post of Senior Deputy Surveyor General (training) in the Survey Department, it is my great pleasure to publish the 1st ISMD Journal (1)-2021-1 as the most needed academic endeavour of the institution.

Through our great vision "To be the focal point in Geo informatics Education, Training and Research in the South Asian Region" we are performing our mandatory duties while facing the professional challenges against the true mission of "Planning and Conducting Training Courses relating to Geoinformatics, Updating Educational Curriculums, Guidance in Developing Professional Capacity Building and Providing Technical Expertise and Consultancy Services".

With establishment of the Survey Department on 2nd August 1800, being the pioneer in surveyor professional training, institute for surveying & mapping Diyatalwa; ISMD is performing the utmost responsibility for the surveying and mapping industry from its inception in 1969. Prior to that, the survey training school functioned since 1926, at the same location, had conducted numerous training courses rendering an esteemed service for the profession. Hence, as collective effort, the ISMD has rendered its profound service for nearly a hundred years for thousands of geomatics professionals who work as professional leader today in many countries .

Today, the surveying and mapping technology is being tremendously evolved over the world through many different terminologies such as GIS, LIS, Remote Sensing, GNSS and Artificial Intelligent tools like virtual reality and augmented reality etc. Similarly, training and capacity building too become more convenient and interesting via sophisticated on-line services. Therefore ISMD academia and the respective professionals over the world, most often attend in professional innovations and geoinformatic researches with invaluable outcomes that would intrigue the social well-being and state-of-the-art living status.

Hence, publication of this ISMD journal shall be a great opportunity with a new technological provision for those who wish to share the knowledge and skills for a smart geospatial world to be dawned on tomorrow.

With my big thanks to the editorial board and the authors contributed with innovative research papers, let me end with the saying; “a journey of a thousand miles shall begin with the first step”, I wish this first edition of the ISMD journal would be a beginning of thousands of publications endeavouring incredible research outcomes in future.

Mr. N.J. Wijenayake
Senior Deputy Surveyor General,
Director,
Institute of Surveying and Mapping,
Diyatalawa.

Message from Chairman,
Advisory and Coordinating Board of
Institute of Surveying and Mapping, Diyatalawa.

As a Chairman of Advisory and Coordinating Board of Institute of Surveying and Mapping, Diyatalawa and as the Surveyor General of Sri Lanka, I feel extremely happy and proud of adding this message to the first publication of **Journal of Institute of Surveying and Mapping, Diyatalawa.** I strongly believe that this dedicated approach towards dissemination of knowledge on the subject areas such as Surveying Sciences and Geo-informatics education will be immensely beneficial for the whole surveying profession and it is undoubted that this journal is a precious collection of research articles with high academic value to the surveying profession.

Research exploration on Surveying Sciences and Geo-informatics education has become a timely requirement as the surveying profession needs to be broadened in the knowledge-based current world. In catering to this need, I strongly believe that publishing this journal towards the dissemination of knowledge related to the surveying profession will be immensely beneficial for the whole country.

In conclusion, I convey my warmest congratulations and sincere thanks to the Director of the Institute of Surveying and Mapping, Diyatalawa who directs and guided his professional staff to cope with contemporary educational trends. And also I take this opportunity to appreciate the knowledge explorers, the authors, the Editorial Board and reviewers for developing first class articles with rich content in research disciplines. I wish and hope that this journal would make its progress over years by nourishing to the surveying profession.

Mr. W.T.M.S.B. Tennakoon,
The Surveyor General,
Chairman, Advisory and Coordinating Board of
Institute of Surveying and Mapping, Diyatalawa.

Authors' Detail

Mr. A. Dissanayake

B.Sc. (Hons) (University of Ruhuna, Sri Lanka), Higher Diploma in Surveying (Institute of Surveying and Mapping, Sri Lanka), M.Sc. in Geodetic Science & Surveying (The Ohio State University, Ohio, USA).

Mrs. K.G. Lakshika

B.Sc. in Surveying Sciences (Institute of Surveying and Mapping, Diyatalawa), B.Sc. in Industrial Statistics and Mathematical Finance (University of Colombo), B.Sc. in Information Technology (University of Colombo), M.Sc. in Applied Statistics (University of Colombo), Master of Business Administration (University of Moratuwa), B.Sc in English (Aquinas College of Higher Studies)

Miss. R.S.S. Rangali

B.Sc. in Physical Sciences (University of Colombo), B.Sc. (Hons) in Surveying Sciences (Institute of Surveying and Mapping, Sri Lanka) M.Sc. in Surveying Sciences (Reading) (University of Sabaragamuwa).

Mr. N.J.Wijenayake

B.Sc. (Hons) (University of Ruhuna, Sri Lanka), Higher Diploma in Surveying (Institute of Surveying and Mapping, Sri Lanka), M.Sc. in Geoinformatics (University of Twente, The Netherlands), Certificate in Urban Land Administration Swedesurveys (Sweden).

Director, Institute of Surveying and Mapping, Diyatalawa.

Mr. N.M.A.Wijeratne

B.Sc. (University of Peradeniya, Sri Lanka), B.Sc. in Surveying Sciences (Institute of Surveying and Mapping, Sri Lanka), M.Sc. in Geoinformatics (University of Twente, The Netherlands)

Senior Lecturer, Institute of Surveying and Mapping, Diyatalawa

Mr. M.T.M. Rafeek

B.Sc. in Surveying Sciences (Institute of Surveying and Mapping, Sri Lanka), Higher Diploma in Surveying (Institute of Surveying and Mapping, Sri Lanka), M.Sc. in Geoinformatics (University of Twente, The Netherlands)

Senior Lecturer, Institute of Surveying and Mapping, Diyatalawa

Mr. W.R.M.Fernando

B.Sc. in Computation and Management (University of Peradeniya), B.Sc. in Surveying Sciences (Reading) (Institute of Surveying and Mapping, Sri Lanka)

Apprentice Surveyor, Institute of Surveying and Mapping, Diyatalawa.

Dr. K.Thavalingam

B.Sc. (University of Peradeniay, Sri Lanka), Higher Diploma in Surveying (Institute of Surveying and Mapping, Sri Lanka), Post Graduate Diploma (University of Twente, The Netherlands), M.Sc. (University of Moratuwa, Sri Lanka), Honorary Doctor (IUMA, USA), FSI (SISL)

Retired Surveyor General

Mr. B.C.P. Bogahawatta,

B.Sc. in Surveying Sciences (Sabaragamuwa University of Sri Lanka), M.Sc. in Geoinformatics (University of Peradeniya), Specialized Trainings at AIT-Thailand, JAXA and University of Tokyo - Japan.

Mr. V.Nitharsan

B.Sc. in Mathematics (University of Jaffna), B.Sc. in Surveying Sciences (Reading) (Institute of Surveying and Mapping, Sri Lanka)

Apprentice Surveyor, Institute of Surveying and Mapping, Diyatalawa.

Content

1

A STUDY ON ACCURACY AND EFFICIENCY OF USING THE EXISTING SRI LANKA CONTINUOUSLY OPERATING REFERENCE STATION NETWORK (SLCORSnet) IN SRILANKA

A.Dissanayake [1], K.G.Lakshika [2] and R.S.S.Rangali [3]

[1] Additional Surveyor General, Survey Department of Sri Lanka (SDSL)
[2] Government Surveyor, Survey Department of Sri Lanka (SDSL)
[3] Government Surveyor, Survey Department of Sri Lanka (SDSL)

ABSTRACT: *Accuracy is critically important in surveying measurements. This study focused on the consistency and positional accuracy of observed measurements from SLCORSnet over the distance, and to reveal the capacity of using SLCORSnet at different locations and for the different purposes in Sri Lanka. For this, departmental established control points were observed according to the high and low observation accuracy levels acceptable to the survey work as specified in Survey Regulations, published by Survey Department of Sri Lanka. The measured coordinates were evaluated against the published coordinates of National Geodetic control network of Sri Lanka. The data were collected according to the mount point of VRS. As aimed, the integrity of using CORS network was rectified for Cadastral and other surveying requirements over the country, by fulfilling the required accuracy standards of the survey department. This study can be enhanced by using more different mount points in future.*

Keywords: ***HRMS, SLCORSnet, VRS, VRMS***

INTRODUCTION

In the present context, the Survey Department could not cater the user demands on high accurate terrain information on time. Therefore, it has been identified the need of modern technology for the SDSL in order to cater the requirements of Geo-Information community by providing up to date high accurate map and terrain information to the users. Hence an alternative technology needs to be used and the most appropriate solution is to establish island wide Continuous Operating Reference Stations (CORS) and use it accurately. As the first phase, six CORS were already established covering the Western part of the country in Colombo, Awissawella, Katana, Ratnapura, Kegalle and Kalutara. This Continuously Operating Reference Station Network which is governed by the SLSD is known as the SLCORSnet; which is used to give highly accurate value for position using Global Navigation Satellite System (GNSS) technology. By connecting several reference stations, a network is formed to act as a virtual reference network for clients to log in and obtain Radio Technical Commission for Maritime Services (RTCM) corrections to increase the positional accuracy. This transmitted raw data is processed using a GNSS network processing software (GEO++ GmbH) housed at the Control Centre.

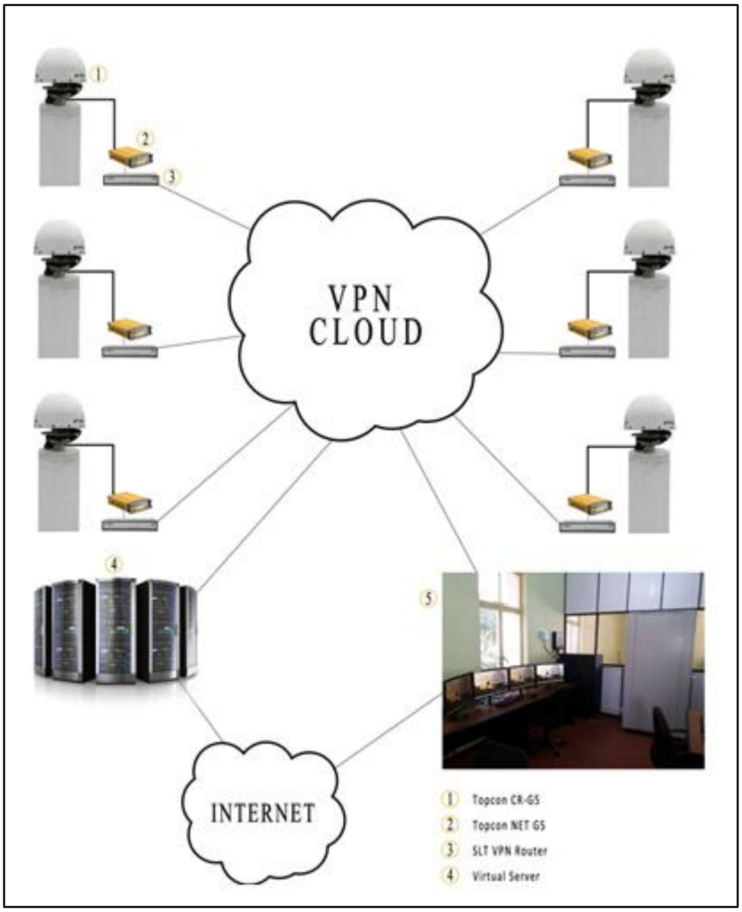


Figure 1: Components of SLCORSnet System

The capacity of distributing correction depends on the SLCORSnet System Software and Mobile network coverage. Normally Geo++ is recommended 15 km distance from the outer edge of the CORS bases towards outside the network for Cadaster surveying purpose. Therefore, this study was objected to rectify the accuracy of using the SLCORSnet for surveying work with the distance from the existing network.

METHODOLOGY

The accuracy of the measured coordinates of this case study was evaluated against the published coordinates of National Geodetic Control Network of Sri Lanka, since SLCORSnet is differentially connected to Primary Geodetic Control Points; established by SLD 99 datum (Sri Lanka Datum).

The accuracy evaluation was mainly divided into two segments as within the area of SLCORSnet and outside the area of SLCORSnet. According to the mount point of Virtual Reference Station (VRS), the points were observed in different distances within and outside of the network. Network Real Time Kinematic (NRTK) observations were carried out according to accuracy levels acceptable to the survey work as specified in the Departmental Survey Regulations: for the control point observation: Horizontal Root Mean Square (HRMS) = 0.015 and Vertical Root Mean Square (VRMS) = 0.030 and for Topographic point observation: HRMS = 0.050, VRMS = 0.100; and examined the required consistency and accuracy. All the observations were taken when the fixed status was shown, according to the given specifications for the control and topographic accuracy.

RESULTS AND DISCUSSION

Control points of the National Geodetic Control Network were observed using the mount point of VRS for the stated two observation accuracy levels as control and topographic; where five zones were selected for this assessment. These zones were located including the entire country as shown in Figure 2: Inside the CORS network, 0-20 km, 20-40km, 40-60km and 60-80km from outer boundary of the SLCORSnet region.

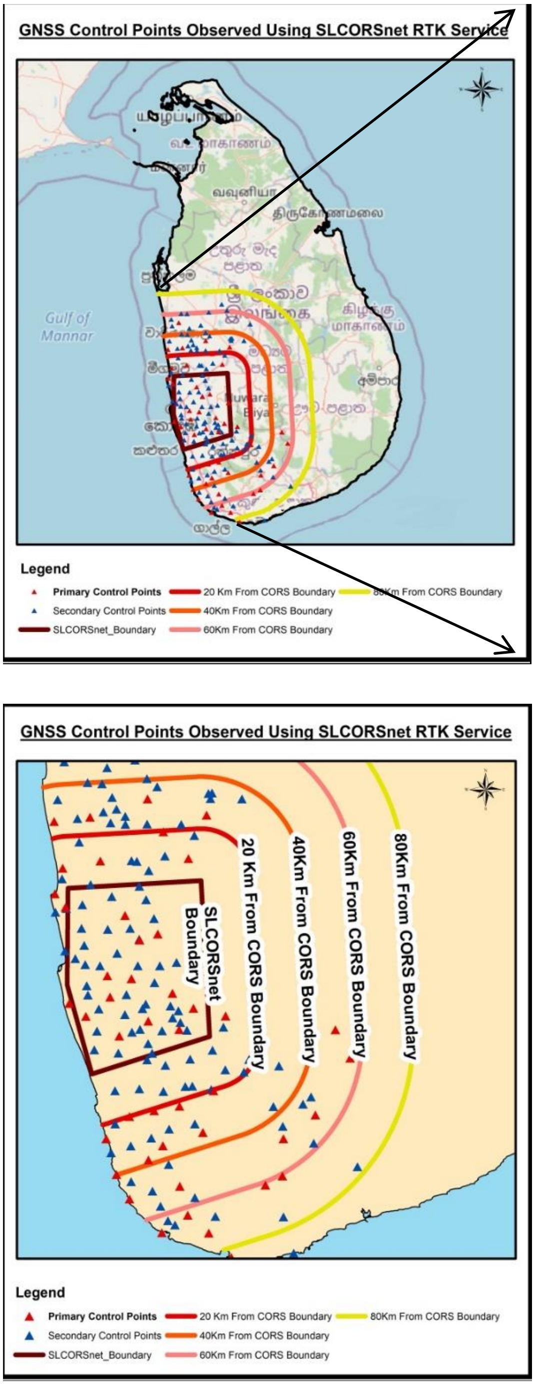


Figure 2: Distribution of Observed points for the defined seven regions

All the point observations were done by using VRS mount point and the observed points were analysed according to two observation accuracy levels as Control and Topographic respectively.

Control Observation Accuracy

The fixed status observations were taken according to the control point observation accuracy of HRMS =0.015 and VRMS =0.030. Following Figure 3 shows that most of the points in the SLCORSnet covered area are within the difference ranges up to 0.03m, which means that the variation from the original coordinate with the observed coordinate is up to 0.03m in the SLCORSnet covered area. Also, it can be seen that all the points are below the deviation of 0.05m in the SLCORSnet covered area.

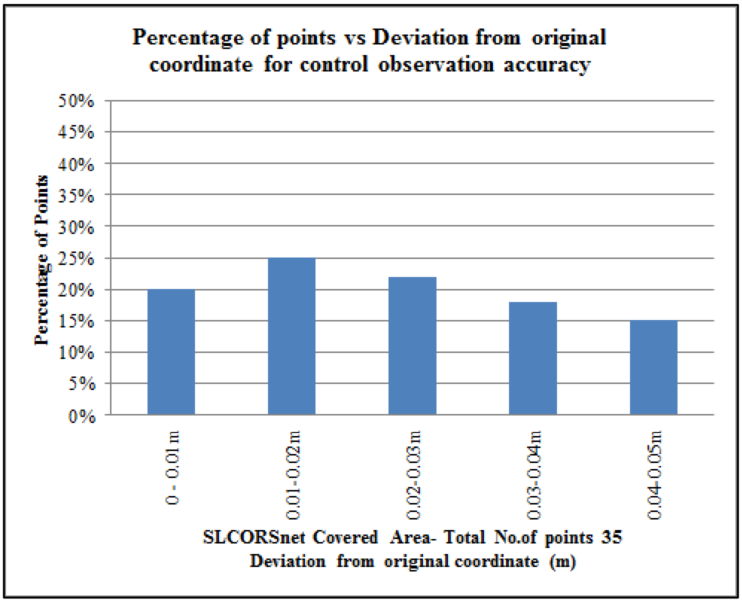


Figure 3: Distribution of Observed points percentage vs Deviation from the original coordinates inside the SLCORSnet covered area by using Contol point observation accuracy

Also the control accuracy observations of the departmental established points were taken and analysed according to the distance from the SLCORSnet area. Figure 4 illustrates that the points in the ranges away from the SLCORSnet 0-20km, 20-40km and 40-60km, most of the points percentages are below the 0.05m, where the percentages show a dramatical decrease with the increment of the distance. In the range of 60-80 km away from the SLCORSnet, most of the points percentages are in the deviation range of above 0.05m.

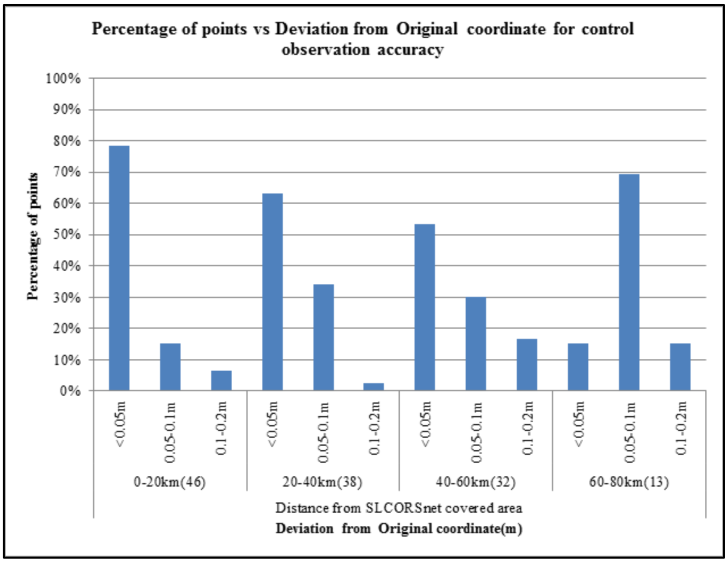


Figure 4: Distribution of Observed points percentage vs Deviation from the original coordinates outside the SLCORSnet by using Contol point observation accuracy

Topographic Accuracy

The fixed status observations were taken according to the topographic point observation accuracy of HRMS =0.050 and VRMS =0.100. Following Figure 5 shows that most of the points in the SLCORSnet covered area are within the difference range of 0.03m to 0.04m, which means that the variation from the original coordinate with the observed coordinate is in between 0.03 to 0.04m in the SLCORSnet covered area with the topographic accuracy observations where some observed points were deviated beyond the difference range of 0.05m also in the Topographic observed accuracy.

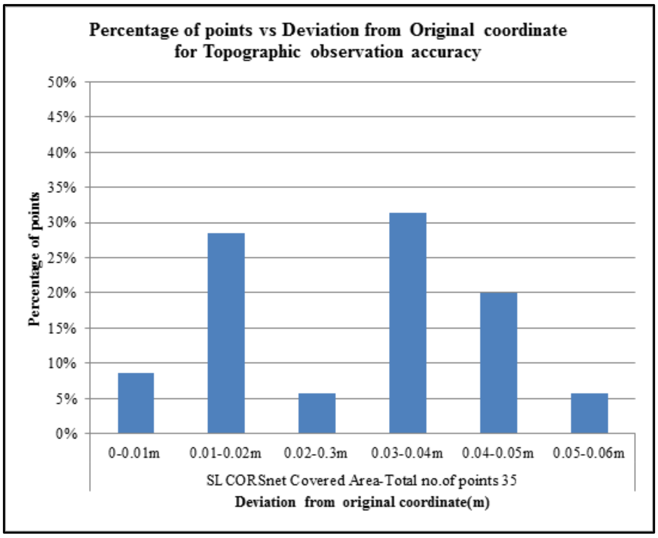


Figure 5: Distribution of Observed points percentage vs Deviation from the true coordinates inside the SLCORSnet covered area by using Topographic point observation accuracy

Also, the Topographic accuracy observations of the observed points were taken and analysed according to the distance from the SLCORSnet area. Figure 6 illustrates that the points in the ranges away from the SLCORSnet: 0-20km and 20-40km, most of the points percentages are below the deviation of 0.05m. The percentages of points beyond the range of 40km, the point percentages show higher variances with the original coordinates in the Topographic point observation accuracy.

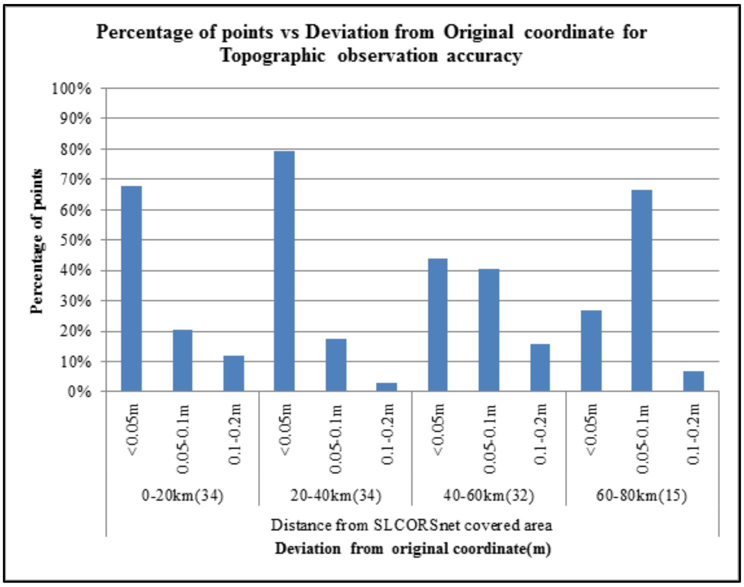


Figure 6: Distribution of Observed points percentage vs Deviation from the true coordinates outside the SLCORSnet by using Topographic point observation accuracy

CONCLUSION AND RECOMMENDATION

The accuracy assessment was done to the departmental established points in seven ranges as inside the CORS network, 20 km, 20-40km, 40-60km, 60-80km, 80-100km, and 100km onward from outer boundary of the CORS region. Inside the SLCORSnet, with the control and topographic observation accuracy, the difference between the original coordinates vs the observed coordinates' variation is up to 0.04m. When considering the ranges away from the SLCORSnet, both Control and Topographic observation accuracy observed points in the range of 0-20 km, mostly the points scattered in first two bars; which means that Geo++ is giving good corrections for 15 km distance from the outer edge of the CORS bases towards outside the network, which prove the Geo++ recommendation from the study also. So, SLCORSnet is good for cadastral surveys inside the network as well as 15 km away from the outside of the network; where the acceptable accuracy level of the department is 0.05m for Cadastral surveys. Although the Cadastral Survey work is limited to the area of SLCORSnet, the low accuracy surveys, depending on the accuracy requirement, can be conducted even outside the SLCORSnet area.

Commonly the effectiveness of surveys with SLCORSnet depends on the availability of satellite signals. The obtained results and the achievements were depending on the satellite configuration and availability of satellite signals at the time of this study in 2018. Presently with the availability of Gallio signals, other than the previously available GPS, GLONASS and BeiDou signals, more precise and accurate results can be gained. Due to the rapid changes in GNSS technology and satellite configuration, these types of studies are needed to be conducted continuously for every 1 to 2 years to get the integrity of the accurate survey work.

REFERENCES

Data Source: Survey Department, NRTK Point Observation Survey using SLCORSnet conducted in 2018

Gibbings, P.G (2005). How well does the Virtual Reference Station (VRS) system of GPS base stations perform in comparison to conventional RTK: Spatial Science Journal, University of Southern Queensland.

Positional Accuracy Handbook (1999), Minnesota Planning Land Management Information Center, USA

Sri Lanka Continuously Operating Reference Network, www.slcorsnet.gov.lk

Report on Sri Lanka Datum 1999, Survey Department of Sri Lanka

Survey Regulations, sixth edition (2020), Survey Department of Sri Lanka
Geo++web site, www.geopp.de

2

AGRO-GIS REALITY DATA MODEL AND TECHNICAL GUIDE

N.J. Wijenayake[1]

[1] Director, Institute of Surveying & Mapping Diyatalawa, Sri Lanka

ABSTRACT: *With an extended vision for supporting the national agriculture and irrigation sectors through modern GIS and Remote Sensing technology, the Institute of Surveying and Mapping (ISM) is learning its responsibility in upgrading of state-of-the-art technology for improved agricultural infrastructure planning, livestock management, crop yield prediction etc. Most the students, graduated from the national universities, are thorough with theoretical aspects of agricultural engineering and related modern sciences. However practical use of modern GIS and Remote Sensing applications in agriculture and irrigation farming sector is yet at conventional approach.*

'Agro-GIS Reality Model Technical Guide' is a real application model, designed for object-relational spatial database technology in order to apply through any GIS application software. This research paper elaborates the proper approach in Agro-GIS database technology at reality modular perspectives. It is worthy to understand that the proposed model is completely independent from GIS application software and the developers are guided to map the real world in to application models through the proposed schema.

The modular approach is basically designed with the intention of application towards the national scope agriculture in Sri Lanka. Designing of Agro-GIS model as the protocol for bridging agriculture and GIS, was tremendously intrigued by the

Regional Agriculture Research and Development Centre (RARDC) Bandarawela with the utmost technological guidance of the research officers therein.

Agro-GIS research, education and on-going collaborative project shall be a new paradigm in ISMD academia for rendering state-of-the-art technology towards the new generation awakening the national agriculture production in attractive perspectives.

Keywords: ***Agro-GIS, Data Model, Technical Guide, Agriculture, GIS***

INTRODUCTION

Beyond the theoretical approach for the Agro-GIS conceptual design and the research & educational project, Agro-GIS reality shall be a functional model which can be adapted for spatial database development as a database modular approach and also in the aspect of respective Agro-GIS data dictionary. Hence this document will be useful to the interested users in both the aspects such a way to use for data modelling purpose and technical guidance. It is worthy to note that agriculture related parameters adapted in this context are not well documented in a best applicable way to use in digital geospatial data environment. Therefore, the compilation of agriculture parameters in geo-spatial data forum should be further updated in research level and also the technical guide in this context too should be frequently updated for better use at the state-of-the-art applications.

Crops in View of Geospatial Domain

In Concern with the agriculture and geo-spatial data domain, the large crops can be considered as individual trees denoted by point coordinates with specific buffer zone and the short-run cultivations can be counted as land-plot or parcels which shall be studied in land-use or ownership units basis.

The crops in agriculture domain are in different types such as Vegetables, Root Crops, Paddy, Floriculture (Flowers & Decorative Plants), Fruits Horticulture and Perennial Crops (eg; Mango, Durian, Pears, Apple, Mandarin). These crops types are further studied as annual crops, Bi-annual Crops and perennial crops for accounting in agricultural issues.

RESEARCH OBJECTIVES

Agro-GIS concept and the project in Sri Lanka, is a new approach to link agriculture and GIS into real working model in view of developing the real application scenarios. Even-though, commercially available GIS application software can be customized to use with agriculture monitoring and infrastructure development, structuring of geospatial data in correct order to facilitate in processing for spatial database would be rather complicated issue. Hence, following research objectives shall be answered in this collection.

1. Identification of agriculture related geospatial entities and defining them in GIS domain.
2. Designing of Agro-GIS data model on basis of object relational database modelling.
3. Modelling of relational attribute fields for spatial and none-spatial data.

4. To develop a complete Agro-GIS data model and data dictionary in order to elaborate a prototype which is scalable at national level applications.

RESEARCH METHODOLOGY

The concept for Agro-GIS "Data Model & the Technical Guide" was subsequently triggered after the submission of "Agro-GIS concept proposal" and the "Agro-GIS collaborative project proposal". This sequential approach was commenced with understanding the real needs for practical direction of the Agro-GIS implementation point of view. Even-though there are many GIS application software for direct uses, rather spending time for modular approach, with my personnel experience in designing of the Land Information System (LIS) for Sri Lanka, I realized the needs and the value in well-structured methodological approach for Agro-GIS data modelling. Especially, as the new subject for designing of creative link with Agriculture and GIS; Agro-GIS, I had to spend more time to think of data consistency and compatibility in this research approach.

In methodological approach, it was firstly analyzed the agriculture parameters of the crops directly related in geospatial data forum. The specific geospatial entities can be introduced in two different aspects such as;

1. Crops live longer that should be analyzed as single entity with location coordinates representing with point topology linked to tree spacing.

2. Annual crops, those comparatively live for shorter duration shall be considered as polygon entities at individual land-plots or terrace basis.

In concern with the research objectives, identifying of spatial related agricultural parameters was attended by collaborative discussions with the respective research officers of RARDC in a few follow up meetings. Subsequently, all the possible attribute fields and parameters were studied at object relational data modelling aspect in geospatial data forum. Eventually all the attribute fields were considered in to normalized tables with defining of primary keys and relevant foreign keys for developing the object relationships.

Microsoft Access tools in database designing were used for developing the final schema.

AGRO-GIS DATA MODELLING

Crops in relation with the geospatial data can be systematically modelled to elaborate a system which is learned as Agro-GIS. The properties of crops have a close relation with their geographical locations and the ecological parameters. In data modelling process, these interlinked parameters should be carefully analyzed for designing of useful geospatial system in order to map with the available software for developing of friendly systems. The conceptual design of Agro-GIS can be easily mapped in to the diagram as shown in the figure-1.

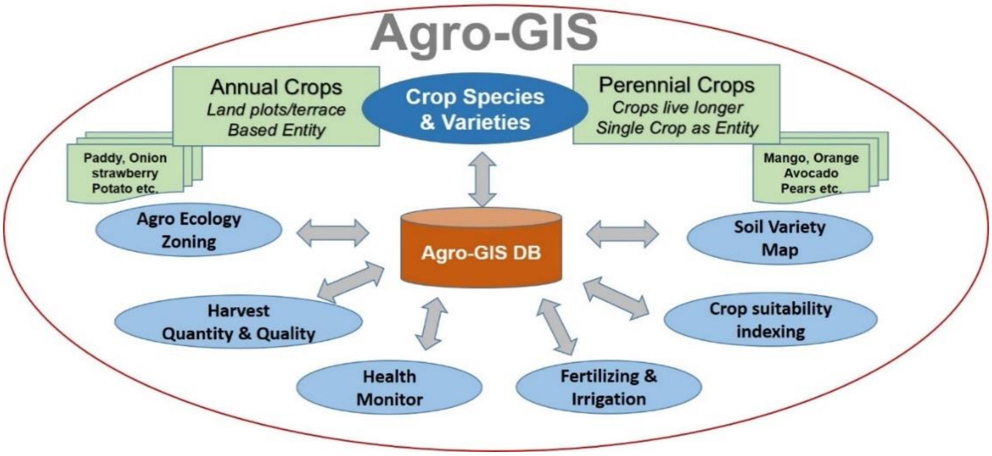


Figure1: Agro-GIS Infrastructure

Agro-GIS Database schema

The feature classes and attribute tables, which are discussed in this research paper have been carefully studied and analyzed to identify their inheritance and relationships in order to maintain the database consistency and compatibility. Some of the attribute fields, such as feature identity numbers and feature codes are not being used at present. Therefore, it is expected to discuss with the agriculture research sectors for introducing of such important means in respective fields under the on-going "Agriculture Research and Education Project" launched recently in the ISMD. The top-level feature identification and classification in proposed Agro-GIS is shown in figure-2.

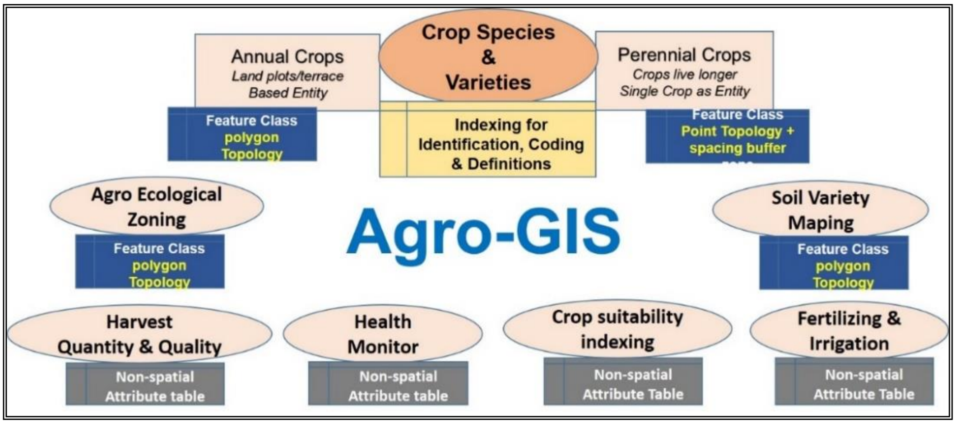


Figure-2: Agro-GIS Feature Classification

The database schema was developed in Agro-GIS system analyzing stage, considering of current usage and application scenarios with better understanding of expected sustainable system. See the system database schema in figure-3.

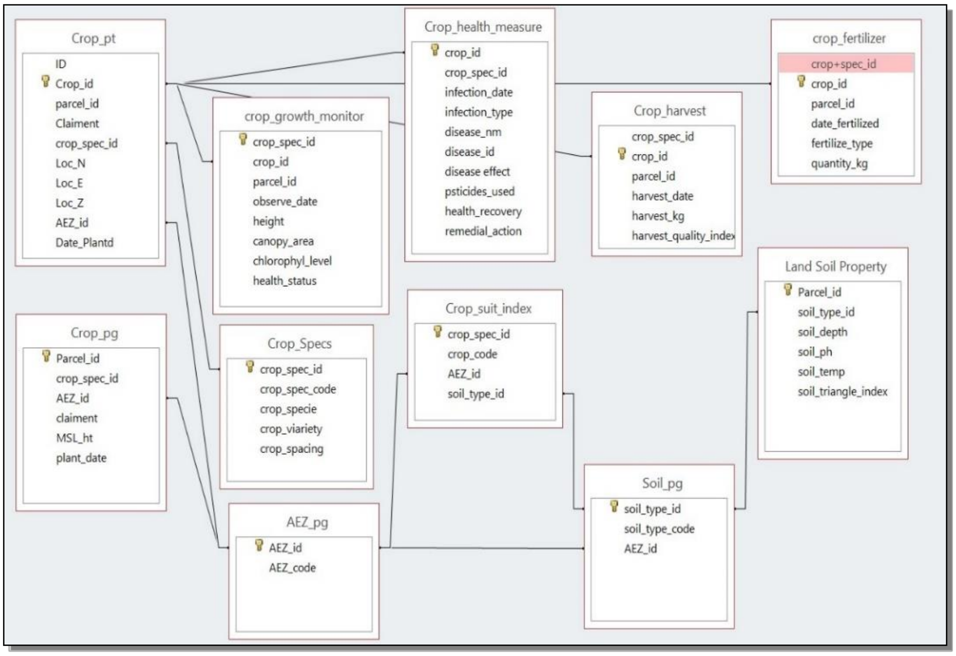


Figure-3: Agro-GIS Database Schema

Perennial Crops - Feature Class; Crop.pt

Perennial crops are scattered apart from each other with certain distance and they have comparatively longer lifetime. Therefore they can be represented geographically with its location point coordinates and the area can be defined with specific buffer zone.

The specific attributes fields, their specifications and data type representing in the spatial database are also formatted in the same table so that compilation to database can be easily followed in regular manner.

Table-1; Feature Class: **Crop.pt**

Feature Class: **Crop.pt**		
Geometry	**Capture**	**Definition**
Point	Location Coordinates N,E,Z	The Crop is the basic spatial entity in Agro-GIS, defined with an identical location coordinates and respective buffer zone. Radius of the buffer zone is defined in respect of crop type.
Point Attribut Table		
Field Name	**Data Type**	**Specifications**
Crop id	Text/Int	Identity number assigned to individual crop. This is the Key attribute for feature class
Parcel id	Text	Land-plot id; foreign key to LIS parcel_ID
Crop spec ID	Text	Crop spec id, assigned to relevant crop specie
Claimant	Text	Owner/Claimant’s name or identity

Location Node N Location Node E Location Node Z	Text	Measured Coordinates in meters with 3-decimals
AEZ ID	Text	Climate zone id ; Foreign key to feature class: AEZ.pg
Date planted	Date	Date planted to be checked from date picker

Annual and Bi-Annual Crops Feature Class; Crop.pg

The crops that can be geospatially studied as a cluster of crops in a garden or individual ownership based land-plot which shall be basically modelled in Agro-GIS with the geospatial entity as polygon in formats given in the table-2, below. Relevant polygon attribute fields are also classified and shown in regular manner with necessary specifications.

The crops learned under this feature class are mostly smaller in size and also they are grown in clusters like paddy, onion and strawberry etc. Both the crops learned under identical trees or cluster of crops in specific area unit as defined in feature classification tables are referred to specified "crop spacing" as defined by the agriculture department.

Table-2; Feature Class: **Crop.pg**

Feature Class: **Crop.pg**			
Geometry	**Capture**		**Definition**
Polygon	Map/Plan/Image digitized, GPS traced or Field Surveyed parcel boundary and vertexes.		Identical Polygon with specific identification based on recognized Cropspec feature or Identified as ownership or Claimant based.
Polygon Attribut Table			
Field Name		**Data Type**	**Specifications**
Parcel id		Text	Land-plot id assigned or foreign key to LIS
Crop spec ID		Text	Crop spec id, assigned to relevant crop types
AEZ ID		Text	Climate zone id; key to feature class: AEZ
Claimant		Text	Owner/Claimant's name or identity
Avg. MSL Height		Text	Average MSL height of the land parcel as Measured height (MSL) in nearest meter
Date planted		Date	Date planted to be checked from date-picker

Agro Ecological Zone Feature Class; AEZ.pg

Agro Ecological Zone (AEZ) map published by the agriculture department will be used as the AEZ feature class at country domain. The same map has been digitized by the Natural Resource Management Center; Peradeniya and it is available in '*ESRI*.shp' file format. However, assigning of AEZ identity numbers and identification codes for each zone should be introduced at uniform manner. AEZ feature class was designed with polygon topology and the attribute fields; AEZ id numbers and feature code attributes were introduced respectively in the data model.

AEZ.pg feature class and the attribute fields are detailed in the table-3 below;

Table-3; Feature Class: **AEZ.pg**

Feature Class: **AEZ.pg**		
Geometry	**Capture**	**Definition**
Polygon	AEZ map digitized by the Natural Resources Management Center; Peradeniya	Defined Agro Ecological Zones (AEZ) by the Agriculture Department. Forty six (46) zone codes assigned and the zone identification numbers.
Polygone Attribut Table		
Field Name	**Data Type**	**Specifications**
AEZ ID	Text	Defined ID for each AEZ zone
AEZ Code	Text	Defined Code of the each zone

Soil Type Feature Class: Soil.pg

Soil Types map published by the agriculture department will be used as the Soil feature class at country domain. The same map has been digitized by the Natural Resource Management Center; Peradeniya and it is available in

‘*ESRI*.shp’ file format. However, assigning of soil identity numbers and identification codes for each areas should be introduced at uniform manner. Soil feature class was designed with polygon topology and the attribute fields; Soil type id numbers and feature code attributes were introduced respectively in the data model.

The Feature class: Soil.pg and the attribute fields are detailed in the table-4 below;

Table-4; Feature Class: **Soil.pg**

Feature Class: **Soil.pg**		
Geometry	**Capture**	**Definition**
Polygon	Soil series map digitized by the Natural Resource Management Centre, Peradeniya	Defined Soil type areas by the Agriculture Department shall be taken as polygon geometry with the attribute fields; soil type identification numbers and soil series codes
Polygone Attribut Table		
Field Name	**Data Type**	**Specifications**
Soil_type_id	Text	Defined ID for each Soil Type
Soil_type_Code	Text	Defined soil type Code for each Soil Type
AEZ ID	Text	Reference ID for each AEZ zone

NON-SPATIAL ATTRIBUTE FIELDS ASSOCIATED WITH AGRO-GIS

Considering the extended national scope and the vast area of agriculture and livestock farming in Sri Lanka, it was a critical task to summarize the necessary crop related attributes as a minimal super set that shall not be duplicated in different perspectives. However with the expertise knowledge of the officers in agriculture research institute, a minimal set of attribute data fields were identified in order to facilitate the data model.

Crop Specie codes and Identity

There are various crop species and also subsequently defined varieties which are conventionally used by the agriculture department. Crop species and Varieties classification and coding have not been followed in regular methodology and no customary published crop species dictionary found available. However as an initiative collection with the intention of further elaboration, it is expected that the agriculture department will follow up to develop a dictionary on this aspect.

Table-5; Attribute table '**Crop Species'**

Attribute Table: **Crop Specie**				
Attribute Field	Data Type	Specifications	Example	
Crop spec ID	Text/Int	Identity number assigned		
Crop spec code	Text	Assigned Code		
Crop Specie	Text	Crop Identity name	Mandarin	Pears
Crop Variety	Text	Crop variety name	Ehimi	Raha ngala

Crop Spacing	Num/m	Recommended space between two crops in metres		

Crop suitability Index

Crop suitability in agriculture researches ‘point of view, has a great impact in sustainable agriculture development. Agro ecological zoning has been developed in respect of certain basic parameters, such as; climate, rainfall and soil type etc. However, in Agro-GIS point of view, it will be rather easier and very much useful to introduce a “Crop suitability index” which would be an exciting outcome to the agriculture community. Crop suitability index can be generated with spatial analysis of basic feature classes; AEZ_pg, Soil_pg and Crop_spec_id. Agriculture researchers are yet to validate the proposed Crop Suitability Index to assure its credibility.

Table-6; Attribute table ‘**Crop Suitability Index’**

Attribute Table: **Crop_Suit_Index**		
Attribute Field	Data Type	Specifications
Crop spec ID	Text/Int	Identity number assigned
Crop Code	Text	Assigned Code
AEZ id	Text/Int	AEZ id Reference
Soil_Type_id	Text/Int	Soil_Type_id Reference

Soil Properties of Lands

The soil map published by the agriculture department provides a good picture to indicate the country-wide variance of soil types. In concern with other physical and chemical factors as detailed by the agriculture researchers, a few more parameters described in following table are essential to study at individual land-plot basis in order to upgrade or fertilize the soil quality for respective crop species.

Table-7; Attribute table '**Land Soil Property**

Attribute Table: **Land Soil Property**		
Attribute Field	Data Type	Specifications
Parcel_id	Land Plot Identity reference	
Soil_Type id	Text/Int	Soil_Type id Reference field
Soil_Depth	Text	To measure by Agro specialist
Soil_Ph	Text	To measure by Agro specialist
Soil Temp	Text	To measure by Agro specialist
Soil Triangle Index	Num/Text	To refer

Crop Growth Monitor

Crop growth as an individual, terrace or land parcel has a quantifiable and measurable parameters which have a great value in agricultural farming for developing of good marketing strategy. The parameters detailed in the following table can be identified as a minimal set of attributes that can easily account.

Table-8; Attribute table ‘**Crop Growth Monitor**’

Attribute Table: **Crop Growth Monitor**		
Attribute Field	Data type	Specifications
Crop spec ID	Reference ID for Crop specie	
Crop id	Crop identity reference	
Parcel id	Land Plot Identity reference	
Observe Date	Text	Date picker
Height	Text	Height in meters
Canopy area	Text	Area in sqm
Chlorophyll Level	Text/Int	To follow the intl. standards
Health Status	Text	Domain selected

Crop Healthy Measure

Crop healthy is an essential means for every plant that gives a value in updating with the past records. The information can also be further extended with costing parameters in order to find the productivity measures. This data can be utilized to remove the un-economical crops and to develop a re-planting programme. Most related minimum set of attributes fields are shown in table-9.

Table-9; Attribute table '**Crop Healthy Measure**'

Attribute Table: Crop Healthy Measure		
Attribute Field	Data type	Specifications
Crop_ID	Crop identity reference	
Crop spec ID	Reference ID for Crop specie	
Infection Date	Date picker	
Infection Type	Domain Select	
Disease nm	Domain Select	Disease name and code if any
Disease id	Domain Selected	
Disease effect	Domain Select	Type of effect & which part
Pesticide used	Domain Select	Name of pesticides to select
Health Recovery	Domain Select	Recovery status and date
Remedial Action	Domain Select	Action taken against

Crop Harvest

The final and most important fact in crop are the harvest. The amount and the quality of yield is too an essential facts that would decide the crop sustainability. The simplest and most important fields are tabulated in the table-10; below.

Table10; Attribute table '**Crop Harvest**'

Attribute Table: Crop Harvest		
Attribute Field	Data Type	Specifications
Crop spec ID	Crop spec ID reference	
Crop id	Crop identity reference	

Parcel id	Land Plot Identity reference	
Harvest Date	Date picker	
Harvest	In kg.	
Harvest quality Index	To follow the standards	

Crop Fertilizer

Applying of fertilizers are generally a difficult in crop growth. The time, the type of fertilizers and quantities that are easily measurable with simple past record has a great impact in agriculture farming. Therefore a minimal set of attribute fields are listed in the table-11 below;

Table-11; Attribute table '**Crop Fertilizer'**

Attribute Table: Crop Fertilizer		
Attribute Field	Data Type	Specifications
Crop spec ID	Crop spec ID reference	
Crop id	Crop identity reference	
Parcel id	Land Plot Identity reference	
Date Fertilized	Date picker	
Fertilize Type	Domain Select	
Quantity	In kg.	

ADAPTION OF ADMINISTRATIVE BOUNDARIES

All the legally accepted administrative boundaries, maintained by the Survey Department; listed below, will be adapted as Agro-GIS associated feature classes in order to follow up in mapping and geo-spatial data analyzing purpose.

- Grama Niladari boundaries
- Local Authority (Municipality/Town/Pradeshiyasabha) boundaries
- Divisional Secretary Boundaries
- District Boundaries
- Provincial Boundaries

Land information system's (LIS) administrative boundary modelling concept and the same feature definition formats will be used in Agro-GIS too.

ADAPTION OF TOPOGRAPHICAL FEATURE LAYERS

Topographical feature classes published by the Survey Department, which are useful as Agro-GIS associative layers will be adapted to develop the Agro-GIS objectives and goals.

Agro-GIS Associated Topographic Feature Classes

Roads and Transport,

Water bodies & Hydrographic features

Ground elevation, contours and Digital terrain models

Topological features are necessary for adding real values in Agro-GIS reality in order to perform necessary analysis and mapping needs. Since the above data layers are readily available to use interactively, National Spatial Data

Infrastructure (NSDI) protocol can also be utilized to make Agro-GIS working model approach towards the easy interoperable phenomena amongst the stakeholder institutions.

Ground elevations and also the digital terrain models which are available in certain geographical domains would reflect the landscape and geographical means to the proposed system.

IMAGE DATA MOSAIC AND IMAGE CATALOGUE

It is expected that the use of modern remote sensing; satellite images and UAV drawn images are immense in Agriculture and remote sensing so that Agro-GIS must have a mechanism for image archiving and retreating facility. Hence, it is proposed to create an image catalogue and also image mosaic within the system considering the required specifications as facilitated by the application software.

Most of the commercial GIS software facilitates with advance user privileges to archive and process with satellite and UAV images. Therefore it is not required to specify and restrict the use of satellite images in Agro-GIS. However, it is necessary to concern with the image resolution, grid coverage, cloud free visions,

CREATING OF USER-FRIENDLY SYSTEM

Designing of user friendly interface is a specific need to accompany with mapping the geospatial database model in to application software. GIS application software are mostly technical advance and the respective users should undergo in required training. Since, the Ago-GIS reality model has been designed for the users who are interested in GIS and remote sensing for agriculture, a friendly interface is a must in order to promote the system usage in agriculture sector employees.

Since the Agro-GIS project is a vision to develop a geo-spatial database systems with interactive updating mechanism and data sharing protocol, NSDI is an ample opportunity in the same aspect. Therefore, I would suggest that an extended Agro-GIS at national scale shall be very much effective in agriculture information sharing and updating means through NSDI. In view of this broad mission, this pilot stage prototype application can be incorporated with NSDI enabling facility for launching of agriculture story build up scenario.

CONCLUDING REMARKS

1. Integration of modern technology in the field of agriculture can be learned as the most important issue in this era. Therefore, the efforts in the geo-spatial data forum which enables smart GIS and Remote Sensing applications, must be a reality via sustainable agriculture projects and they should be productive for economic growth of the respective stakeholders.
2. 'Agro-GIS Data Model and the Technical Guide' is a collection of necessary formats and definitions directly applicable in geospatial data forum that will be easily linked with real world scenarios. Agriculture related attributes tabulated in the modular approach herein are subject to modify for needs of specific scenarios as applicable.

3. The research study and the compilation of agriculture related geospatial field attributes and the necessary specifications were compiled with support of the research staff in Regional Agriculture Research Institute, Bandarawela. Hence, most of the agriculture attributes used in this collection are confined with regional applications. Customizing and developing the system for national scale may have to collect other regionally valued set of data fields. Especially, land-use list needs to be updated with introducing valid codes and identities as applicable.

4. Use of the common datasets such as; roads & transport, hydrography, elevation, administration boundaries and linking to the parcel based land information system are subject to the prior approval of the Surveyor General, as the Survey Department as the authorized national organization for geospatial data,

5. While modeling of agriculture parameters in Agro-GIS feature classes, there might be technological inconsistencies triggering further researches which may open access towards innovative researches.

6. There are many application software used around the world in respect of Agro-GIS. Meanwhile, familiar GIS application software too can be customized to suit the specific needs. However, it is necessary to study the specific requirements and identifying the specific geospatial entities as detailed in the data model to achieve the realistic measures and sustainability.

7. Agro-GIS database schema developed in Microsoft Access database can be used to model the ESRI personnel geodatabase and then convert to enterprise geodatabase solution as required. However, if the user wish to

use open source like QGIS, schema can be easily mapped in to the same system.

8. Introducing of systematic identification and coding criteria in agricultural parameters like AEZ, crop species, crop varieties and soil mapping etc. a better approach in national scope Agro-GIS can be designed.

REFERENCES

Belcore, E., Angeli, S., Colucci, E., Musci, M. A., & Aicardi, I. (2021). Precision agriculture workflow, from data collection to data management using FOSS tools: An application in northern Italy vineyard. ISPRS International Journal of Geo-Information, 10(4), 236. https://doi.org/10.3390/ijgi10040236

Wijenayake, N. (n.d.). (2015) Corporate-LIS for Effective Land Administration of Sri Lanka, Sri Lankan Journal of Real Estate - 2015 https://journals.sjp.ac.lk/index.php/SLJRE/article/view/2251/1223

Wijenayake, N. Concept Paper for ISM Agro-GIS Education and Research, Surveyor Journal 87; 2021; Survey Department of Sri Lanka

Matt McIntyre, (2009), Review of Land Information Systems for Land Administration, Land-use Planning and Management.

Nyark J.O. C.H.J. Lemmen, (2007), improving land value information process through the use of geo-information technology. [Online] Available at: http://webcache.googleusercontent.com/search?q=cache:FIuTbm9zlkMJ:www.isprs.org/proceedings/ XXXVII/congress/4_pdf/161.pdf+&cd=1&hl=en&ct=clnk&gl=lk., Accessed 08 April 15. e)

Stig Enemark, and Hans Sevatdal. (1999), Cadastres, Land Information Systems and Planning- Is Decentralization a significant key to sustainable development?

Survey Department of Sri Lanka; 2014 https://www.survey.gov.lk/sdweb/pdf/download/publications/survey%20journel/The%20Survey%20Journal%2082.pdf

Wijenayake, N. Land Administration and Land Information System Approach in Sri Lanka, Journal of Cadastre 2013 – Korea Cadastral Survey Corporation http://lx.or.kr/ebook/03study/siri2013_2/EBook.htm

Wijenayake, N. From Inventory Based Digital Archives to Corporate–LIS in Sri Lanka FIG Congress 2014 Engaging the Challenges – Enhancing the Relevance Kuala Lumpur,

3

APPLICATION OF MARKOV RANDOM FIELD BASED SUPER-RESOLUTION MAPPING FOR IDENTIFYING FOREST ENCROACHMENT FROM COARSE RESOLUTION SATELLITE IMAGES

N.M.A. Wijeratna

Senior Lecturer, Institute of Surveying and Mapping, Diyatalawa, Sri Lanka.

ABSTRACT: *The Forests are major determinants of a landscape's identity and help to maintain ecological and environmental stability, also they play a key role in subsistence economy. The encroachments of forest are major problems for the environment. The identification of illegal encroachments in forest is vital as it is badly affected to the stability of the forest, and to the ecology & environment. This research was carried out to check the effectiveness of Markov Random Field (MRF) based Super Resolution Mapping (SRM) for identification of forest encroachments. In this study ASTER image with spatial resolution of 15 m was used for the experimental tests. The Quality of SRM was compared with MLC (Maximum Likelihood Classification) classified image. The parameter of MRF based SRM was evaluated on ASTER data. Accuracy was assessed with kappa statistics and error measures. It is observed that SRM was superior to MLC in case of coarser resolution. Experimental test was done to find the optimal neighborhood system size with respect to various Scale factor (S). It is found that MRF based SRM is successfully identified the forest encroachment at S =10 by using ASTER image with spatial resolution of 15 m.*

Keywords: Markov Random Field (MRF), Super Resolution Mapping (SRM), ASTER, Forest Encroachment, Root Mean Square Error (RMSE), Correlation Coefficient, Scale factor (S), Fine resolution, Coarse resolution, Maximum Likelihood Classification, Smoothing Parameter.

INTRODUCTION

The identification and mapping of the Forest Encroachment is a big challenge due to the common problems to find something small than the spatial resolution of the image like objects forest encroachment which occupy small areas inside larger forests or small clearings in agricultural areas. Some of these patches are even less than 0.5 ha with background or the surrounding land cover is another barrier in proper identification. Furthermore, the relatively coarse spatial resolution of sensors does not enable the detection of all small fragments such as copses, hedgerows and scattered trees (Sheeren et al., 2009). Studies have also shown that identifying small patches is often not easy, which elements should be included and which should not, and how to describe elements discretely. Another challenge remains in getting high spectral and spatial resolution satellite imagery for a particular area and within a specific period. If we use high resolution data, it will be noisier than coarse resolution data, high resolution data is too expensive and it requires costly hardware and software for its processing. When we do classification of spectrally similar vegetation types using coarse resolution data, we are getting mixed pixel results. It is difficult to study land use or land cover at high resolution data due to large variation of the spectral values for the same classes and local variation within homogeneous fields and it has few spectral bands than coarse resolution sensors (Tolpekin and Stein, 2009).

The possible solution for the above mentioned problem may be Markov Random Field (MRF) based super-resolution mapping (SRM). The Identification of forest encroachments has been previously carried out using aerial photography and remote sensing data. One major objective within the framework of the Remote Sensing and the landscape monitoring was to investigate the added value of very high spatial resolution (VHSR) satellite data compared with digital topographical maps (1:10,000) and aerial photographs, especially in relation to small land elements (Groom et al., 2006). Medium and high spatial resolution remotely sensed data (e.g. SPOT and Landsat Thematic Mapper (TM) images) are mainly used to identify forest areas. These data provide richer spectral information and cover larger areas (Sheeren et al., 2009). A hybrid approach using both aerial photographs and ancillary data of coarser resolution to automatically discriminate small forest elements (Sheeren et al., 2009), shows its usefulness and the prospects for future ecological applications. For the proper management of forest encroachments by the concerned authorities an efficient tool is needed for clear identification of encroached areas. Super Resolution Mapping (SRM) can be effective as it results in a higher spatial resolution image from a given coarse spatial resolution image. Data from the satellite sensors like LANDSAT-TM, IRS-LISSIII, and ASTER are rich in spectral bands, economically cheap and a huge volume of archive data is available, which will help for identifications of actual changes on the earth surface. Hence, by using these coarse spatial and high spectral resolution data as an input to SRM, it is possible to solve the issues in class reparability.

Several studies have been carried out on the MRF based SRM, to study the suitability for land cover classification and change analysis. Therefore, the main objective of this research is to apply the MRF based SRM technique for identification of forest encroachments.

LITERATURE REVIEW

In the past, several attempts had been done to identify and to map the forest encroachments using remote sensing data and Geographical Information System (GIS) technique. There are several related work has been done for identification of forest encroachments using remote sensing techniques. In Abdulkadir-Sunito and Sitorus, 2007, two forests margin villages Sulawesi in Indonesia is presented to clarify the scenario of forest encroachments. Here encroachment was not only perceived as an economic action, but also an arena of ethno political action, it also explained how encroached ownership is changed. This paper describes the land use and landownership patterns in the context of inter-ethnic relationship. The forest encroachment was studied by using optical and microwave image fusion to detect and monitor illegal logging and tropical rain forest encroachment in east Kalimantan, Indonesia (Vega et al., 2006). In this paper, it was reported that the output classifications from Principal component analysis (PCA) were relatively better than other two techniques used. Comparison was made between the results of Maximum Likelihood Classification (MLC) and sub pixel classification to identify gaps by a single tree felling and it was observed that sub pixel classification outperformed MLC. It has been suggested that if the remote sensing techniques, combined with the appropriated classifiers, demonstrated better performance and reliable results. In (Vega et al., 2005), three remotes sensing fusion techniques using two different data combinations i.e., multispectral and Panchromatic from Landsat ETM; and multi-spectral and Radar data from ASAR-ENVISAT C band VV polarization were studied for the forest encroachment monitoring. However, this study has showed that the fused images obtained from multi-spectral and panchromatic data were more appropriate with exception of

Intensity Hue-Saturation created some confusion during interpretation.

In (Tatem et al., 2002b) Super Resolution map was produced by using Hope field neural network. In that study the SRM was implemented on synthetic and simulated Landsat TM imagery and it was validated by verification data derived by ground survey and manually prepared map from the digital aerial photographs with 0.5 m spatial resolution. Sub pixel mapping was obtained by using genetic algorithm in Mertens et al., 2003 here the latter mentioned algorithm was tested on synthetic and degraded real satellite imagery. The resultant Super Resolution map was compared with conventional hard classification i.e., Maximum Likelihood Classification (MLC) for the purpose of accuracy assessment.

In another study Super Resolution mapping was performed on artificial imagery and tested on artificial and real synthetic imagery (Mertens et al., 2004). In this study validation of SRM was conducted with MLC map. An algorithm was developed for super resolution target mapping from remotely sensed images in which was dependent on soft classification results (Atkinson, 2005). This algorithm was tested for its accuracy by generating realistic irregular polygon shape in SPLUS TM software. Earlier SRM was applied on real remote sensed satellite data (Kasetkasem et al., 2005). In this study SRM was obtained from IKONOS and LANDSAT imageries validated with reference data generated from panchromatic image of IKONOS and digital aerial photograph with spatial resolution of 1 m and 0.6m respectively. In (Thornton et al., 2006) sub pixel mapping was conducted for identification of hedgerows and trees and the resultant map was validated with Field data including the detailed information available on the field site. Issues associated with SRM reveals that validation of SRM is not easy (Atkinson, 2008). However, this study paves the way for accuracy assessment by providing different types of accuracy assessment methods.

SRM was conducted on normally distributed synthetic images in Tolpekin and Stein (2009). In this study accuracy assessment was done by kappa statistics at fine resolution level and accuracy at coarse resolution was assessed by Area Error Proportion (AEP), Root Mean Square (RMSE) and by using Correlation Coefficient (CC). In subsequent studies (Ardila Lopez et al., 2010 & Tolpekin et al., 2010) which were extension of method proposed in the (Tolpekin and Stein, 2009) validation of SRM was assessed by using ground survey followed by manual digitization of very high spatial resolution digital aerial photographs and they also performed pixel and object-oriented based method for accuracy assessment.

In Atkinson, 2009 it is suggested that it is very crucial to determine the goal of SRM in terms of its dimension i.e., whether it is binary or multivariate and resolution case. After knowing the latter said aspects algorithm was designed and applied to provide the solution. The SRM algorithm falls into two categories. The first contains regression type algorithms and another one is learning algorithms. The testing scenarios which involves in assessing uncertainty are provided in (Atkinson, 2009) next step is adopted which is described in the latter said paper for accuracy assessment wherein different types of accuracy assessment methods are mentioned.

But still there is need to do further research on forest encroachments. In the latter said cases Markov Random Field (MRF) based SRM was not used to study the forest encroachments. The pertaining literature with respect to forest encroachments has reviewed and found that in most of the cases forest encroachment was detected with the integrated approach of using remote sensing and GIS tools. It is clear that there are two forms of forest encroachments i.e., shifting cultivation and Illegal logging. In this research it is going to identify forest encroachment sites using MRF based SRM.

METHODOLOGY

The issues of mixed pixel in the remotely sensed satellite data occur when the sensor's instantaneous field-of-view includes more than one land cover class on the ground and it can be accommodated by using sub-pixel classification. The key problem of sub-pixel classification is determining the most likely locations of each land cover class within the pixel. In general, spatial dependence is the phenomenon that observations close together are more alike than those further apart (Chiles and Delfiner, 1999; Curran et al., 1998). Hence, an approach to consider the spatial distribution i.e., spatial dependence within and between the pixels was introduced by Atkinson et al.; 1997 in the form of SRM also called as sub pixel mapping. SRM leads to an increase in the spatial resolution of the classified image by resolving the pixel into smaller units, known as sub pixels based on spatial dependence (Thornton et al., 2006). It is assumed that the land cover class are normally distributed and they have spatial dependency both within and between the pixels. Markov Random Field (MRF) is a useful tool for characterizing contextual information and has been widely used in image segmentation and restoration. Therefore, contextual SRM method based on MRF is adopted for this research with ASTER image. The methodology of this research is shown in Figure 1 below. ASTER data is used as an input to the applied the technique and finally the result was checked for its accuracy on fine and coarse resolution level.

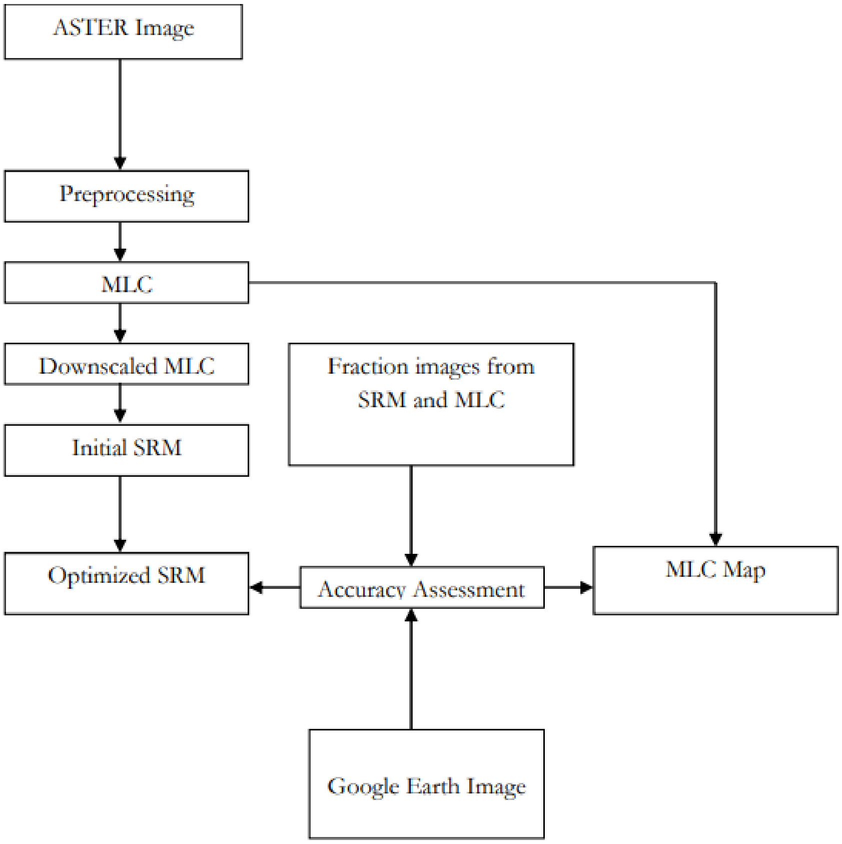
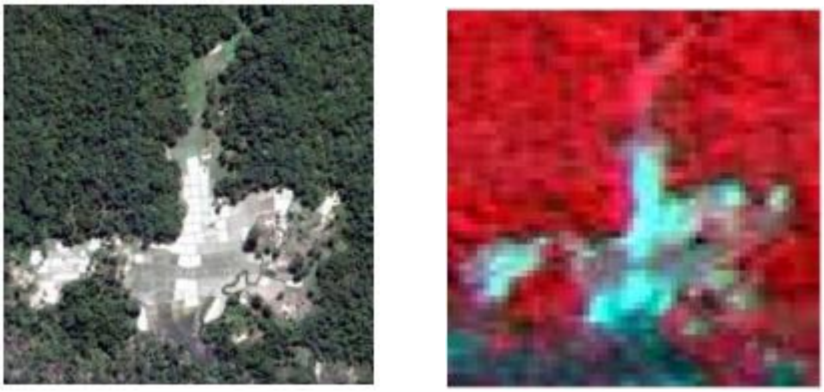


Figure 1: Methodology

In this method smoothness parameter (λ) plays an important role in MRF based SRM and it is estimated before method applied. Generally is determined by two procedures i.e., by trial and error method or by estimation done from training sites. At one hand first procedure is time consuming on the other hand second procedure is computationally expensive. In this research the internal parameter of MRF based SRM is firstly estimated by trial-and-error method. The study area for the method is shown in fine and coarser resolution images in figure 2 below.



(a) (b)

Figure 2: Study area (a) on fine resolution image (b) on coarser resolution image

RESULTS AND DISCUSSION

The results obtained from MLC for courser and fine images are given in figure 3.

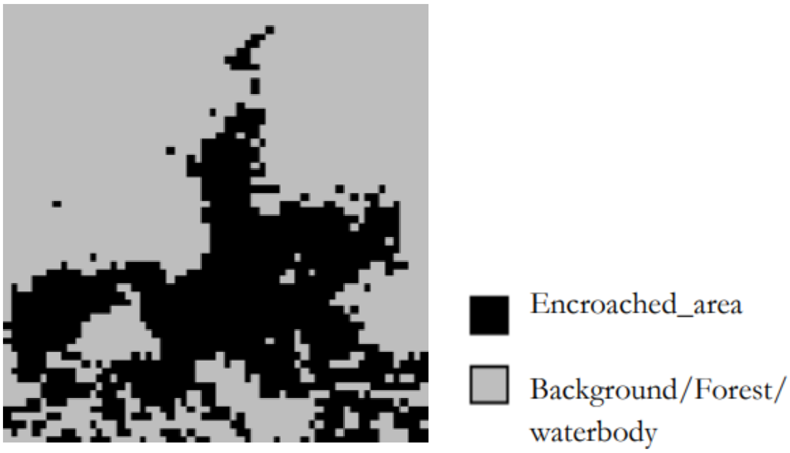
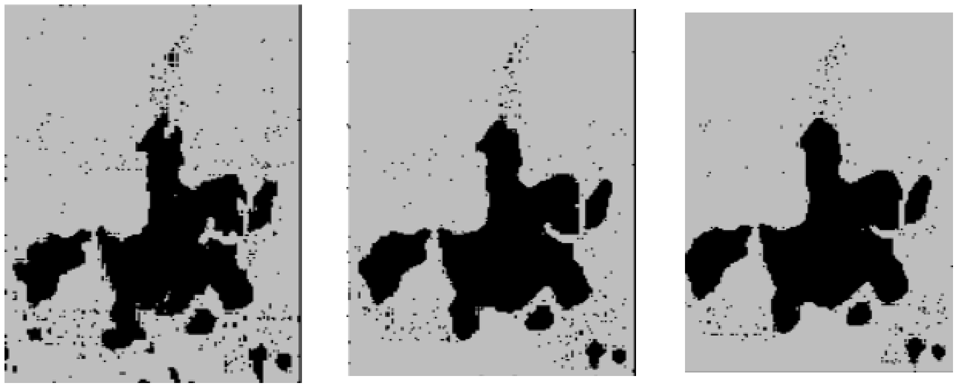
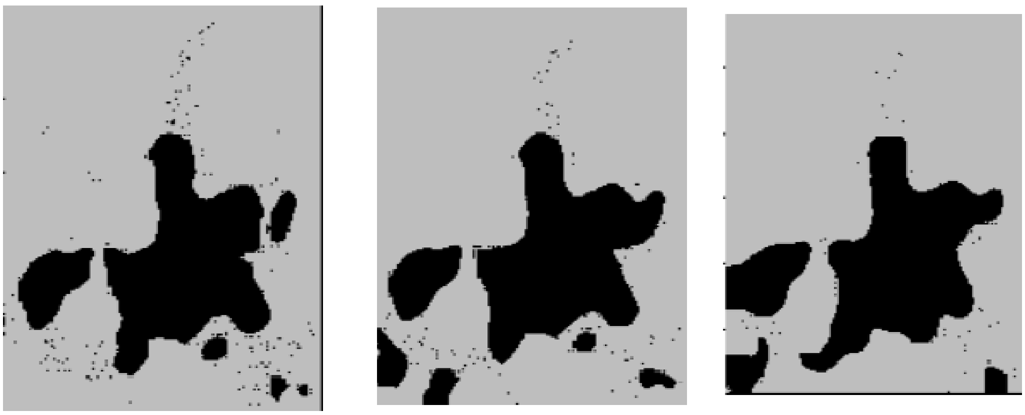


Figure 3: Encroachment area from MLC

The results of MRF based SRP achieved at S=10 with varying values are shown in Figure 4 (a)-(f) as the optimal value for scale factor is 10 (S=10).



(a) S = 10, λ = 0.3 (b) S = 10, λ = 0.5 (c) S =10, λ = 0.6



(d) S = 10, λ = 0.7 (e) S = 10, λ = 0.8 (f) S = 10, λ = 0.9

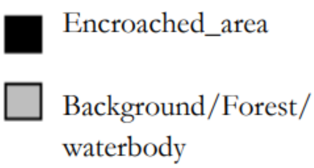


Figure 4: (a) to (f) are SRMs at S = 10 with varying λ values from 0.3 to 0.9

According to the visual inspection of the Figures 2 and 3 above, it indicates that SRM is detected forest encroachments more accurately than MLC and it is supported by the values of Root Mean Square Error (RMSE), Correlation Coefficient (CC) and Area Error Proportion (AEP) provided in the Tables 1 below. In all maps, Area Error proportion (AEP) values are reported smaller in case of SRM whereas it is high in MLC. Correlation Coefficient (CC) values are higher in SRM which shows that target and estimated fractions are strongly correlated whereas correlation is low in MLC. The RMSE is higher in MLC while RMS is lower in SRM which shows that SRM has less variance and biasness. After considering all these statistics it is revealed that SRM is better than MLC in detecting forest encroachments.

Table 1: Results of accuracy assessments.

Map	Maximum Likelihood Classification (MLC)			Maps in Figure 4	Super Resolution Mapping (SRM)		
	RMSE	CC	AEP		RMSE	CC	AEP
Figure 3	0.515	0.46	0.66	a	0.325	0.75	0.02
				b	0.412	0.57	0.05
				c	0.289	0.74	0.02
				d	0.217	0.81	0.05
				e	0.298	0.72	0.03
				f	0.312	0.75	0.04

CONCLUSION AND RECOMMENDATION

The identification of forest encroachments from courser resolution images is not more accurate from the existing classification algorithms like Maximum Likelihood Classification in present image processing software. According to the results obtained from this research it is possible to detect the forest encroachments more accurately. The shape of all maps obtained from Markov Random based Super Resolution mapping techniques are moreover preserve the shape of the encroached area but not from MLC. Therefore it is concluded that MRF based SRM technique is better for the identification of forest encroachments from the courser resolution remote sensing images.

From this research it is not concluded the optimal value for the smoothing parameter for Super Resolution Mapping technique. Therefore it is recommended to carry out further research for the determination of optimal value for smoothing parameter.

REFERENCES

Abdulkadir-Sunito, M., and Sitorus, M. (2007). From ecological to political buffer zone: ethnic politics and forest encroachment in Upland Central Sulawesi. In T. Tscharntke, C. Leuschner, M. Zeller, E. Guhardja & A. Bidin (Eds.), Stability of Tropical Rainforest Margins (pp. 165-178): Springer Berlin Heidelberg.

Ardila Lopez, J. P., Tolpekin, V. A., and Bijker, W. (2010). Markov random field based super - resolution mapping for identification of urban trees in VHR images. IGARSS 2010 : Proceedings of IEEE international Geoscience and Remote Sensing Symposium, 25-30 July 2010, Honolulu, USA. ISBN 978-1- 4244-9564-1. pp. 1402-1405.

Atkinson, P. M. (2005). Super-resolution target mapping from soft classified remotely sensed imagery. Photogrammetric Engineering and Remote Sensing, 71(7), 839-846.

Atkinson, P. M. (2008). Issues of uncertainty in super-resolution mapping and the design of an inter-comparison study.

Atkinson, P. M. (2009). Issues of uncertainty in super-resolution mapping and their implications for the design of an inter-comparison study. International Journal of Remote Sensing, 30(20), 5293 - 5308.

Atkinson, P. M., Cutler, M. E. J., and Lewis, H. (1997). Mapping sub-pixel proportional land cover with AVHRR imagery. International Journal of Remote Sensing, 18(4), 917-935.

Chiles, J. P., and Delfiner, P. (1999). Geostatistics: Modeling Spatial Uncertainty: by Jean-Paul Chilès and Pierre Delfiner, Wiley, New York, 1999, 695 pp., ISBN 0-471-08315-1, US $125.00. Computers & Geosciences, 27(1), 121-123.

Curran, P., Milton, E. J., Atkinson, P. M., and Foody, G. M. (1998). Remote sensing from data to understanding.

Groom, G., Mucher, C. A., Ihse, M., and Wrbka, T. (2006). Remote sensing in landscape ecology: experiences and perspectives in a European context. Landscape Ecology, 21(3), 391-408.

Kasetkasem, T., Arora, M. K., and Varshney, P. K. (2005). Super-resolution land cover mapping using a Markov random field based approach. [doi: DOI: 10.1016/j.rse.2005.02.006]. Remote Sensing of Environment, 96(3-4), 302-314.

Mertens, K. C., Verbeke, L., Ducheyne, E., and De Wulf, R. (2003). Using genetic algorithms in sub-pixel mapping. International Journal of Remote Sensing, 24(21), 4241-4247.

Mertens, K. C., Verbeke, L. P. C., Westra, T., and De Wulf, R. R. (2004). Sub-pixel mapping and sub-pixel sharpening using neural network predicted wavelet coefficients. Remote Sensing of Environment, 91(2), 225-236.

Sheeren, D., Bastin, N., Ouin, A., Ladet, S., Balent, G., and Lacombe, J. P. (2009). Discriminating small wooded elements in rural landscape from aerial photography: a hybrid pixel/object-based analysis approach. [Article]. International Journal of Remote Sensing, 30(19), 4979-4990.

Tatem, A. J., Lewis, H., Atkinson, P., and Nixon, M. (2002b). Super-resolution target identification from remotely sensed images using a Hopfield neural network. Geoscience and Remote Sensing, IEEE Transactions on, 39(4), 781-796.

Thornton, M. W., Atkinson, P. M., and Holland, D. A. (2006). Sub-pixel mapping of rural land cover objects from fine spatial resolution satellite sensor imagery using super-resolution pixel-swapping. International Journal of Remote Sensing, 27(3), 473 - 491.

Tolpekin, V. A., and Stein, A. (2009). Quantification of the Effects of Land-Cover-Class Spectral Separability on the Accuracy of Markov-Random-Field-Based Superresolution Mapping. Ieee Transactions on Geoscience and Remote Sensing, 47(9), 3283-3297.

Tolpekin, V. A., Ardila Lopez, J. P., and Bijker, W. (2010). Super - resolution mapping for extraction of urban tree crown objects from VHR satellite images. In: GEOBIA 2010 : geographic object - based image analysis, 29 June-2 July 2010, Ghent, Belgium : proceedings / editor E.A. Addink, F.M.B. Van Coillie. - [s.l.] : International Society for Photogrammetry and Remote Sensing (ISPRS), 2010. - (International Archives of Photogrammetry and Remote Sensing : IAPRS : ISPRS ; XXXVIII-4/C7), 7 p.

Vega, B. (2005). Image fusion of optical and microwave data to assess criteria and indicator C&I related to forest encroachment, for certification process of sustainable forest management SFM : case study in Berau, East Kalimantan, Indonesia. ITC, Enschede.

Vega, B., Hussin, Y. A., and Sharifi, A. (2006). Optical and microwave image fusion to detect and monitor illegal logging and tropical rain forest encroachment in east Kalimantan, Indonesia.

4

GEO-SPATIAL TECHNOLOGY FOR LANDSLIDE HAZARD PREDICTION MAP ALONG HILL COUNTRY RAILWAY LINE: A CASE STUDY FROM OHIYA TO BANDARAWELA, SRI LANKA

M.T.M.Rafeek[1] and W.R.M. Fernando[2]

[1]Senior Lecturer, Institute of Surveying and Mapping, Sri Lanka
[2]Apprentice Surveyor, Institute of Surveying and Mapping, Sri Lanka

ABSTRACT: *Landslides are the most recurrent and prominent natural hazard in many areas of the world which cause significant loss of life and damage to properties. By generating landslide susceptibility maps, the hazard zones can be identified in order to produce an early warning system to reduce the damage. In this paper, a case study carryout along the railway line from Ohiya to Bandarawela with 2 km buffer area has been discussed and five prominent environmental factors which mostly influence on making landslides such as* ***Slope variation, Land use pattern, Rainfall distribution, Water features and Soil type*** *were considered.*

The analysis was done on pixel basis and the probabilities obtained for each pixel in the study area using the selected criteria were classified into three such as ***Low, Moderate and High*** *based on Weighted Overly concept in modeling process to identify the risk areas. Further, Analytical Hierarchical Process was applied to weight assigning with respect to produce the relative result compared with the reality map of actual landslide occurred.*

Out of five considered environmental factors slope variation, rainfall and land use were underlined as most influencing factors for landslide while water features and soil condition were indicated as low affected factors for the landslides. To conclude, prepared landslides hazard zonation map considering identified environmental factors was validated with ground truth map and directed to the recommendation

that this study shall be continued related to manage and prevent the landslide hazards along the upcountry railway line of Sri Lanka.

Key words: Landslide hazard, GIS, Zonation map, Weighted overlay function.

INTRODUCTION

Landslide is a rapid displacement of a mask or rock, residual soil or sediments adjoining a slope in which the centre of gravity of the moving mass advances in a downward and outward direction and it is a common natural hazard in many areas of the world. Annually landslides cause many fatalities and property losses each year (Chit Ko Ko, 2001). Particularly in hilly areas this is the most recurrent and prominent natural hazards in many part of the world. Actually, landslides are one of the normal landscape building processes in them mountainous regions with respect to environmental and social factors and they become a problem when they interfere human activities. Landslides pose serious threats to structures that support transportation, natural resources management and tourism. They cause considerable damage to highways, railways, waterways and buildings (Ranjan Kumar Dahal, 2017).

In Sri Lanka too hilly terrain in the central part of the country is most vulnerable for landslides and this is become as a common problem along the hill country railway lines of the country. In recent times a series of landslides has occurred along this railway line and most of these landslides have occurred on cut slopes or on embankments alongside roads and railway lines in hill country of the Island. Sri Lanka's hill country railway line created by the British colonial to connected the upcountry areas and low country areas with the purpose of transportation of the coffee, tea, rubber etc. to the Colombo port form hill country areas. But at present this railway line became as the passengers transportation system. At present more than 20 rail transportations services take place around the upcountry railway lines per a day. Further, according to the analyzed detail report about different kind of disaster types in Sri Lanka, landslide hazard rapidly increase in the upcountry areas and specially it mostly affect to the transportation facility in upcountry furthermore this report reveals that main course of landslide in this areas are because of highly intensity rainfall, soil erosion, soil structure, land slope, geological structure and other anthropology activates etc (Kumari M. Weerasinghe, A. M. 2006; Tharaka Rathnaweera & Udeni P Nawagamuwa. 2016).

Potential sites that are particularly prone to landslides should therefore be identified in advance to reduce disaster damages. Landslide hazard assessment can be a vital tool to understand the basic characteristics of the terrains that are prone to failure especially during extreme climatic events. Landslide hazard zonation is defined as the mapping of areas with an equal probability of occurrence of landslides within a specified period of time (Crozier, M. J., & Glade, T. 2012). On the other hand Geo-Spatial technology has been used virtually everywhere in the world, including both developed and developing countries. Geographic Information System (GIS) has been almost a compulsory tool in landslide hazard and risk assessment (Varnes, D. et al, 1993). This is due to its capability in data input, manipulation of large quantity of spatial data, data management, analysis, and query of the inferable meaning of data. GIS also has the capability to make spatial prediction by combining data layers according to purposely embodied rules. Using these functions of GIS, spatial analysis of areas that susceptible to landslide can be performed (Shukla, D. P., et al, 2016).

Therefor this study is aimed to study the possibilities of identification landslide zonation area in up country railway line from Ohiya to Bandarawela and develop a landslide hazard zonation map based on environmental factors using Geo-Spatial technologies.

LITRATURE REVIEW

Environmental Factors Associated with Landslide

There are several environmental factors identified and it is important to note that the most significant factor that influenced with landslides. When identifying these factors which are responsible for landslides, slope variation of a location can be considered as key natural factor. Secondly heavy rainfall cause widespread of landslides and during last ten years it has become evident that the most devastating landslide even tend to occur as a result of comparatively short duration, high intense rainfall in this area (Rathnaweera T.D. & Nawagamuwa U.P. 2013). Another key factor of landslide occurrence is the land use type due to human activity. Among the land use types, barren land and cultivations are more prone to landslides and the forest areas tend to decrease landslide occurrences due to the natural protection provided by the thick vegetation cover. Depth of the ground water is another key factor associated with landslides and available water features with in a particular area influence a lot on landslides. Furthermore, soil types also another key factor influence on occurrence of landslides on these areas. Therefore this study includes five major factors that highly affect to the landslides such as Slope variation, Rainfall, Land use, Water Features and

Soil Type (Ranjan Kumar Dahal, 2017; Rathnaweera T.D. & Nawagamuwa U.P. 2013; Jayasinghe, G.J.M.S.R., et al, 2017).

Analytical Hierarchical Process (AHP)

AHP is one of Multi Criteria decision making method that was originally developed by Prof. Thomas Saaty. The AHP considers a set of evaluation criteria, and a set of alternative scenarios among which the best decision is to be made. It generates a weight for each factor according to the parameters determined. The AHP is hierarchical because it reduces complex decision-making problems into pair wise comparisons. The AHP both allows for inconsistency in the judgments and provides a means to improve consistency. The AHP considers a set of evaluation criteria, and a set of alternative options among which the best decision is to be made (Dericks P., et al, 2016).

Rightly, AHP generates a weight for each evaluation criteria according to pairwise comparisons of criteria. The criteria with higher weight are selected since it is most important of all the criteria. Further, for fixed criteria, it assigns a score to each alternative option according to pairwise comparisons of options based on those criteria. Higher the score for an option, better the performance of that option with regard to considered criteria. Information is then arranged in a hierarchical tree. Finally, the AHP generates global score for each option using the combinations of the criteria weights and options scores and determines relative ranking of alternatives. A simple hierarchy with three levels designed for this particular study is shown in Figure.1.

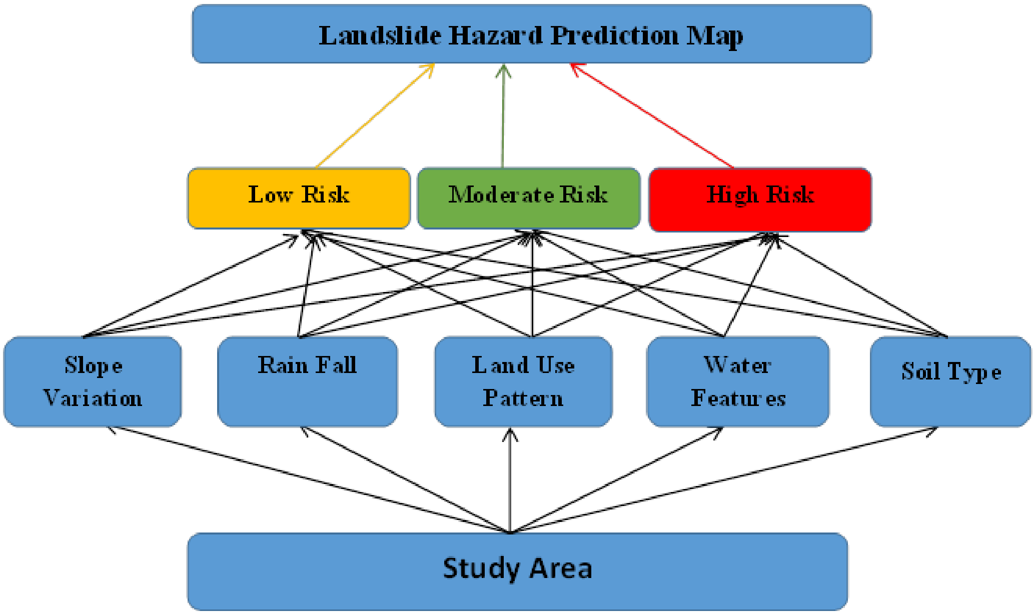


Figure: 1 Three Level hierarchy in AHP

AHP can be implemented in three simple steps

i. Computation of weight vector for all criteria

ii. Computation of score matrix for all options

iii. Ranking of options based on final score

Once the goal has been set, then for all the alternatives, different ranks are given based on the criterion fixed to reach that goal. In this way, the priorities are set, and these factors are compared pairwise. For example, in case this study, the goal was to identify the areas that are prone to landslide and the factors, such as slope, rainfall, land use types, distance to water features and soil types. And to select the areas prone to landslides, the criteria mentioned under Methodology. Hence, the area fulfilling these criteria will be selected. This way of preparing the landslide predication map is area specific, and the criteria applicable to one location may not be true for other location. Hence, a different approach is needed where the system adjust itself with the given conditions and scenarios. (Dericks P. Shukla, Sharad Gupta, Chandra S. Dubey and Manoj Thakur, 2016).

Weighted Overlay

Weighted Overlay is a technique for applying a common measurement scale of values to diverse and dissimilar inputs to create an integrated analysis. The Weighted Overlay tool accepts only discrete raster (integer values) as input. Continuous raster must be reclassified to discrete raster before they can be used (Ranjan Kumar Dahal, 2017). The output raster is calculated according to the following equation.

Output Map = Classified Map (Slope) *weight1 + Classified Map (Rainfall) *weight2 + Classified Map (Land Use) *weight3 + Classified Map (Water Features) *weight4 + Classified Map (Soil Type) *weight5

STUDY AREA AND DATA

Study Area

Hill country railway line in Sri Lanka is starting from Polgahawella to Badulla. By considering the time limitation, data availability and high risk possibilities of landslide in up country railway line this study is limited from Ohiaya to Bandarawela in Badulla district. The following Figure 2 shows the study area location.

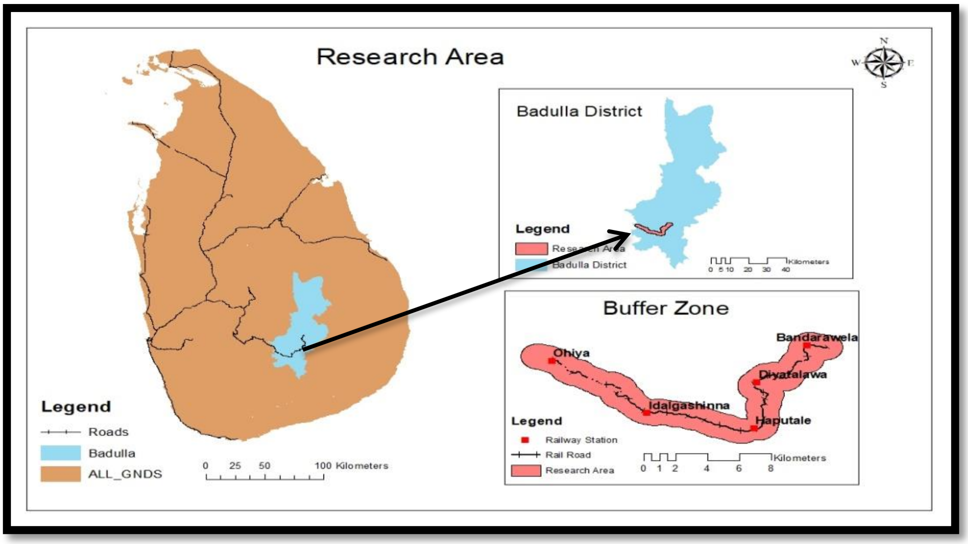


Figure: 2 Location of the Study area

Data Description and Data Preprocessing

Descriptions for collected five environmental factors data are given below;

Land Use:

Considering the study area there are different types of land use patterns can identified, due to the increase of population in villages of the hill country, there is an increase in demand for land for urban development, settlement and agriculture. That probably affect to the landslide in this area. Accordingly following land use types were identified such as Chena, Forest, Home Stead, Other cultivation, Paddy, Rock, Stream, Tank, Tea & Water Features. The Figure 3 shows the land use map in the study area.

Soil Type:

Soil type in upcountry railway line is another important factor which leads to landslide hazards with other factors. There are different kinds of soil types can be identified in study area. Mainly consists of Red-Yellow Pdzolic soils with dark B horizon & Red Yellow Podzolic soils with prominent A1 horizom rolling terrain, Red-Yellow Podzolic soils & Mountain Regosols mountainous terrain, Red-Yellow Podzolic soils steeply dissected hilly and rolling terrain. The Figure 4 shows the soil types in the study area.

Slope:

There are several visible indicators can be applied to identification slide, fall and flow of rocks, earth and debris in steep slopes. There for considering slope variation in upcountry railway line is very important factor. For identify variation of slope contour map along the hill country railway line has be utilized. Using contour map Digital Elevation Model (DEM) of the area was created DEM. Finally using DEM can produce relevant Slope map. Consider slope angle variation in my research area varies from 0 degree - 61 degrees. Slope variation categorized into three classes as < 15^0, 15^0 – 45^0 &, < 45^0. The Figure 5 describes three classes of the slope variation in the study area.

Rainfall:

Four climatic seasons can be identified according to rainfall patterns in up country area as follows.

1. Summer scattered showers (months of March & April)
2. South - West Monsoons (June- Sept.)
3. Autumn, Convectional, Cyclone (End of September to End of January)
4. North-East Monsoons (November to January)

The occurrence of landslide in upcountry is highly related to these rainy seasons. Therefore rainfall data is major factor to analyze about landslide. For this study rainfall data from 7 respective rainfall stations such as Nuwara Eliya, Ohiya, Idalgashinna, Beragala, Haputale, Diyatalawa & Bandarawela were collected for last 10 years (2009- 2018) and shown in following Table 1 (WorldWeatherOnline.com. Retrieved May 10, 2020, from https://www.worldweatheronline.com)

.

Table: 1 Rainfall Data

Rainfall Station	**2009-2018**				**Average Rainfall (ml)**
	September (ml)	**October (ml)**	**November (ml)**	**December (ml)**	
Nuwara Eliya	115	267	295	254	233
Ohiya	158	255	251	216	220
Idalgashinna	128	265	283	228	226
Haputhale	176	245	233	233	219
Diyatalawa	142	274	253	157	206
Bandarawela	142	279	262	175	214
Beragala	87	182	192	102	140

Water Features:

Identifying existing water features in this area is another important factor for landslide and 1:50,000 Topographical Map Series data has been utilized to identify available Streams in the study area and those steams were categorized according to their width & type and shown in following Figure 5.

METHODOLOGY

The summary of whole methodology process of this study is given Figure 7. In the main process land use pattern, soil type and slope variation were converted into raster format before the reclassification process. The rainfall distribution and available water features were processed separately to convert into raster data.

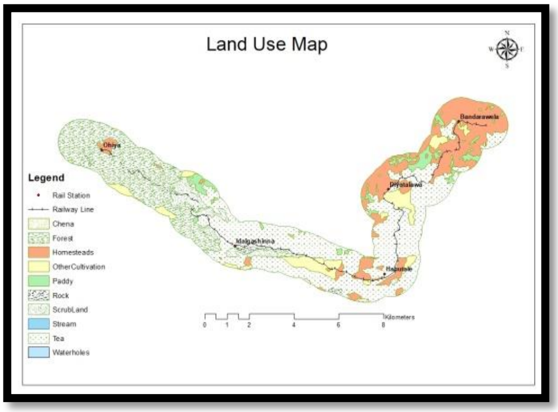


Figure: 3 Land Use Map

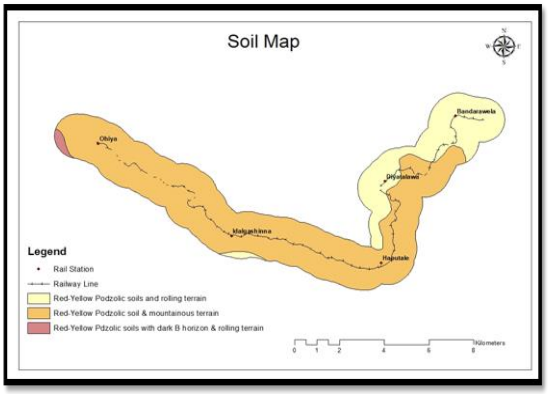


Figure: 4 Soil Map

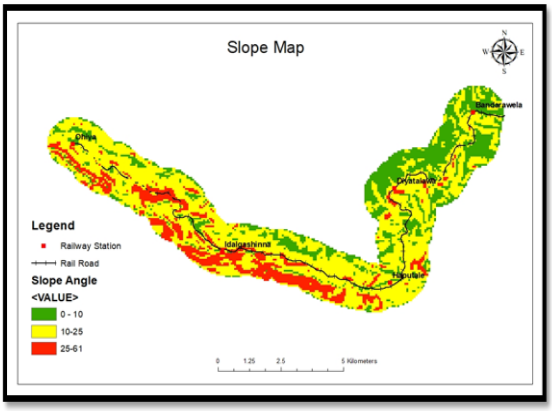


Figure: 5 Slope Map

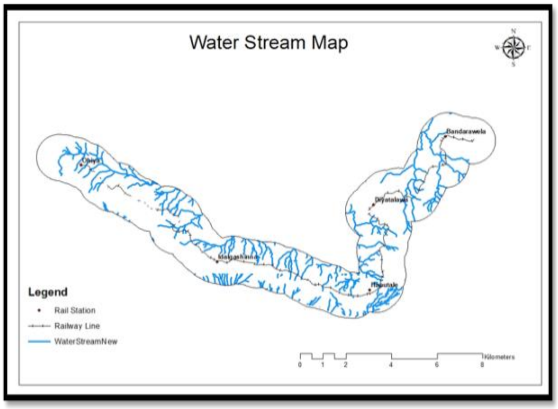


Figure: 6 Water Feature Map

Reclassification Process

For this study based on the ground investigations, past experiences, status of five considered environmental factors and literature reviews, it was decided to category the whole study area into three risk area for landslide hazards namely ***Low Risk Area, Moderate Reis Area and High Risk Area***. According to this decided categories, classification of five environmental factors were described in following paragraphs.

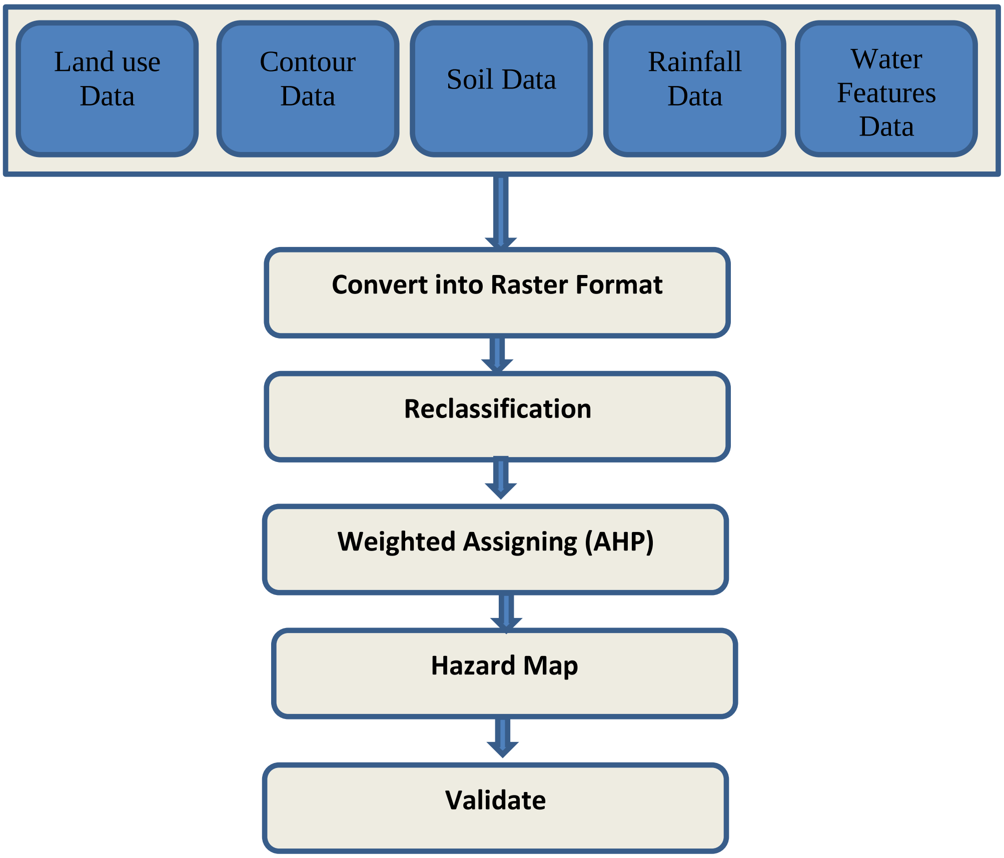


Figure: 7 Methodology Flow Chart

In the land use pattern according to the guide lines of Natural Resource Management Centre (NRMC) land use types such as Chena, Tea and Other Cultivation were classified as highly influence soil types for landslides while land use types Homesteads, Streams an Water Features were categorized as moderated risk land use types and land use types such as Forest, Paddy, Rock and Scrub Land were categorized as low risk. Reclassified land use map is shown Figure 8.

When identifying the factors which are responsible for landslides, slope aspect, slope angle and elevation of a location can be considered as some key natural factors. According to the knowledge of experts, the probability of occurrence of landslides is high when the slope angle is in between 15^0 and 45^0 and it is relatively low when it is more than 45^0. Moreover, landslides may occur in flat areas as well due to excessive pressure placed on the respective area (Jayasinghe, G.J.M.S.R, et al, 2017). Accordingly in this study area range variation reclassify into three groups such as slope variation from 1^0 to 15^0 was categorized as low risk area and slope variation from 15^0 to 45^0 and slope variation above 45^0 were identified as high and moderate risk areas respectively. Reclassified slope map is shown Figure 9. After studying the rainfall pattern in the study area for last ten years rainfall range for respective area were classified as areas having rainfall below average of 212ml was classified as low risk area while areas having rainfall average between 212ml to 218 ml was categorized as moderate risk area and areas having more than 218ml rainfall listed as high risk area. Reclassified rainfall map is shown Figure10.

There are only three categories of soil types were identified in the research area as shown in table 2 (Jayasinghe, G.J.M.S.R, et al, 2017) and classified soild map is shown in Figure 11.

Table: 2 Soil type map category according to risk type

Soil type	**Hazard zonation area**
Red-Yellow Pdzolic soils with dark B horizon & RedYellow Podzolic soils with prominent A1 horizom;rolling terrain	Low
Red-Yellow Podzolic soils & Mountain Regosols; mountainous terrain	Moderate
Red-Yellow Podzolic soils; steeply dissected, hilly and rolling terrain	High

Based on the field visit normally nearest areas to the water stream are high risk area as well as far away from the water streams are considered as low risk areas. Accordingly the high risk area selected as less than 100 m buffer area of the water features. The moderate risk area selected as between 100 m and 200 m buffer area of the water features. As well as low risk area selected as more than 200 m far away from water features. The classified soil type map shows in Figure 12.

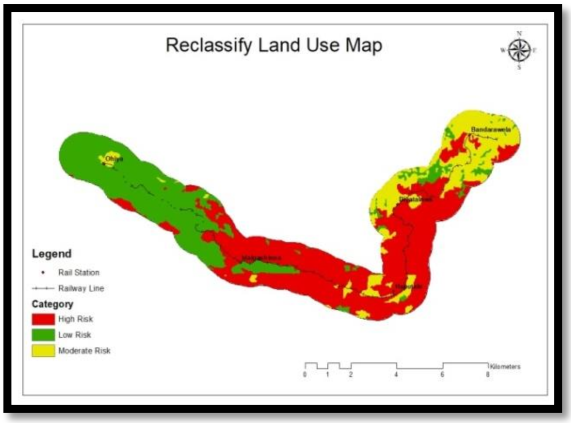


Figure: 8 Classified Land Use Map

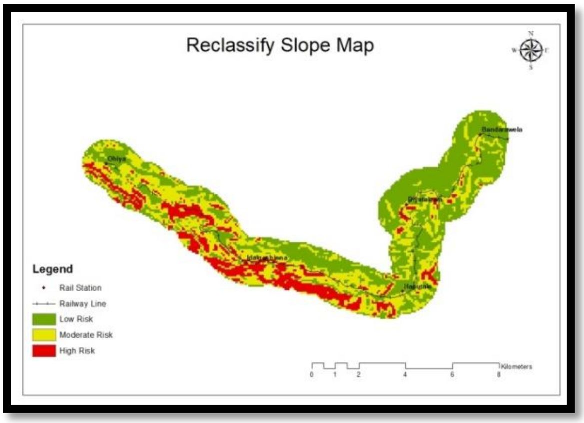


Figure: 9 Classified Slope Map

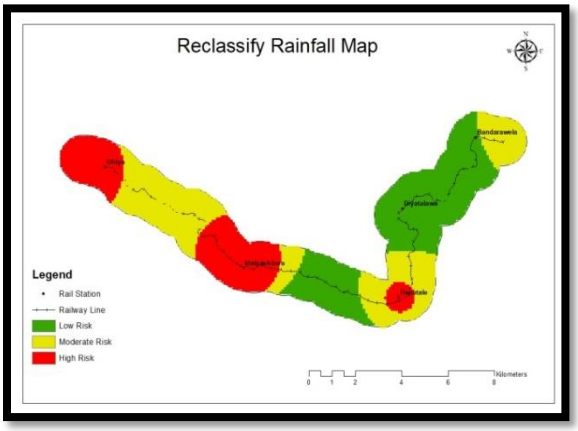


Figure: 10 Classified Rainfall Map

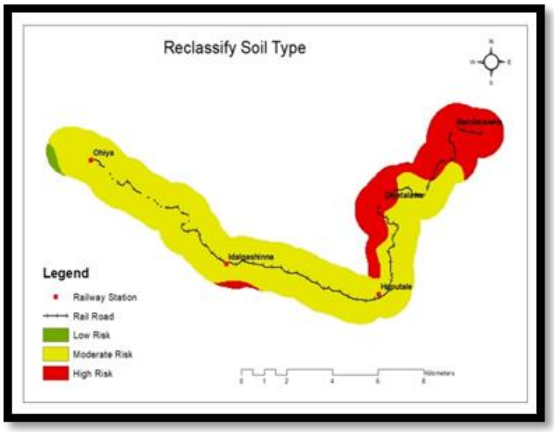


Figure: 11 Classified Soil Map

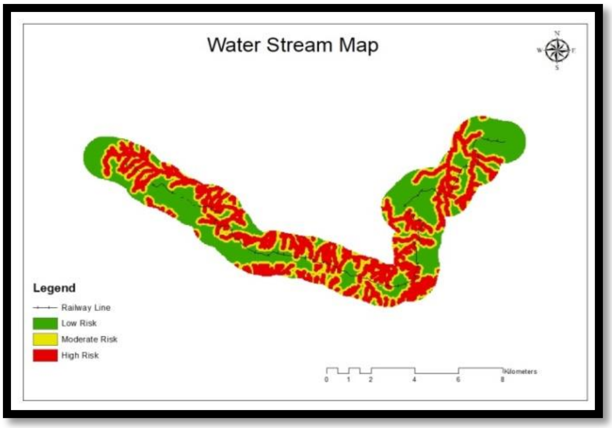


Figure: 12 Classified Water Feature Map

Creation of GIS Model for Landslides and Apply of Weighted Overlay to Prepare Landslides Hazard Map

For the study area based on the classification discussed above the AHP process was implemented in three simple consecutive steps. In the first step weights criteria of the vector was computed and in the second step matrix of option scores was calculated and finally ranking was done. All these AHP priorities were calculated using online AHP calculator (Goepel, K. D. (n.d.). BPMSG – Business Performance Management Singapore. Retrieved May 10, 2020, from https://www.bpmsg.com). These priority values vary on 1 to 9 based on the priority with each other. Table 3 shows the obtained standardized pair wise comparison matrix.

Table 2: Standardize Pair Wise Comparison Matrix

Environmental Factors	**Slope**	**Land Use**	**Rainfall**	**Water Stream**	**Soil**	**Sum**	**Weight**
Rainfall	0.201	0.300	0.172	0.286	0.200	1.158	0.231
Land Use	0.066	0.100	0.104	0.190	0.133	0.594	0.119
Slope	0.601	0.500	0.521	0.381	0.467	2.470	0.494
Water Stream	0.066	0.050	0.130	0.095	0.133	0.475	0.095
Soil	0.066	0.050	0.073	0.048	0.067	0.303	0.061
Total	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**5.00**	**1.00**

Based on above Pair Wise Comparison matrix slope factor was assigned as higher weight value of 0.49/49, secondly rainfall was weighted with the value of 0.23/23 and thirdly land use was weighted with value of 0.12/12. Water Features and Soil Type were assigned as fourth and fifth weight values respectively as 0.1/10 and 0.06/6. Based on this weight factors landslides hazard map equation was created in the GIS model as follows;

Hazard Zonation Map = Slope*0.49 + Rainfall*0.23 + Land use*0.12 + Water Features*0.10 + Soil*0.06

Using above mentioned process suitable landslide hazard zonation map produced based on above calculated weighted. Weighted overlay tool in Arc GIS used to produce that final output. Following Figure 13 shows the landslide hazard zonation map in upcountry railway line. Red color area show the highly risk area and yellow color area show the moderate risk area and green color show the low risk area in the study area.

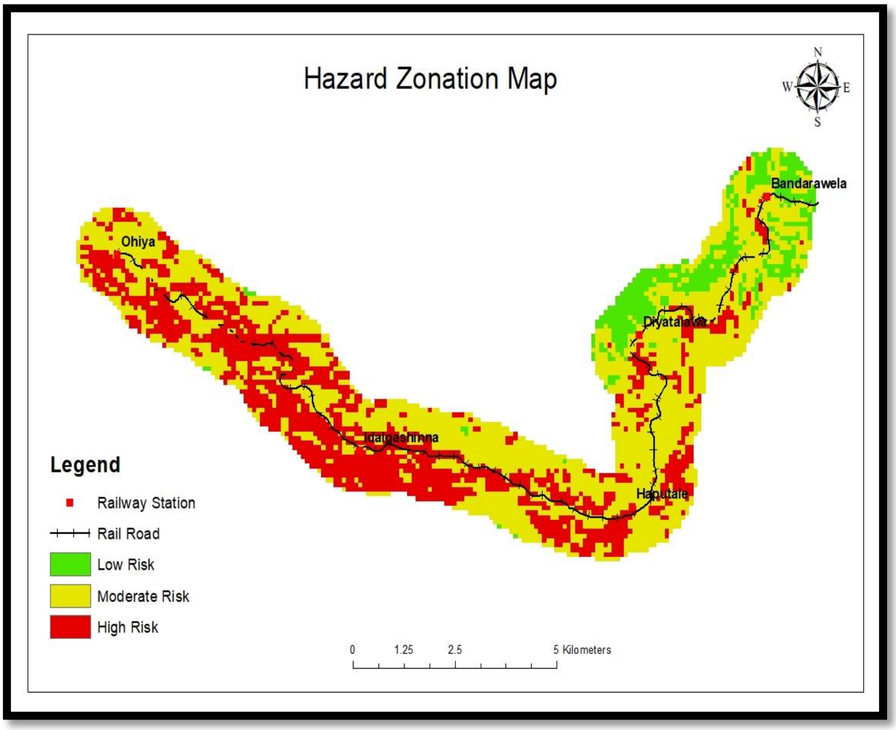


Figure: 13 Landslides Hazard Predication Map

RESULTS AND DISCUSSION

To prepare this hazard prediction map five identified environmental factors were considered out of these five factors based on above Pair Wise Comparison matrix shown in Table 2, Slope aspect is the most responsible natural factor causing landslide hazards which was also proved through validation process. Second important factors were rainfall and which was ensured the period of landslides in the study area and the rainfall data obtained from the relevant institution. Third significant factor was considered land use pattern which is mostly related human activities and land use types such as Chena, Tea and Other Cultivation were identified as most significant land use types to cause landslide hazards. Water Features was considered as fourth factor but within the study area as there is no significant water features feature studies need to consider on this factor. Finally the soil type doesn't make a significant effect on the landslide hazard within the study area.

Further statistical calculation was done to identify the percentage of predicted area with ground truth validation data collected using handheld GPS in 52 locations in the study area and found that 35% of the study area fallen into high risk area for landslide hazards while 58% of the study area fallen into Moderate risk and rest of the 7% of total area fallen into low risk area. Therefore totally more than 90% of the areas can be considered as risk area together with high risk and moderate risk areas along the railway line from Ohiya to Bandarwela.

Furthermore, finally obtained map was compared with ground truth data and validate map is shown in Figure 14, where the blue color area shows the past landslides occurred areas. It can be identified most of the actually landslides occurred areas coincided with predicted landslides hazard map.

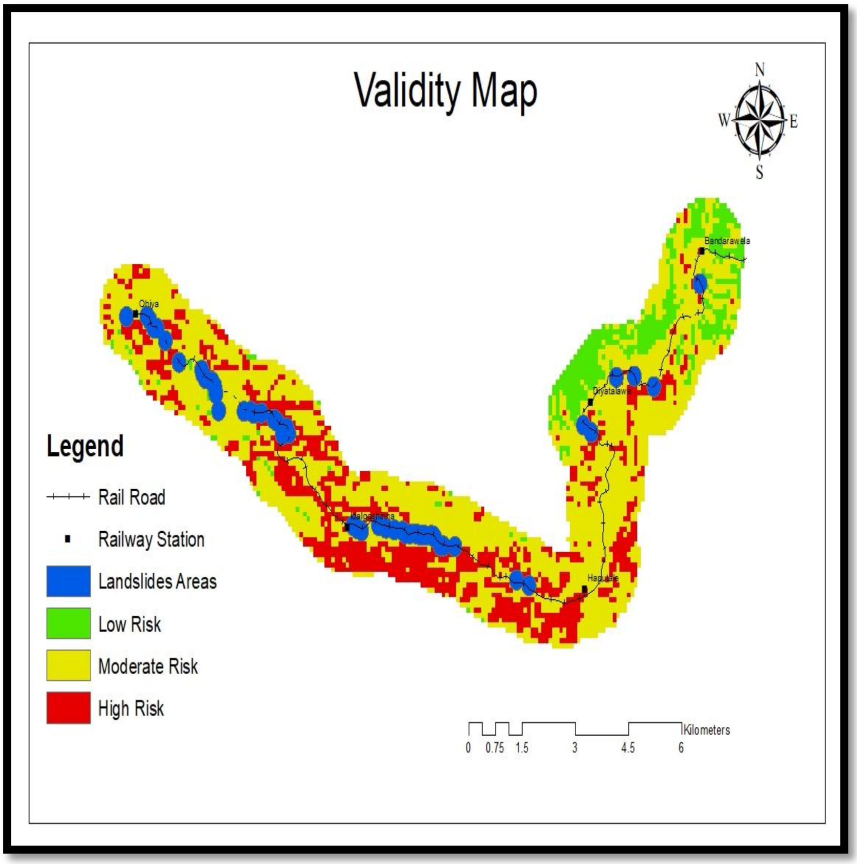


Figure: 14 Validated Map of Landslides Hazard Predication Map

CONCLUSION

Landslide is an acute problem in many mountain regions of the world. Generating GIS weighted model based on the identified environmental factor is found to be very effective in landslide hazard zonation mapping along hill country railway of Sri Lanka. Further this study reveals significant impact on slope variation and rainfall distribution to the landslides occurrences. The other hand land use pattern, available water features and soil type have some impact on the landslides occurrences in the study area. In addition used AHP application exposed more efficient method for weights assigning in complex decision making process. Geo-spatial Technology along with the other geo-informatics tools are found to be highly useful in landslides hazard predication mapping through this case study.

REFERENCES

Chit Ko Ko (2001). Landslide hazard and risk assessment along a railway line. Doctor of Philosophy Thesis, Department of Civil, Mining, Environmental Engineering, University of Wollongong.

Crozier, M. J., & Glade, T. (2012). Landslide hazard and risk: Issues, concepts and approach. Journal of Landslide Hazard and Risk, 1-40.

Dahal, R. K. (2017). Landslide hazard mapping in GIS. Journal of Nepal Geological Society, 53, 63-91.

Goepel, K. D. (n.d.). BPMSG – Business Performance Management Singapore. Retrieved May 10, 2020, from https://www.bpmsg.com

Jayasinghe, G.J.M.S.R., Wijekoon, P. & Gunatilake, J., (2013). Landslide Susceptibility Assessment Using Statistical Models: A Case Study in Badulla District, Sri Lanka. Ceylon Journal of Science, 27-41

Kumari M. Weerasinghe, A. M. (2006). Learning to live with Landslide, Natural Hazards and Disasters. Ministry of Education and National Institute of Education,Education for Social Cohesion, Disaster Risk Management

Rathnaweera, T.D. & Nawagamuwa, U.P., (2013). Study of the Impact of Rainfall Trends on Landslide Frequencies; Sri lanka Overview. Journal of The Institute of Engineers Sri Lanka.

Shukla, D. P., Gupta, S., Dubey, C. S., & Thakur, M. (2016). Geo-spatial technology for landslide hazard zonation and prediction. Journal of Environmental Applications of Remote Sensing.

Varnes, D., Smith, W., Savage, W., & Varnes, K. (1993). Control and deformation surveys at the Slumgullion slide, Hinsdale County, Colorado; a progress report. WorldWeatherOnline.com. Retrieved May 10, 2020, rom https://www.worldweatheronline.com

5

OLDEN DAY LAND MEASURE IN SRI LANKA

Dr. K.Thavalingam

Retired Surveyor General

ABSTRACT: *The very earliest civilizations needed measurement for purposes of agriculture, construction and trade. Early standard units might only have applied to a single community or small region, with every area developing its own standards for lengths, areas, volumes and masses. Often such systems were closely tied to one field of use, so that volume measures used, for example, for dry grains were unrelated to those for liquids. With development of manufacturing technologies, and the growing importance of trade between communities and ultimately across the Earth, standardized weights and measures became critical. Starting in the 18th century, modernized, simplified and uniform systems of weights and measures were developed. The olden days in Ceylon, the surface areas were measured not by lineal or squared measure, but by a measure of the quantity of seed required to sow the land i.e., "sowing extents." is in terms of grain capacity for sowing or "sowing extents". Under the British Empire, imperial units became the official units of measurement and remained so until Sri Lanka adopted the metric system in the 1970s. Extents of un-surveyed land are sometimes given in deeds in the form of sowing extents or some other system and very frequently in our Courts when a land is defined by these measures the question is raised as to their equivalents in imperial units or metric units. Hence surveyors should not merely accept the direct converted values. Surveyors should give the extent in Hectares and decimals of hectares in plans and related documents. However, if a client insists the extent may, in addition to be given acres, roods and perches and also approximate sowing extent or approximate number of Kulis.*

Keywords: Area units, Surface measures, Capacity measures

INTRODUCTION

Ceylon being primarily an agricultural country, Land Measures used to be computed according to the extent of land required to sow either Paddy or Kurakkan or Varagu. It will be obvious how difficult it is to correlate sowing extents accurately with surface areas, as there are so many variable factors, depending on the size and quality of grain, the peculiarities of the Sower, the fertility of the soil, etc., which make any assessment of surface areas by sowing extents very doubtful of comparison. In fertile lands the seed would be sown much less thickly than in poor soil. An inexperienced Sower would scatter the seed unevenly. No rigid correlation of surface areas by sowing extents is possible and the amunam (measuring unit) sowing extent consequently varies in different parts of the Island. For instance, an Amunam in a fertile area will sometimes be twice as many square feet as an Amunam in an unfertile area.

AREA UNITS USED IN OTHER COUNTRIES

Acre- The (English) acre is a unit of area equal to 43,560 square feet, or 10 square chains, or 160 square poles. It derives from a plowing area that is 4 poles wide and a furlong long. A square mile is 640 acres. The Scottish acre is 1,27 English acres. The Irish acre is 1.6 English acres. Furlong is unit of length equal to 40 poles (220 yards). Its name derives from "furrow long", the length of a furrow that oxen can plow before they are rested and turned.

Arpent- Unit of length and area used in France, Louisiana and Canada. As a unit of length, approximately 191.8 feet (180 old French 'pied', or foot). The (square) arpent is a unit of area, approximately 0.845 acres, or 36,802 square feet.

Colpa- Old Irish measure of land equal to that which can support a horse or cow for a year. Approximately an Irish acre of good land.

Cuerda- Traditional unit of area in Puerto Rico. Equal to about 0.971 acres. Known as the "Spanish acre".

Ground- A unit of area equal to 2400 square feet, or 220 square meters, used in India.

Gunter's Chain- Unit of length equal to 66 feet, or 4 poles. Developed by English polymath Edmund Gunter early in the 1600's, the standard measuring chain revolutionized surveying. Gunter's chain was 22 yards long, one tenth of a furlong, a common unit of length in the old days. An area one chain wide by ten chains long was exactly an acre. In 1595 Queen Elizabeth-I had the mile redefined from the old Roman value of 5000 feet to 5280 feet in order for it to be an even number of furlongs. A mile is 80 Chains.

Hide- A very old English unit of area, a hide was of variable size depending on locale and the quality of the land. It was the amount of land to support a family, and ranged from 60 to 180 acres. After the Norman conquest in 1066 it became standardized at around 120 acres.

Virgate- An old English unit of area, equal to one quarter of a hide. The amount of land needed to support a person.

Hundred- An administrative area larger than a village and smaller than a county. In England it was 100 hides in size, and the term was used for early settlements in Virginia, Maryland and Delaware states in USA.

Labor- The labor is a unit of area used in Mexico and Texas. In Texas it equals 177.14 acres or 1 million square varas.

Vara- Unit of length (the "Spanish yard") used in the U.S. southwest. The vara is used throughout the Spanish speaking world and has values around 33 inches, depending on locale.

League (legua)- Unit of area used in the southwest U.S., equal to 25 labors, or 4428 acres (Texas), or 4439 acres (California). Also, a unit of length, approximately three miles.

Morgen- Unit of area equal to about 0.6309 acres. It was used in Germany, Holland and South Africa, and was derived from the German word Morgen ("morning"). It represented the amount of land that could be plowed in a morning. The exact size varied from region to region. The number of *roede* in a *morgen* also varied from place to place, and could be anywhere from 150 to 900.

Roede - The *roede* (literally, "rod") was generally somewhat smaller than the English rod, which is 16.5 feet (or 5.0292 metres). The length of a *roede* varied from place to place. The *roede* used in the Netherlands for the measurement of long distances was generally the Rijnland rod. One Rijinland rod (*Rijnlandse roede*) was 3.767 m. Today the word *roede* is not in common use in the Netherlands as a unit of measurement.

THE SYSTEM OF SURFACE MEASURES USED BY THE PORTUGUESE OR THE DUTCH

The system of surface measures in sowing extents does not appear to have been altered at all by the Portuguese or the Dutch during the periods of their occupations. The Portuguese "Forals" and the Dutch "Thombos" particularly the latter, give reference to the areas of the land in terms of sowing extents, i.e., Amunams and Kurunis. The Portuguese "Forals" and Dutch "Thombos were registers prepared mainly for the purpose of taxation and therefore they concerned themselves with only the produce of the land, and left apart the question of surface areas, these latter being merely recorded in the then established systems of sowing extents of Kurunis and Amunams. Such Dutch Thombos as are accompanied by plans, make reference to the extent in Dutch measures, together with a statement of the generally accepted sowing extent of the land. An *amunam* of land being the area which could be sown with an *amunam.*

Surveyors who have to use any records maintained during the Dutch period may use the following conversion factor: - One *Rijnlandse* is equal to 18.75 links (approximately 12 feet) and One morgen is a little over 2 Acres.

Northern and Eastern Provinces, the system of land measurement would seem to have been in sowing extents, and this system still prevails except in Jaffna, where in addition to the sowing measures a surface measure termed the “Kuli” appears to have been in use from ancient times. This measure the “Kuli” is the extent of land contained within a square, of side equal to a "Kole” or pole, in length approximately equal to 12 ft.

The surveyors may also come across documents where lengths are given in the following ancient linear or surface measurements. Most in North & East provinces.

1 Hasta or Cubit or Span = 9 inches; 16 Spans x 16 Spans = 1 Kuli = about 144 Sq.ft (* more equivalent 151 Sq.ft); 100 Kulies = 1 Ma; 20 Mas = 1 Veli .

ANCIENT MEASURES OF CAPACITY IN SRI LANKA

The following Ancient Measures of capacity are still in common use in some place in the Southern part of Sri Lanka. 4 Hunduwas (or Patas) = 1 Neliya; 4 Neliyas = 1 Laha; 4 Lahas = 1 Timba; 10 Lahas =1 Pela; 4 Pelas = 1 Amunam.

The measures actually in use were only the "Neliya" and the "Laha", the others being merely terms used for deriving the larger measures. The “Laha “was the largest dry measure and the “Neliya", the largest liquid measure, this latter measure being used as both a grain and a liquid measure. For grain the "Neliya” was sometimes made of rattan, but for oil it was always made of bamboo, being equal in capacity to the space contained between two consecutive joints of a bamboo, whence it derives its name "Neliya". The 'Laha' was also a measure of varying size. Within the same district and sometimes in the same Chief Headman's division, in different parts, a different size of Laha was in use.

These measures have been related to the English standard measures (eg. Bushel) which, according to the Ceylon Blue Book, are as follows: 1 Amunam = 4 Pelas = 40 Lahas = 8 Parahs= 5 Bushels or 160 Quarts or Seers or Neliyas.

The 'Parah' which is a Dutch measure, which was again divided into 24 'Seers'. A 'Seer' being a cylinder of equal depth and diameter measuring 4.35 inches. The sub-divisions and multiples of the 'Parah' as follows: 4 Cut Chundus = 1 Cut Measure; 4 $^{4}/_{5}$ Cut measures = 1 Kuruni; 2 $^{1}/_{2}$ Kurunis = 1 Marsal; 2 Marsals = 1 Parah; 8 Parahs= 1 Amunam; 9 $^{3}/_{8}$ Amunams = 1 Last.

The above measures in "Neliyas," "Lahas" and "Pelas," in varying forms are still used in some villages of the Kandyan Provinces. In the low-country too, it is noteworthy, that in spite of the long periods of Portuguese and Dutch rule, the systems of measurement, as quoted above still prevail. Apart from the introduction of measures of capacity such as the "Parah" and "Marsal", which appear to be the equivalent of the Tamil terms ("Parah* and "Marakkal"), the Portuguese and Dutch appear to have left the local measures un-interfered.

The standard of accuracy of ancient units of measurements cannot be compared with modern standards. Modern measurement systems are scientifically with very great accuracy. Hence anyone should not merely accept the direct converted values from one to other.

SINHALESE SOWING EXTENTS VS ENGLISH STANDARD EXTENT MEASUREMENTS

The equivalents of the above terms in English standard measurements are as follows: - 1 Amunam's sowing extent = 2 ½ acres; 1 Pela's sowing extent =

2 roods and 20 perches; 1 Laha's or Kuruni's sowing extent = 10 perches; 1 Parrah's sowing extent = 1 rood 10 perches; 1 Bushel's sowing extent = 2 roods; 1 Peck's sowing extent = 20 perches; 1 Quart's or Seer's sowing extent = 2 ½ perches;

The above table giving the English equivalents refers to paddy sowing, In the case of kurakkan sowing 1 laha is equivalent to 1 acre and 1 pela is therefore equivalent to 10 acres. Generally high land is measured in 'kurakkan' and low lands (fields) in paddy.

DRY MEASURES AND SURFACE MEASURES IN THE TAMIL DISTRICTS

The Dry Measures and Surface Measures in the Tamil Districts vary in the Northern and Eastern Provinces. According to the Ceylon Manual, the Tamil measures of capacity and their relation to the English Standard Measurements as given in the Ceylon Blue Book are as follows:

Dry Measures & related Surface Measures in Northern Province

Jaffna- 32 Quarts (or Seers) = 1 Bushel; 12 Measures = 1 Lacham; 2 Lachams = 1 Parah

- **Paddy Cultivation (Paddy Land) -** 12 Kulis =1 Lacham; 24 Lachams = 1 Acre
- **Varaku Cultivation (High land) -** 18 Kulis =1 Lacham; 16 Lachams = 1 Acre; (Note- one Acre is equal to 288 Kulis)

- **Mixed Cultivation-** 16 Kulis = 1 Lacham

Vavuniya and Mannar- 16 Seers = 1 Marakkal; 2 Marakkals = 1 Bushel;

Mannar - 2 ¼ Bushels = 1 Acre

Vavuniya North- 5 Marakkals or 2 Bushels = 1 Acre

Vavuniya South- 2 Bushels = 1 Acre

Mullaitivu - 12 Quarts (or Seers) = 1 Marakkal; 2 Marakkals= 1 Bushels; 6 Marakkals= 1 Acre

Dry Measures & related Surface Measures in Eastern Province

Batticaloa- 8 Cut Measures, Seers or 7 heaped Measures = 1 Marakkal; 4 Marakkals = 1 Bushel; 7 ½ Bushels = 1 Avanam

- **Wet Cultivation (seed paddy) -** 2 ½ Bushels = 1 Acre (low land); 2 ¾ Bushels = 1 Acre (high land)
- **Dry Cultivation- (Fine grains) -** 2 Measures = 1 Acre; Indian corn: - 2 Measures = 1 Acre

Trincomalee - 12 Quarts = 1 Marakkal; 2 ½ Marakkals = 1 Bushel; 10 Bushels = 1 Avanam; 6 Marakkals = 1 Acre; 4 Acres = 1 Amunam

- **Thampalakamam-** 2 ½ Quarts (or Seers) = 1 Nali; 15 Nalis = 1 Peddi; 8 Peddis= 1 Avanam; 1 Avanam = 10 Bushels; 1 Avanam = 5 Acres in Thampalakamam; 1 Avanam = 4 Acres in Kantalai; 1 Avanam = 3 Acres in Kinniya

- **Koddiyar -** 3 Measures (or Seers) = 1 Nali; 15 Nalis = 1 Peddi; 8 Peddis or 64 Marakkals = 1 Avanam; 1 Avanam = 12 Bushels; 3 Bushels = 1 Acre; 1 Avanam = 4 Acres
- **Kaddukulam (Tamil Village) -** 5 Measures = 1 Nali; 2 Nalis = 1 Marakkal; 24 Marakkals = 1 Avanam; 1 Avanam = 9 Bushels; 2 ½ Bushels = 1 Acre
- **Kaddukulam (Sinhalese Village) -** 6 Measures = 1 Marakkal; 10 Marakkals = 1 Pela or Pedi; 4 Pelas or Pedis = 1 Avanam

EXTENTS IN ACRES OF THE SOWING EXTENTS IN OTHER PROVINCES

The following is a very general statement of the equivalent extents in acres of the sowing extents in various parts of Sri Lanka.

Surface Measures in the Central Province

- **Dry Zone-** Paddy sowing (mud land) 1 am = 2 acres; Kurakkan sowing (high land) 1 am = 30-40 acres
- **Wet Zone-** Paddy sowing (mud land) 1 am = 2 acres; Paddy sowing (high land) 1 am = 2-4 acres

Surface Measures in the Sabaragamuwa Province

- **Dry Zone-** Paddy sowing (mud land) 1 am = 2 acres; Kurakkan sowing (high land) 1 am = 20-30 acres
- **Wet Zone-** Paddy sowing (mud land) 1 am = 2 ½ acres; Paddy sowing (high land) 1 am = 4-5 1/2 acres

Surface Measures in the Uva Province

- **Dry Zone Paddy** sowing (mud land) 1 am = 1 $^{1}/_{3}$ acres; Kurakkan sowing (high land) 1 am = 30-40 acres
- **Wet Zone Paddy** sowing (mud land) 1 am = 1 acre; Kurakkan sowing (high land) 1 am = 13 $^{1}/_{3}$ acres

CONCLUSION

The ancients of Sri Lanka used a complex set of measures of length and distance, ranging from the noola (⅛ of an inch or 3.17 mm) and riyana (cubit - 18 inches or 450 mm) to the gauwa (Sinhalese league - 5600 yards or 3¼ miles or 5.12 kilometres) and yoduna (Sanskrit yojana - 4 gauwas). Agricultural land was traditionally measured mainly in Amunams; an amunam of land being the area which could be sown with an amunam. This unit was in use well into the middle of the 20th century, particular in litigation. However, when the all-encompassing British Empire took over, it imposed its own imperial system of weights and measures. Imperial feet and miles took over from *riyanas* and *gauwas*. The land area was measured in acres, roods, and perches. An acre has 4 roods and a rood, 40 perches. A perch is defined as a square pole (or rod or goad or perch). In modern use a pole is 5½ yards (16½ feet or 5.03 m), so a square perch is 30¼ square yards (272.25 square feet or 82.98 m^2).

Nowadays all land measurements are supposed to be in the metric system, with square metres and hectares. However, property is still sold by the perch and by the acre. As we mentioned the sowing extents vary from district to district. Even within the district itself it is different. In spite of these variations these measures continue to be used by the villagers even at present (extents of un-surveyed land are sometimes given in deeds in the form of sowing extents or some other system.) and very frequently in our Courts when a land is defined by these measures the question is raised as to their equivalents in imperial units or metric units. Hence surveyors should not merely accept the direct converted values. Surveyors should give the extent in Hectares and decimals of hectares in plans and related documents. However, if a client insists the extent may, in addition to be given acres, roods and perches and also approximate sowing extent or approximate number of Kulis.

REFERENCES

"Ancient Land Measures of Ceylon" written by D.B. Ellepola, former Assistant Superintendent of Surveys, Ceylon Survey Department.

http://www.directlinesoftware.com/survey.htm

wikipedia.org/wiki/Sri_Lankan_units_of_measurement

6

POTENTIAL OF USING UAV SURVEY FOR VOLUME COMPUTATION OF OFFSHORE SAND STOCKPILE

A.Dissanayake [1], B.C.P.Bogahawatta [2] and K.G.Lakshika [3]

[1] Additional Surveyor General, Survey Department of Sri Lanka (SDSL)
[2] Government Surveyor, Survey Department of Sri Lanka (SDSL)
[3] Government Surveyor, Survey Department of Sri Lanka (SDSL)

ABSTRACT: *Recently the importance of efficiency surveys is the requirement for the developments. 3D location-based design, volume calculation and construction work are being highlighted around the world. This study focused to use Unmanned Air Vehicle (UAV), to compare the efficiency of survey using UAV over GNSS RTK survey technology by doing a volume calculation of a sand stockpile survey. As the first step, a level survey was done to transfer the heights for the base points near and around the site, where these levels were transferred from a primary control level line, done by the SDSL. Then, according to a grid and condition of the terrain, the sand surface MSL heights were taken using RTK method and by using a well-controlled UAV survey. Base level of the stockpile was computed according to settlement plates, where those plates had been already placed according to a grid and assuming that the rods of settlement plates were vertical after the compact of sand.*

Then the volume computation has done from settled base to top most surface of the sand stockpile by using both methods. The results were highlighted that the UAV survey is more efficient, effective and precise in doing the surveys like these by concerning urgent requirement, the time and the effort.

Keywords: ***RTK, Settlement Plate, Stockpile, UAV***

INTRODUCTION

Nowadays the importance of smart construction, in which high-tech technologies such as IoT (Internet of Things), UAVs, and Robots are fused to existing construction technology, is being highlighted. Among these technologies, especially UAV surveys are the core technology of smart construction that enables 3D (Three-dimensional) location based design, survey work and construction work. As SDSL is responsible for the standardization and production of all Surveying and Mapping activities in Sri Lanka, it gives the survey output in more efficient manner. So, UAV surveys are conducted in most of the development surveys, where the efficiency and effectiveness with accuracy is highlighted to be considered. Commonly a volume calculation is done by a topographic survey using GNSS RTK method as well as using total station. This study focused to find the potential way to perform such a survey using UAV as well.

Volume calculation of a sand stockpile was done to compare the accuracy of doing such a survey by using RTK method and a UAV survey with its image processing technique. Offshore Sand stockpile is the stockpile filled by washed offshore sand pumped from the sea to inland location.

METHODOLOGY

The area focused for this study is located at Muthurajawela in the Western province of Sri Lanka; also, it was located close to the Western Sea. Hence it was made easier to pump the sand from the deep sea. With completion of the sand pumping, volume computation was the most important task to be finalized the remuneration for the parties, who were engaged for the process as soon as possible. Hence UAV survey was incorporated as a case study to check the efficiency and the effectiveness for future application by using relatively close ground controls. Close range Radio RTK method was used as a ground survey for the volume calculation as well as to validate the result received from the UAV Survey Method.

To conduct the RTK survey, nine GPS control points were well established around the sand stockpile premises by using network RTK method of SLCORSnet, to maintain the short-range baselines and to enhance the RTK accuracy. A precise level line was carried out to establish MSL heights for those control points prior to the RTK survey. The outer boundary of the stockpile was surveyed using RTK method as pointed out by the client. The topographic survey of sand stockpile was carried out at approximately 10m interval of a grid and additional points were surveyed by considering the terrain condition of the stockpile. Totally 12481 RTK points were cumulated to cover the entire top surface of the sand stockpile and created the elevation model of the top surface of the stock pile.

Sri Lanka Land Development Corporation (SLLDC) placed around 73 leveled settlement plates (Figure 1) prior to the compact of the sand in the focused area before pumping sand from the sea. The distribution of the settlement plates is shown in Figure 2. MSL heights of the settlement plates were provided by SLLDC, those were based on the previous survey carried out prior to fill the offshore sand. The height of the starting settlement plate is six meter and when the sand level was exceeded, another iron rod was conjoined by overlapping one meter length from each. Present height of the settlement plate location and the excess height of the iron rod were measured to derive the present level of the settlement plate. Elevation model for the settled base was created by means of all the derived heights of the settlement plates.

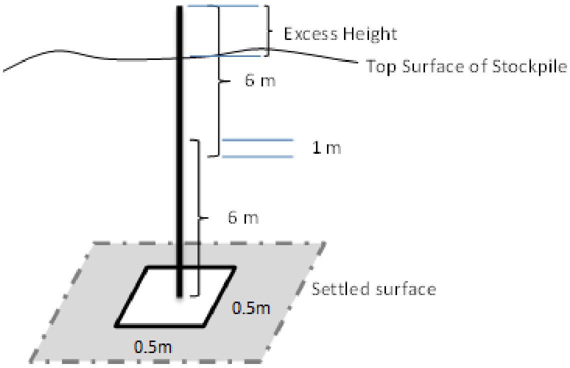


Figure 1: Settlement Plate

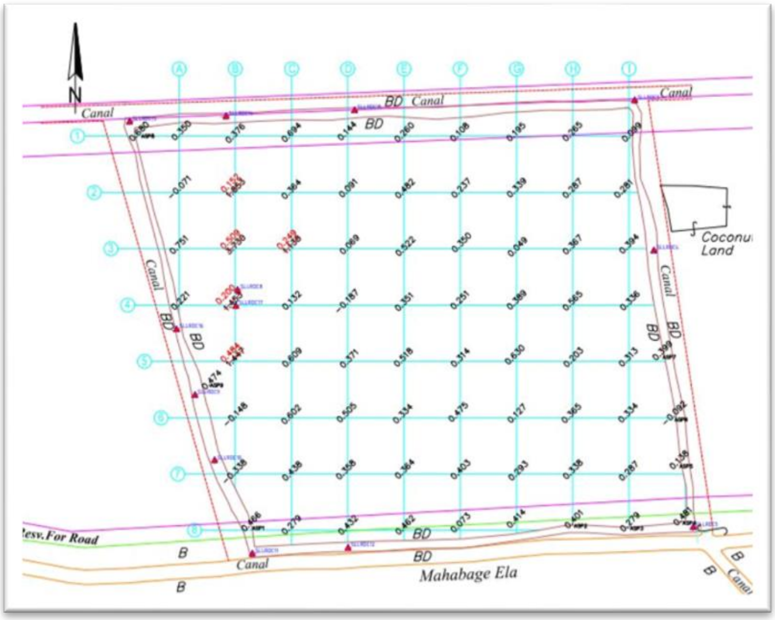


Figure 2: Distribution of settlement plates

For the UAV survey, well distributed pre signalized ground control points (GCP) were placed over the stockpile in a relative close range (100 m to

150m). Three dimensional coordinates (N, E, H) of these GCPs were measured with reference to RTK bases, which have been already established. Then the UAV survey was preceded by covering from and out of the stock pile area. Then the elevation model, orthomosaic and the point cloud were generated.

By means of these three different surfaces *i.e.* from settled base to crested surface from the RTK survey and from settled base to the surface from the UAV survey volumes were calculated for the comparison.
Pix4D Mapper 4.5.1, ArcGIS 10.3, Global Mapper 10.01 and Trimble Business Center 5.0 software were used for image processing and volume calculation.

RESULTS AND DISCUSSION

- Topographic survey on sand stockpile

According to the methodology, following is the Digital Elevation Model (DEM) for the collected data points.

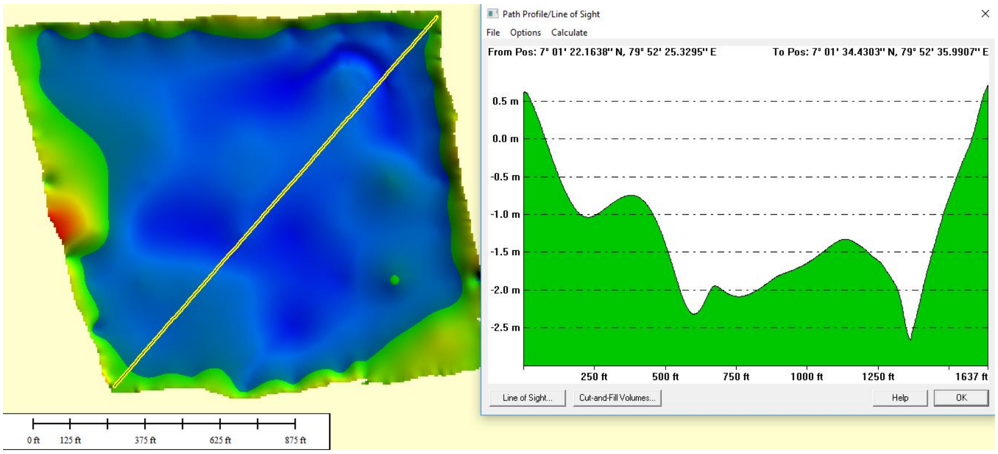


Figure 3: DEM and section view for the settled base

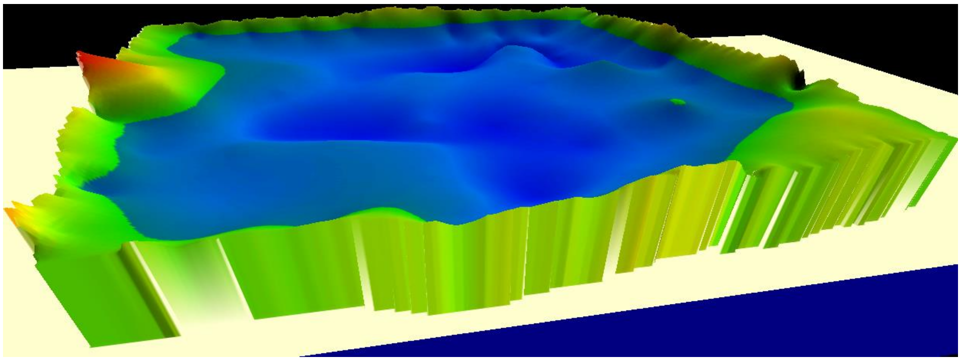


Figure 4: 3D view for the surface of settlement base

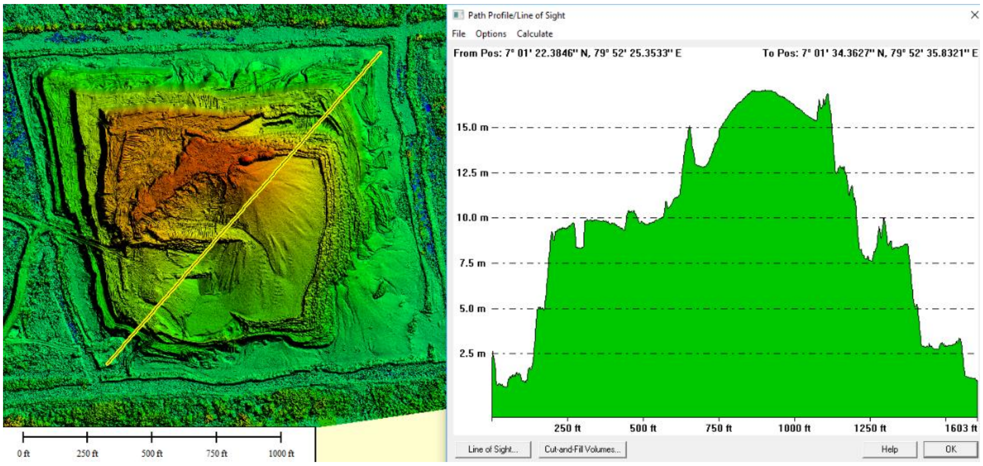


Figure 5: DEM and section view for the sand stockpile surface

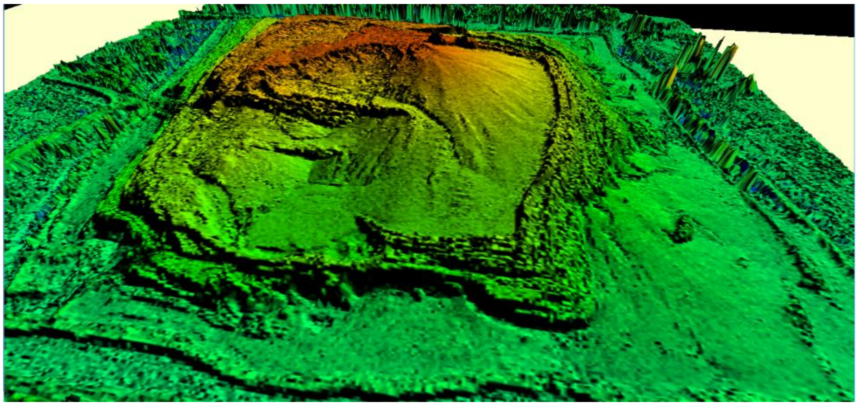


Figure 6: 3D view for the sand stockpile surface

- Orthomosaic results using UAV survey

An orthomosaic was generated after processing the UAV survey images and the output was given in Sri Lanka Datum 99 (SLD99) coordinate system covering the area of 34.474 Ha where the interested area is 15.821Ha.

Figure 7: Orthomosaic image for the UAV surveyed area

- Volume calculation

1. MSL heights of RTK points were transferred based on the established nine control points where the MSL heights were adjusted by the use of precise level line.
2. All the point heights were taken to build the Digital Surface Model (DSM) from RTK adjusted data and UAV DSM data separately.
3. The volume calculation was bounded for the above said surveyed outer boundary for both surfaces.

4. Existing present position of the base plates and heights were calculated based on the lengths of each rod.

Formula for the calculation of the MSL height of settlement plate

$$\text{MSL height of the settlement plate} = \left\{ \begin{array}{l} \text{MSL height on} \\ \text{sand stock pile} \\ \text{at settlement} \\ \text{plate location} \end{array} \right\} + \left\{ \begin{array}{l} \text{Excess} \\ \text{height of} \\ \text{iron rod} \end{array} \right\} - \text{Number of rods x 5m}$$

Following assumptions were considered while computing the volumes,

a. The compaction variation from settled base surface to sand stock pile surface has not been encountered.

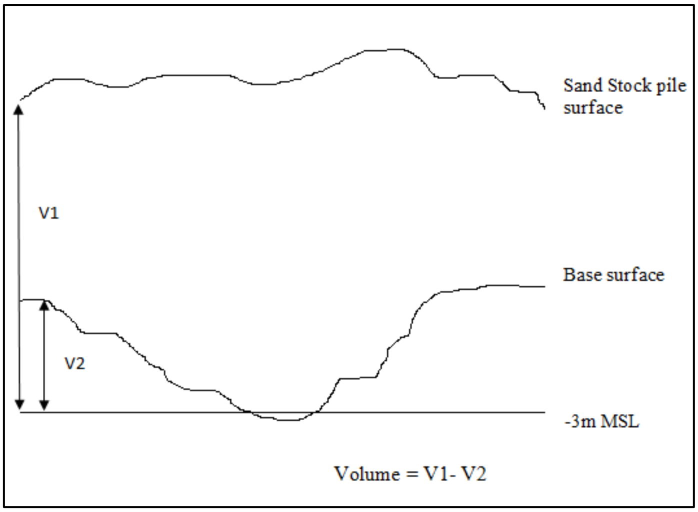
b. The top surface of the sand stock pile and settlement base variation due to weather condition during the carriedout survey period has not been considered.

c. The settlement base was not changed during the above survey period

d. The status of the settled surface was assumed as a triangulated surface

e. The rods of the settlement plates were considered as verticle

Note: The volumes were calculated from -3m MSL to the base surface and to the sand stockpile surface seperately and obtained the volume. Here the reason to get the -3m MSL was, the lowest point height of the base surface is -3.047m MSL.



V1 - Volume of the Sand Stockpile above -3.00m MSL

V2-Volume of the Base Surface above -3.00m MSL

Figure 8: Volume calculation concept

Expected accuracy of survey

According to the methodology of survey and computation of final volume, the values of the volume calculation for the conducted two methods are in Table 1. The value for the difference in the volumes of the two methods is significantly low when comparing to the total volume.

Table 1: Values of the volume calculation for the conducted two methods

Description	**Volume from RTK Survey data (m^3)**	**Volume from UAV survey data (m^3)**	**Difference in the volumes of two methods (m^3)**
The computed volume from the settled base surface to the sand stockpile surface	1,446,657.25	1,446,670.32	13.07

CONCLUSION AND RECOMMENDATION

The accuracy assessment was done to the volume calculation in two ways where the values can be seen in Table: 1. To conduct a RTK survey the time and the effort is gained a lot by comparing to the UAV surveys. The above values show that the two methods show almost the same value for the sand stockpile when taking the values as round off. So, the most efficiency and effective way of conducting such a survey is to do a UAV survey with the conditions as discussed; *i.e.* to increase the DEM accuracy of UAV survey, closed range GCPs are needed to be used.

These types of studies can be enhanced more by doing survey projects using UAVs, with the conventional methods to compare the results.

REFERENCES

Data Source: Survey Department of Sri Lanka

Survey Department of Sri Lanka, Survey conducted on Off-Shore Sand Mining and Pumping for Reclamation and Stock Piling at Muturajawela, Sri Lanka in 2019, for Sri Lanka Land Development Corporation (SLLDC)

Jae Hyoung, L (2002), A Study on DEM-based Automatic Calculation of Earthwork Volume for BIM Application: Journal of the Korean Society of Surveying, Geodesy, Photogrammetry and Cartography

Khomsin.K, Ira Mutiara.A(2018), Analysis of the volume comparison of Total Station and GNSS, Geomatic Engineering Department, ITS Surabaya, Indonesia

7

PREPARATION OF DENGUE RISK MAP BASED ON ENVIRONMENTAL AND SOCIAL FACTORS USING GIS TECHNOLOGY: A CASE STUDY IN JAFFNA DIVISIONAL SECRETARIAT DIVISION

M.T.M. Rafeek[1] and V. Nitharsan[2]

[1]Senior Lecturer, Institute of Surveying and Mapping, Sri Lanka
[2]Apprentice Surveyor, Institute of Surveying and Mapping, Sri Lanka

ABSTRACT: *Dengue Fever and Dengue Hemorrhagic Fever has become one of the most serious epidemic diseases in Sri Lanka over last decade. There were many clinically diagnosed dengue cases reported during the post-war period in Jaffna district, especially in Jaffna divisional secretariat division. As there is no vaccine and specific treatment for dengue, vector control is the major measure adapted to control the disease transmission. Therefore, a study was designed to identify dengue risk areas in Jaffna divisional secretariat division, in order to help the health authorities to prioritize their resources allocation to risk areas and to prevent the spread of the diseases further. Well known risk factors for the transmission of dengue fever such land use pattern, population density, house types, people gathering places and rainfall were considered as main criteria to find out the dengue prevailing.*

These criteria were combined using weighted overlay technique of the Geographic Information System (GIS). Digital image processing, spatial analysis and multi-criteria analysis were put together to prepare dengue risk map based on the identified environmental and social factors. The identified risk areas highly match with the number of reported cases for dengue within the Jaffna Divisional Secretariat Division. The results showed that the high-risk areas for dengue *outbreak in 2017, 2018 and 2019 were in Jaffna divisional secretariat division matched with actually reported dengue cases. While this map is expected to help health authorities to undertake vector surveillance and public awareness programs, and can be prepared as extended map whole Jaffna District.*

Keywords: Dengue Risk Map, Environmental Factors, Social Factors, GIS Technology.

INTRODUCTION

Dengue is a mosquito-borne viral disease that has rapidly spread in all regions of the world in recent years. This arboviral disease is transmitted by two main vectors, which are Aedes Aegypti and Ae Albopictus. Both mosquitoes have adjusted to human neighborhood with larval habitats and ovipositor in natural and artificial (e.g., rock pools, tree holes, blocked drains, pot plants and food and beverage containers, and leaf axis) collections in the urban and sub urban environment (Ajim Ali, S.K., & Ateeque Ahmad, 2018).

According to world health organization (WHO) social and environmental factors as well as expansion of international travel have significant impact to the resurgence of dengue disease. Climate change also may be affected transmission as dengue mosquitoes reproduced more quickly and bite more frequently at higher temperature. Urbanization combined with inadequate waste management also produces litter that can trap small isolated pools of water suitable for aegypti's reproductive habits. The world health organization says 2.5 billion people, two fifth of the world's population are now at risk from dengue fever and estimates that there may be 50 million cases of dengue infection worldwide every year. The disease is now endemic in more than 100 countries. It has been shown that Dengue Fever is one of the important public health problem identified as an endemic in the tropic and sub tropic areas (Nirosha Sumanashinghe, et al, 2016).

As shown in Figure1, Dengue fever is one of the most crucial health phenomenons of today in Sri Lanka and the incidence of dengue was minimal in the Sri Lanka until 2007 with a few sporadic cases reported. However, a large outbreak was noted in 2016. From 2014 to 2016, there was a sudden increase in dengue and from 2016 to 2017 there was a sudden decrease after that from 2017 to 2018 there was an increase in dengue cases. (T.Kumanan, et al, 2019). Especially the northern province of the country which has shown significant incidence rate with related to population from year 2014 to 2019. Out of five districts in the Northern Province, there were many clinically diagnosed dengue cases reported during this period in Jaffna district (Table 1), especially in Jaffna divisional secretariat division.

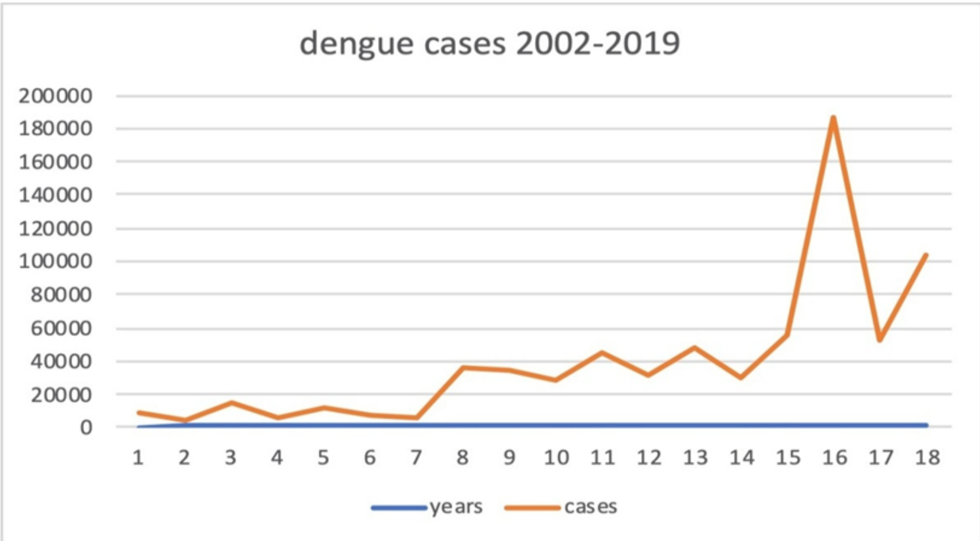


Figure: 1 Dengue trend in Sri Lanka (Source Ministry of Health)

Table: 1 Dengue trend in Districts of Northern Provence (Source RDHS office, Jaffna)

Year	**Jaffna**	**Kilinochchi**	**Mullaitevu**	**Mannar**	**Vavuniya**
2014	1839	90	134	359	142
2015	2016	92	142	105	197
2016	2468	86	182	232	268
2017	6075	518	394	543	1075
2018	4058	342	118	224	603
2019	8261	396	268	271	872

Within the Jaffna District dengue is a major problem in Jaffna Divisional Secretary division and within this division last few years, dengue reported cases were increased in year wise. So, it is necessary to analyze health situation of each Grama Niladhari division and identify the high-risk situations of the disease to prioritize Grama Niladhari divisions for mitigation and preparation of surveillance plan for controlling the prevalence of endemic situation. To identify the high-risk diseases affected areas to prioritize areas for controlling the prevalence of endemic situation in those areas it is necessary to study and analysis environmental and social factor that effected to Dengue Fever. On the other hand, Geographical Information System technologies are capable of integrating, analyzing and displaying spatial, non-spatial and temporal data together. Also advanced Geographical Information System analysis with modeling techniques allows predicting the risk areas of Dengue Fever outbreak. Therefor this study is aimed to practice the possibilities of preparation of dengue risk map based on environmental and social factors using GIS technology for Jaffna divisional secretariat division.

LITERATURE REVIEW

Environmental and Social Factors Associated with Dengue Outbreak Pattern

Generally, dengue incidence is influenced by a complex interplay of factors such as temperature, rainfall, humidity, urbanization, land use pattern, population density, house types, public gathering places, water areas, etc. In Jaffna divisional secretariat contains twenty-eight Grama Niladhari divisions and dengue mosquitoes spread in these areas easily because natural and artificial activities. Based on the ground truth the factors such as Rainfall, Land Use Pattern, Urbanization of the area (Urban/Rural), Population Density, House Type and No of Public Gathering Places were considered for this study.

Analytical Hierarchical Process

The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It represents an accurate approach for quantifying the weights of decision criteria. Individual experts experiences are utilized to estimate the relative comparisons. Each of the respondents has to compare the relative importance between the two items under special designed questionnaire. (Gokulananda Patel, 2018). In this study AHP was used to *Perform pair wise comparisons, assess consistency of pair wise judgments and compute the relative weights*

Weighted Overlay

Weighted Overlay is a technique for applying a common measurement scale of values to diverse and dissimilar inputs to create an integrated analysis.

The factors in the analysis may not be equally important and it should prioritize those factors for some values (Influence). Weighted Overlay only accepts integer raster as input and raster input must be reclassified as integer before they can be used. Generally, the values of continuous raster are grouped into ranges input. Each range must be assigned a single value (scale) before it can be used in the Weighted Overlay tool. The output raster can be weighted by importance and added to produce an output raster. The steps for running weighted overlay are:

- Select an evaluation scale
- Add raster
- Set scale values
- Assign weights to input raster
- Run the weighted Overlay tool

STUDY AREA AND DATA DESCRIPTION

Study Area

The Jaffna Divisional Secretariat area is the major cosmopolitan location in the Jaffna District and is located in the extreme North of Sri Lanka. The total area of the Jaffna Divisional Secretariat is 11.31 sq km (Land Area 10.92 sq km, Water Area 0.39 sq km). It is bounded by Nallur Divisional Secretariat division on its North and part of East, Jaffna lagoon on its part of East and South and Vali south west divisional secretariat division on its West. The study area includes 28 Grama Niladhari divisions.

Data Description

For this study risk factors were identified for 28 Grama Niladhari Divisions in the study area and environmental factors such as Land use pattern and

Rainfall detail were considered for this analysis. Further, following social factors were also considered.

- Population density
- Public gathering places
- House type

For environmental factors the land use in Jaffna divisional secretariat area was collected from Survey Department. It has different type of land use pattern. Figure 2 shows the land use in Jaffna divisional secretariat area.

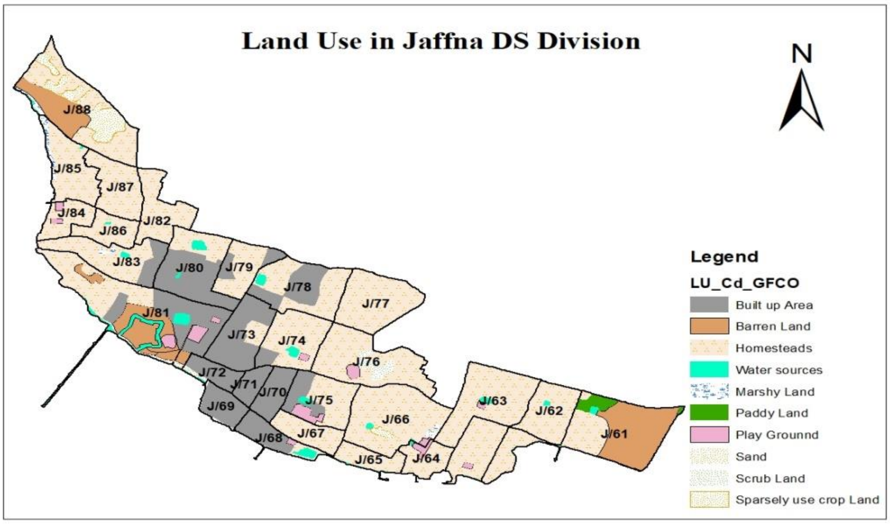


Figure 2 Land Use in Jaffna DS Division

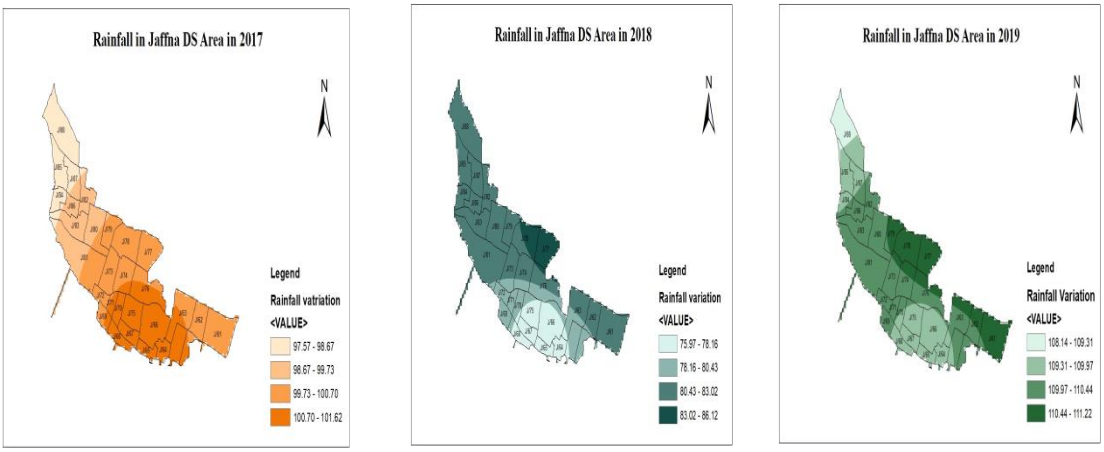


Figure: 3 Rainfall Distributions in 2017, 2018 & 2019

Further, for social factors, statistical data of population of the study area in 2017, 2018 and 2019 were collected from Divisional secretary office in Jaffna. Population density is one of the factors of this research so population density was calculated in each GN divisions. Then GN divisions were categorized into three classes according to population density. And also house type of the study area of Jaffna DS Division was collected from Divisional secretary office of Jaffna. House type was divided as temporary house, semi-permanent house and permanent house and statistical data of public gathering places of the study area was collected from Divisional secretary office in Jaffna. Public gathering places were included school, elder's society, sports club and community center.

METHODOLOGY

Overall methodology is illustrated in Figure 4, which includes data collection, database development, data processing, GIS analysis, development of GIS model, weight assigning, risk map preparation and verification.

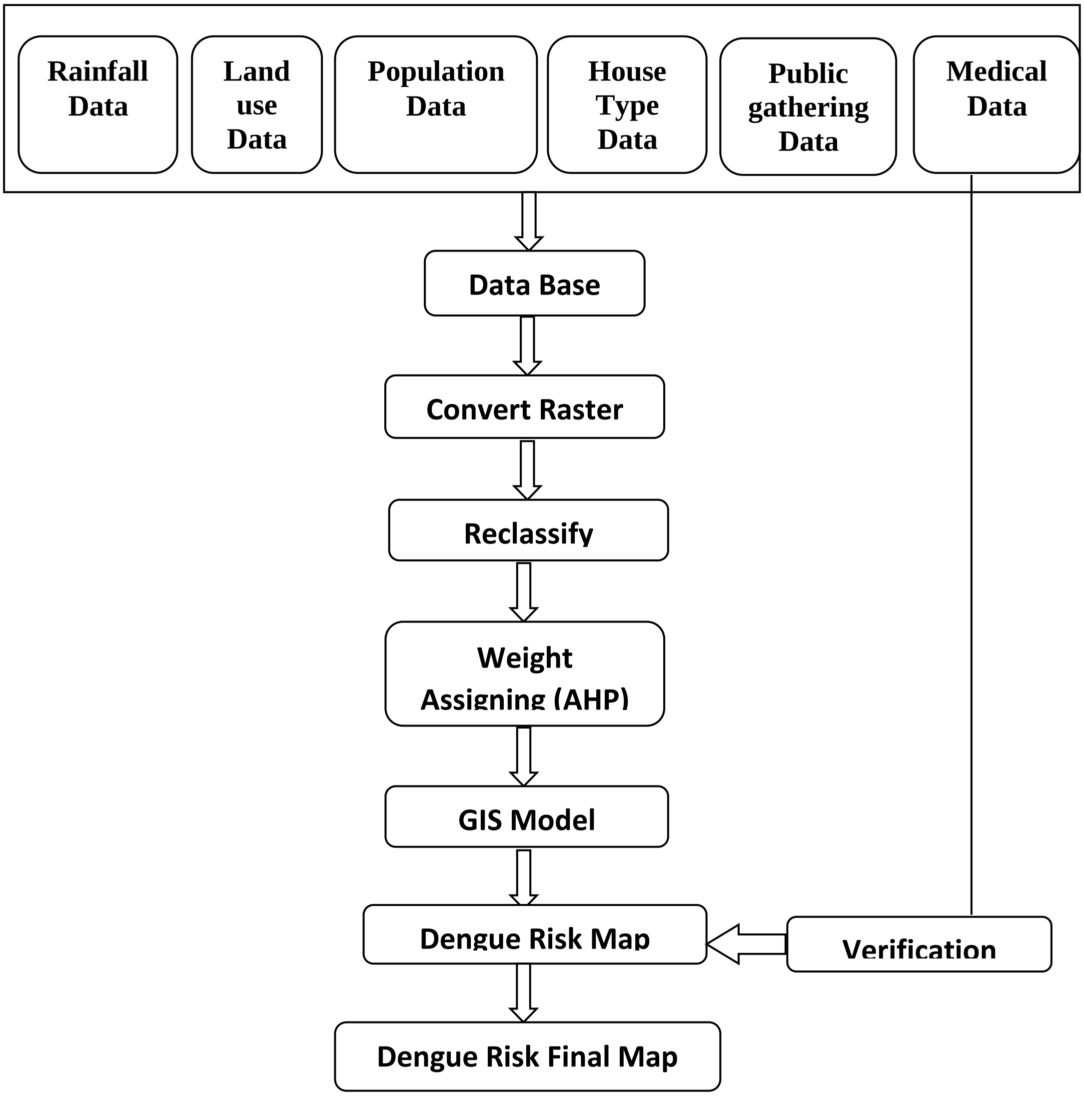


Figure: 4 Overall Methodology

Classification of Rainfall Map

Rainfall range was classified into three classes using natural breaks (jenks) method. The Jenks Natural Breaks classification system is a data classification method designed optimize the arrangement of a set of values into natural classes. A natural class is the most optimal class range found naturally in a data set. If there is a higher rainfall water will gather in any area that is the suitable location for breeding environment for dengue mosquitoes. So high range of rainfall in 2017, 2018 and 2019 were assigned high weight of 3 and similarly medium, low range were considered as medium and low risk value respectively as shown in Table 2.

Table: 2 *Classification of rainfall in 2017, 2018 and 2019*

Criteria	**Range**			**Risk Weight**
	2017	**2018**	**2019**	
High	100.50-101.62	83.00-86.12	110.15-111.22	3
Medium	99.00-100.50	80.00-83.00	109.40-110.15	2
Low	97.57-99	75.97-80.00	108.14-109.40	1

Classification of the Land Use

Water features, build up areas with crowded building, complex drainage system and marshy land are possible to make breeding environment for mosquitoes. So, these areas were considered as high risk and given high risk score. Human activities such as putting the garbage, polythene papers, and waste bottles and ignorance of daily cleanings are also possible to breeding mosquitoes. So, home land, scrub land and paddy land are medium risk areas. Because of the mosquito breeding in this area is increased when watering the cultivation. So these areas were medium risk value. In barren lands, play grounds, sparsely use crop lands and sand mosquito breeding potential is very low. Mosquitoes cannot lay the eggs in the sand because sand has no cover place. So these areas were low risk value (S.Kannathasan et al, 2013). Accordingly, weight values were assigned and given in Table 3.

Table: 3 *Land Use Classification*

Criteria	**Classification of Land Use Pattern**	**Risk Weight**
High	Build up area Marshy Land, Water holes	3
Medium	Home, Scrub land, Paddy Land	2
Low	Barren Land, Play Ground, sparsely use crop Land, Sand	1

Classification of Population Density

Population density was calculated and categorized three classes as shown in Table 4.

Table: 4 *Population Density Classifications*

Criteria	**Range (population per Square km)**	**Risk Score**
High	6250 - 22525	3
Medium	4000 - 6249	2
Low	2065 - 3999	1

Classification of the House Type

House range was classified into 3 classes using natural breaks (jenks) method and types of house were classified as temporary house, semi-permanent house and permanent house. Temporary houses were suffered in many environmental problems including sanitation problems, drainage problem and improper sewage system. So, it was created a suitable breeding environment for dengue mosquitoes. So high risk and given risk value 3. Semi-permanent house was partially permanent and temporary construction.

Proper drainage systems were not fully constructed in semi-permanent house and Temporary house. This is also partly suitable breeding environment for dengue mosquitoes. So medium risk and given risk value 2. Permanent house have all facilities and suitable drainage system and proper sewage system and this is less suitable to the dengue mosquitoes. So low risk value and given risk value 1.

Classification of the Public Gathering Places

Public gathering places of the study area included such as school, community center, elder's society and sports club and those places were classified into three classes using natural breaks (jenks) method. Peoples may not consider rules and regulation of public gathering places. Not removing the garbage, using the plastic goods carelessly and not maintaining the drainage system regularly were the reasons for producing a suitable breeding environment for dengue mosquitoes. Based on the discussion higher number of public gathering places were assigned high risk value and whereas medium and less number of public gathering places created medium and low risk.

Weight Assignment

The environmental and social factors in my analysis may not be equal weight. Some factors highly influent with dengue infection and some factors not highly influent with dengue infection. So it is necessary to prioritize those factors some values. Prioritization and risk factors were identified according to discussed with planning department officers, municipal council officers and Health Sectors. The appropriate weights for considered factors were designed by using AHP method. High weights were assigned for factors with higher prioritize. Rainfall, Land use, Population density, House type and public gathering places were considered the factors of dengue infection. All factors were compared with each other's. Rainfall was compared with land use, population density, house type and public gathering place, this created moderate, strongly and very strongly important with each factor respectively. Land use was compared with population density, house type and public gathering place, this created moderate, strongly and very strongly important with each factor respectively. Population density was compared with house type and public gathering place, this created strongly and very strongly important with each factor. House type was compared with public gathering place this created moderate risk.

According to the priorities rainfall, land use, population density, house type and public gathering places were high to lower weights Priorities were calculated from pair wise matrix. Pair wise matrix was calculated from given formula;

Pair wise comparison matrix element = $\frac{i\ th\ column\ element}{sum\ of\ i\ th\ column}$

Where i =1,2,3,4,5

Based on the outcome of the pair wise compassion matrix weight factors were calculated and shown in Table 5.

Table: 5 Assigned weights for identified factors

Factor	Rainfall	Land use	Population Density	House Type	Public gathering place
Weight	0.44	0.28	0.17	0.07	0.04

According to above values Risk Map equation was developed as follows to prepare the dengue risk map in the study area;

Risk = 0.44*Rainfall + 0.28*Land use + 0.17* Population Density + 0.07* House Type + 0.04* Public gathering places.

RESULTS AND DISCUSSION

Three different dengue risk maps were prepared for the years of 2017, 2018 & 2019 with respect to identified environmental and social factors separately. As per Figure 5, GN division J/88 was identified as low risk area whereas, GN divisions J/65, J/66, J/67, J/68, J/69, J/70, J/71, and J/75 were identified as high-risk areas while other GN divisions were identified as medium risk areas. Further another attempt was made to compare this risk map outcome with actual dengue cases in the year of 2017 and found that GN Divisions J/65, J/67, J/68, J/69, J/70, J/71 and J/75 are common high-risk areas and GN Division J/88 is common low risk area while GN Divisions J/61, J/72, J/73, J/74, J/77, J/78, J/79, J/80, J/81, J/82 and J/83 are found common medium risk areas. 19 GN Divisions are common in both maps. Prepared risk maps showed 68% matching with the number of reported dengue cases.

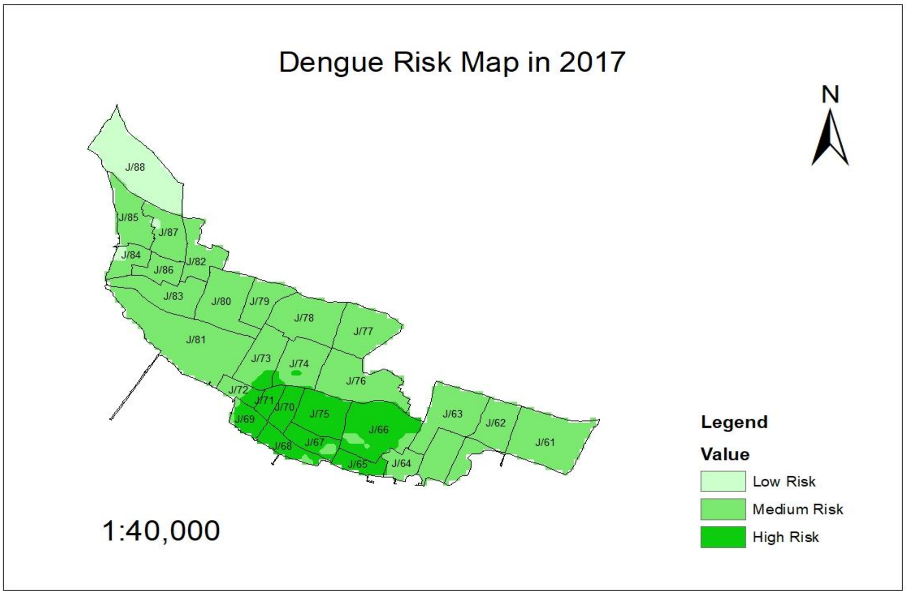


Figure 5 Dengue Risk Map - 2017

As shown in Figure 6, in the year of 2018 GN divisions J/63, J/64, J/65, J/67and J/76 were identified as low risk area whereas, J/78 was part of high-risk area and other GN areas were of medium risk areas. While comparing this map with actual Dengue Cases in the year of 2018 it was noted that GN Divisions J/63, J/64, J/65 and J/76 are common low risk divisions, GN Divisions J/61, J/62, J/68, J/69, J/70, J/71, J/72, J/73, J/74, J/75, J/77, J/79, J/80, J/82, J/83, J/84, J/85, J/87 and J/88 are common medium risk divisions and no common high risk were found. And also noted that 23 GN Divisions are common in both maps. Finally it was proved that 82% of identified risk map for the year of 2018 were matching with the number of reported dengue cases for that year.

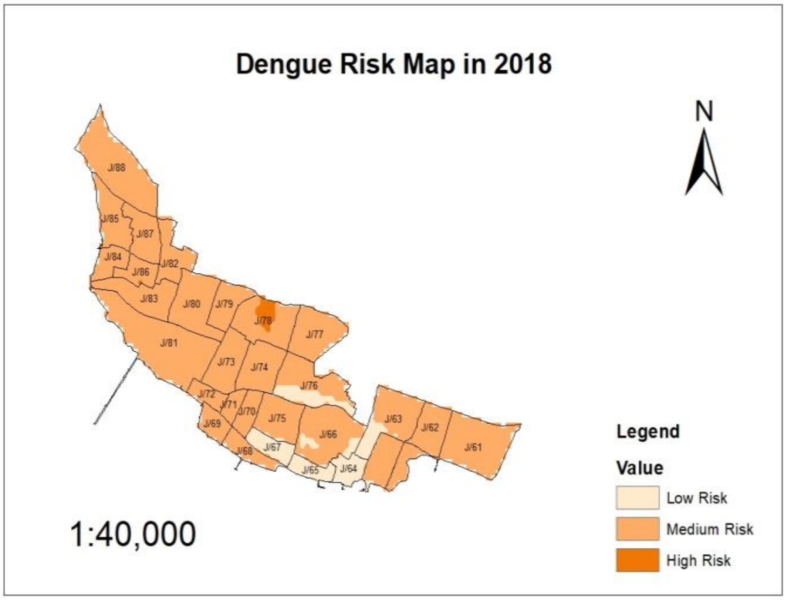


Figure: 6 Dengue Risk Map - 2018

In the year of 2019, as shown in Figure 7, GN division J/88 was identified as low risk areas, GN divisions J/68, J/72, J/73 and J/78 were identified as high-risk areas and other GN areas were classified as medium risk areas. The identified risk areas were compared with actual Dengue Cases Map in 2019 and found that GN Division J/88 is common low risk division. While GN Divisions J/61, J/64, J/65, J/69, J/70, J/71, J/76, J/77, J/80, J/81, J/82, J/84, J/85, J/86 and J/87 are common medium risk divisions and GN Division J/73 is common high-risk division. And also found that 17 GN Divisions are common in both maps. The identified risk areas showed 61% matching with the number of reported cases for dengue map.

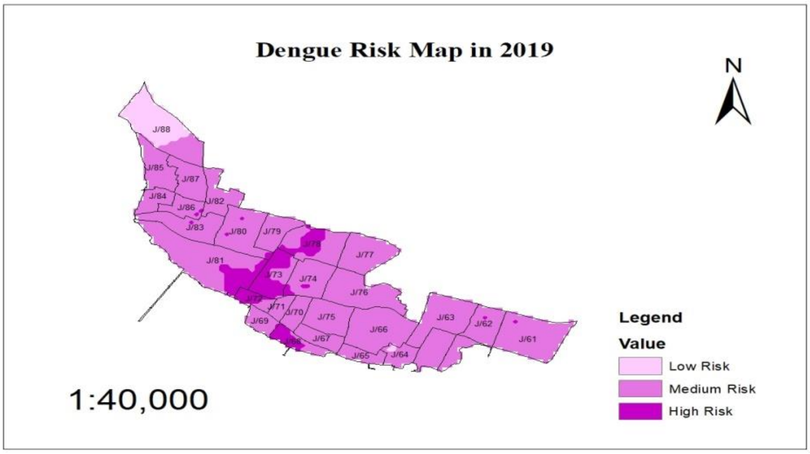


Figure: 7 Dengue Risk Map - 2019

FINAL REMARKS

The identified risk areas have shown clear dependency of dengue cases with environmental and social factors and also iidentified the relationship of dengue incidence with environmental and social factors that significantly influence dengue outbreaks. Further about 70% of the area in this district belongs to highly and moderately risk categories. Therefore it is necessary to get precautions to mitigate and control the prevalence of epidemic situation. Furthermore, GIS technologies along with AHP facilitates could be used to analyze the environmental and social factors influence to the dengue epidemic effective and to prepare dengue risk maps which could be used by health authorities to take prevention activities. Based on findings of this study it was realized that this study can be improved with high resolution images in different time intervals to identify the changes in the data in databases and with more social factors to lead to better risk map preparation.

REFERENCES

Gokulananda Patel, (2018).Weight Derivation in Analytic Hierarchy Process Using Data Envelop Development Analysis.

Nirosha Sumanashinghe, Armin Milker, Chetan Tiwari and Jayantha Muthukudage (2016), Geo-statistical Dengue Risk Model using GIS techniques to identify the risk prone areas by linking rainfall and population density factors in Sri Lanka.

S. K. Ajim Ali and Ateeque Ahmad, (2018), Using Analytic Hierarchy Process with GIS for Dengue Risk Mapping in Kolkata Municipal Corporation, West Bengal, India

S.Kannathasan, K.Suthakar, P.J.Jude and S.N.Surendran, (2013), Potential Risk Areas for Dengue in the Jaffna Municipal Area in Northern Sri Lanka.

T.Kumanan, V.Sujanitha, N.Rajeshkannan, The Impact of Population Mobility on Dengue Fever: An Experience from Northern Sri Lanka