BUMITOUCH plmc (813270D)

LANDSLIDE HAZARD ZONATION MAPPING USING LIDAR DATA

GEOSMART ASIA

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CONTENTS

- BACKGROUND
- METHODOLOGY
  - SELECTION OF STUDY AREA
  - MODEL DEVELOPMENT
  - DATA COLLECTION
  - DATA PROCESSING
  - DATA ANALYSIS
- RESULTS AND ANALYSIS
- CONCLUSIONS

BACKGROUND

- The increasing population and expansion of settlements over hilly areas has greatly increased the impact of natural disasters such as landslide.
- Over the years, various techniques and models have been developed to predict landslide hazard zones.
- The development of these models are based on nine different landslide inducing parameters i.e. slope, land use, lithology, soil properties, geomorphology, flow accumulation, aspect, proximity to river and proximity to road.
- Rank sum, rating, pairwise comparison and AHP techniques are used to determine the
- weights for each of the parameters used. Four
- Criteria considered
- The need for accurate DEM
- LiDAR technology
- Models - MCDM

BACKGROUND

- The increasing population and expansion of settlements over hilly areas has greatly increased the impact of natural disasters such as landslide.
- Over the years, various techniques and models have been developed to predict landslide hazard zones.
- The development of these models are based on different landslide inducing factors such as:

Main Groups	**Factors**
Ground Condition	Geomorphology
	Geology
	Soil
	Land use
Distance Related	Roads
	River
	Drainage density
	Faults
Geomorphometry	DEM
	Slope
	Aspect
	Elevation
Triggering	Rainfall
	Earth quakes

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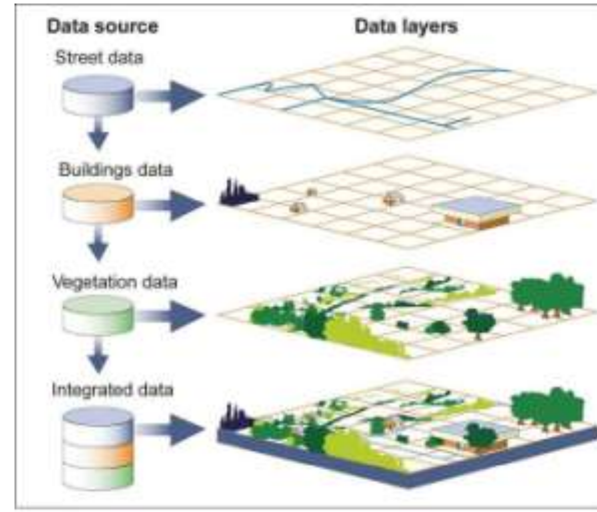
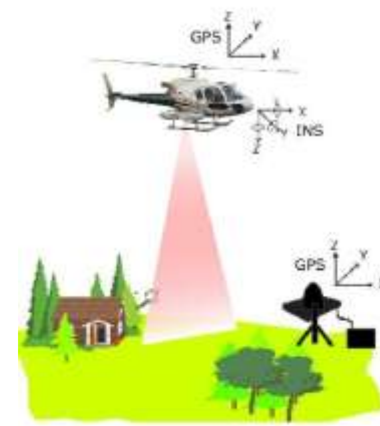
BACKGROUND

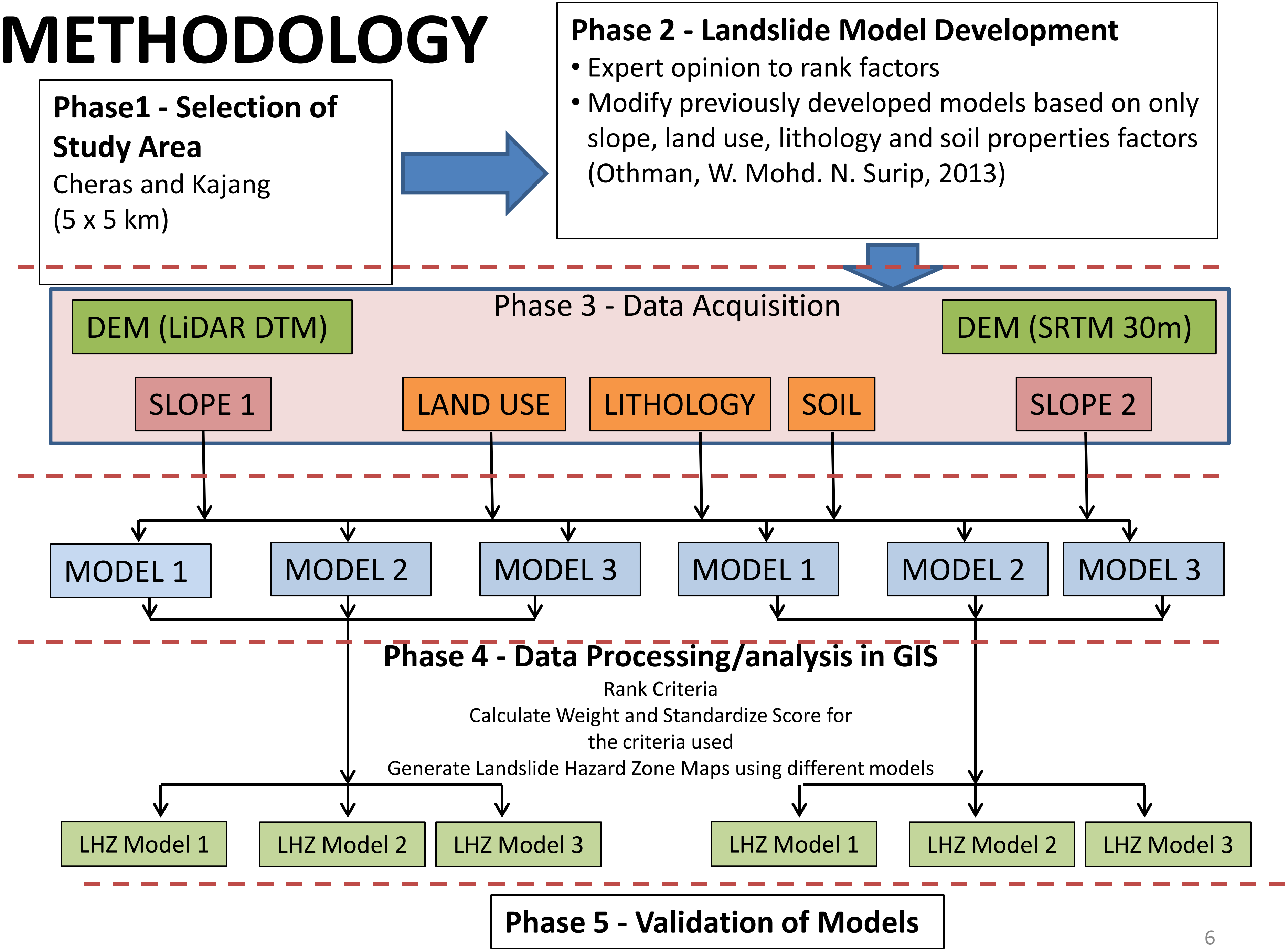
- Slope is one of the most important factor in assessing landslide hazard areas – need high accuracy and high resolution DEM
- LiDAR technology and Geographical Information System (GIS) are important tools in assessing landslide hazards
- Multi-criteria Decision Making (MCDM) Multi-criteria decision making approach also play important role in determining relative importance of landslide factors





Source : Sight Power

METHODOLOGY



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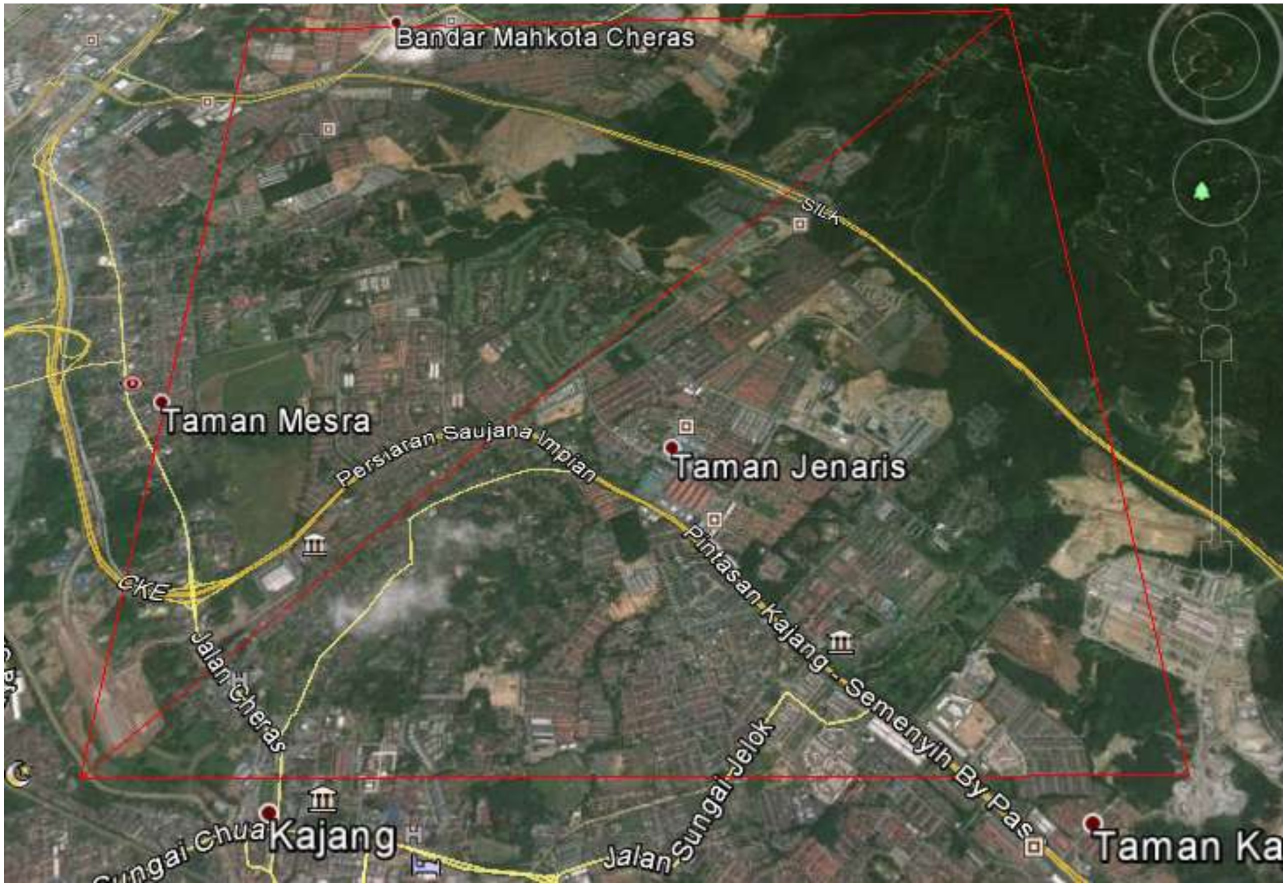
STUDY AREA – PART OF CHERAS AND KAJANG



Area Coverage

- Size : 5 x 5 km
- From Cheras to Kajang
- Elevation Range : 20 – 321 m above MSL
- Mukim : Kajang, Semenyih and Cheras

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DATA COLLECTION

- Digital Terrain Model (DTM) – from LiDAR
- Digital Surface Model (DSM) – from LiDAR
- Orthoimage
- Digital Elevation Model from SRTM – from USGS website
- Soil Properties - derived from soil map
- Land use – Digitised from Orthoimage
- Lithology

DATA ACQUISATION FROM LIDAR

- Data acquisition - Hazard and Slope Risk Mapping Project at Cheras Selatan-Kajang-Bangi-Putrajaya, Selangor for RS & GIS Consultancy Sdn Bhd and Department of Mineral & Geoscience.

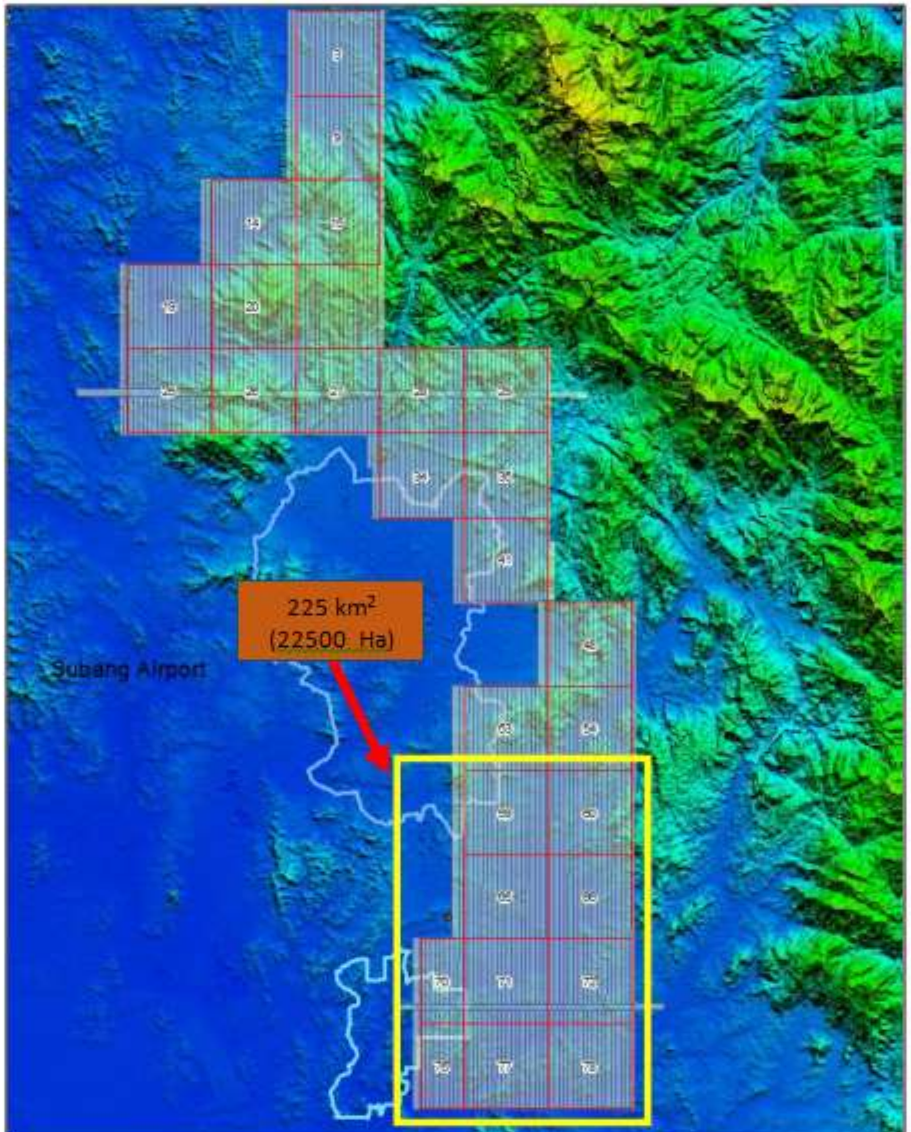
EQUIPMENT DETAILS:

- LiDAR System is **LiteMapper 6800-400(Riegl 680i-400kHz)**
- This Laser Scanner is **Full Waveform** which has **unlimited** number of return echoes.
- This System comes with high resolution RGB Camera System **60 Mega Pixel** and automatic geo-correction system which is equipped with **512kHz Fiber Optic IMU**.

DATA ACQUISITION:

- Date: 19 December 2014, 30 December 2014 – 3 January 2015
- Requirement RSGIS & JMG for data acquisition:
- Helicopter type : Eurocopter EC 120B
- Helicopter Speed : 60 knot
- Flying Altitude : 600 m AGL
- Laser Scan Angle : 60^0
- PRR laser : 400 kHz (maximum range)

LiDAR Project Area



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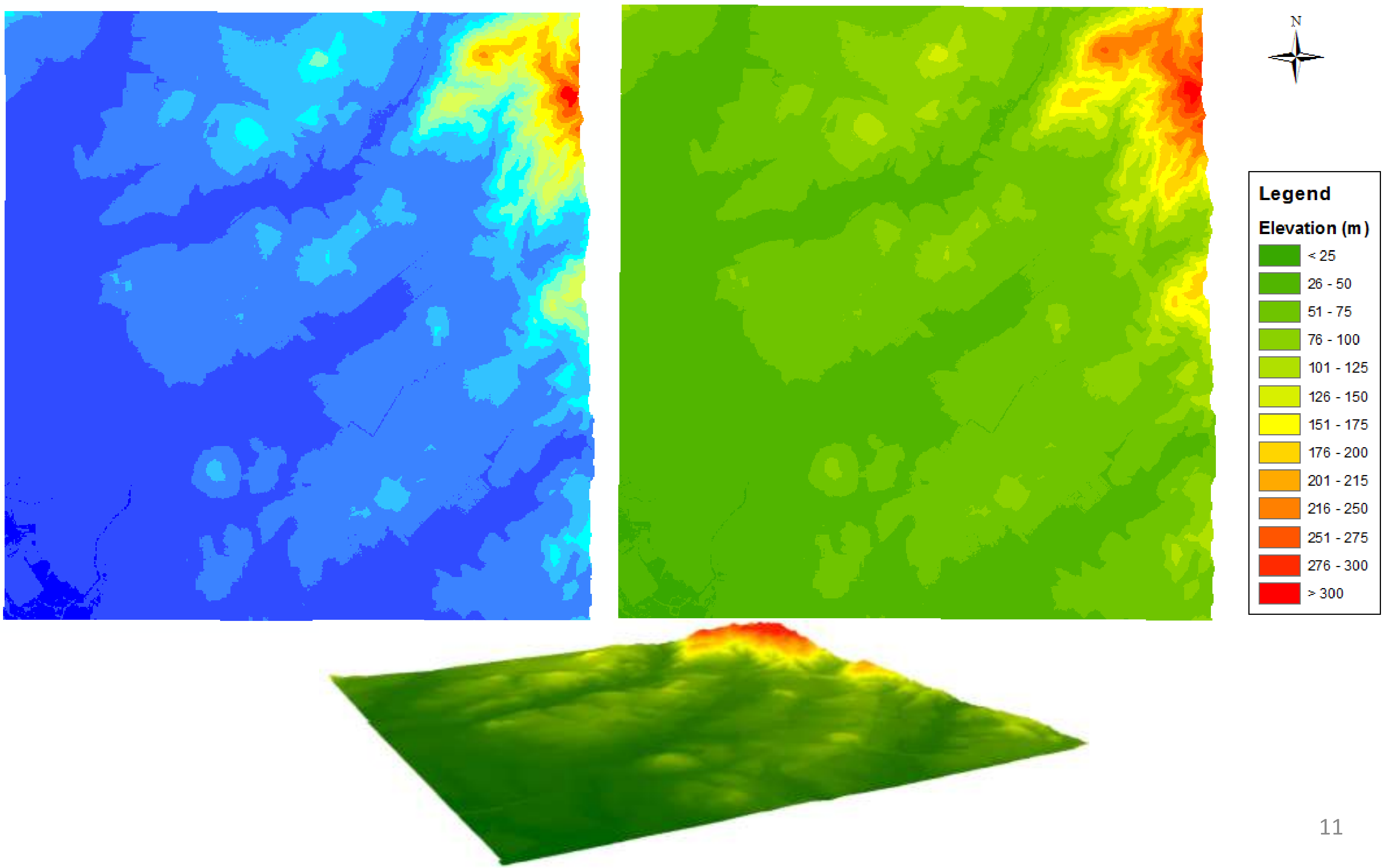
DTM derived from LiDAR



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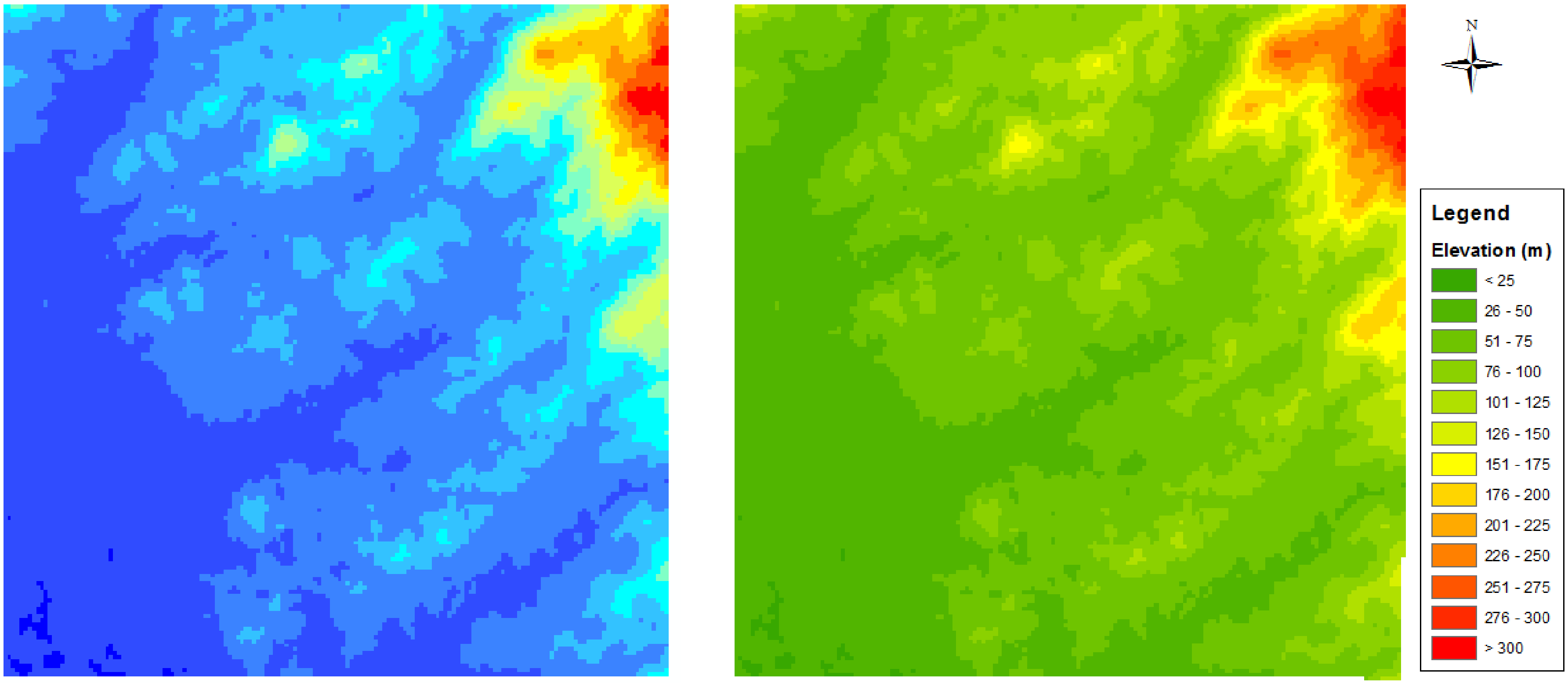
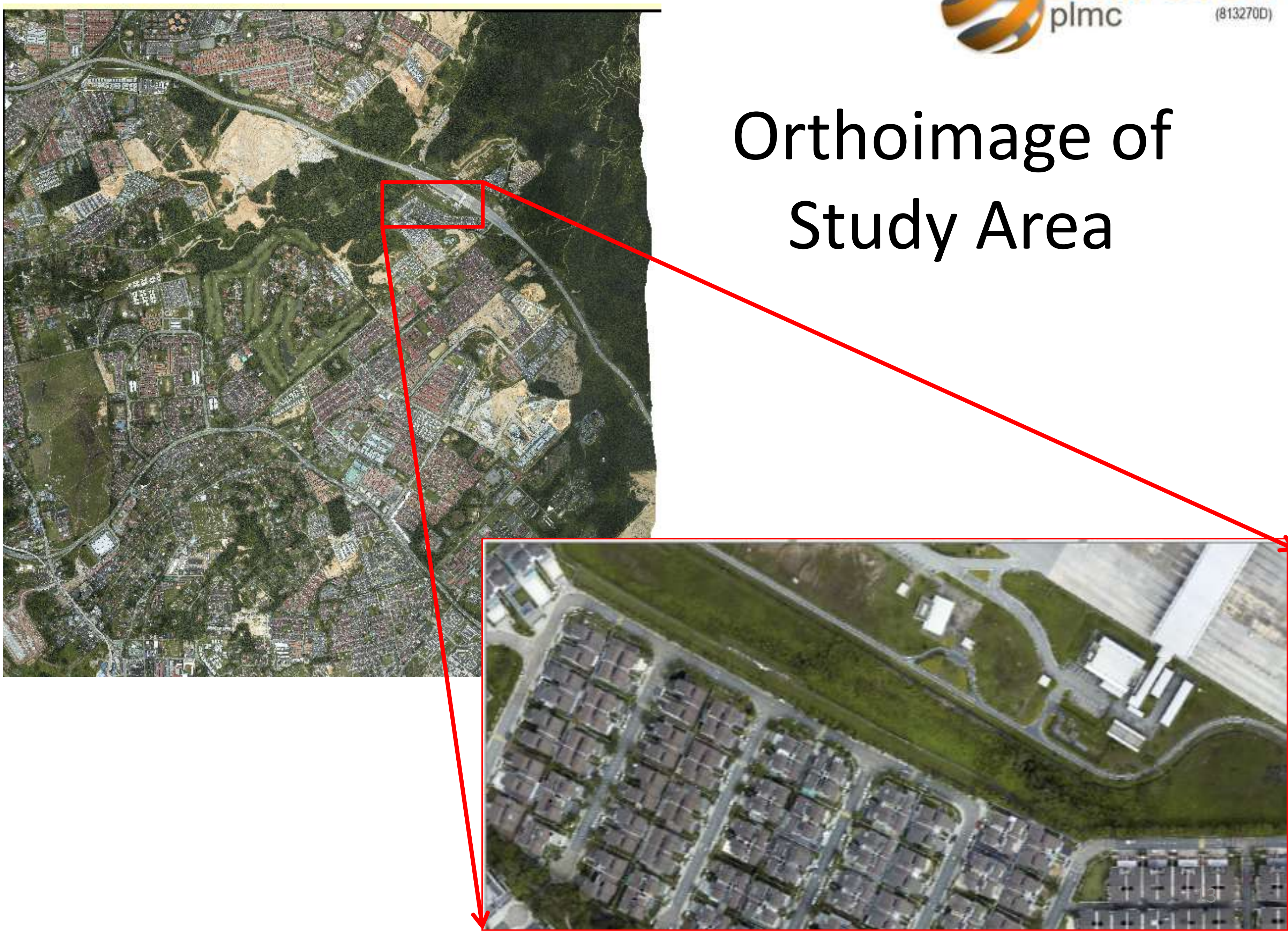
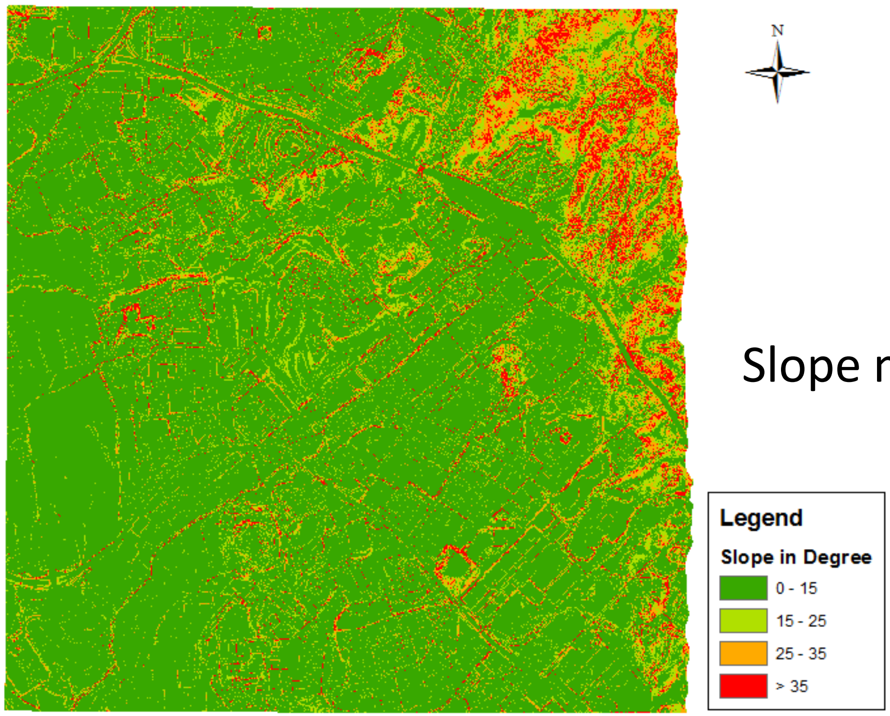
DEM – Shuttle Radar Topographic Mission (SRTM) – 30 x 30 m

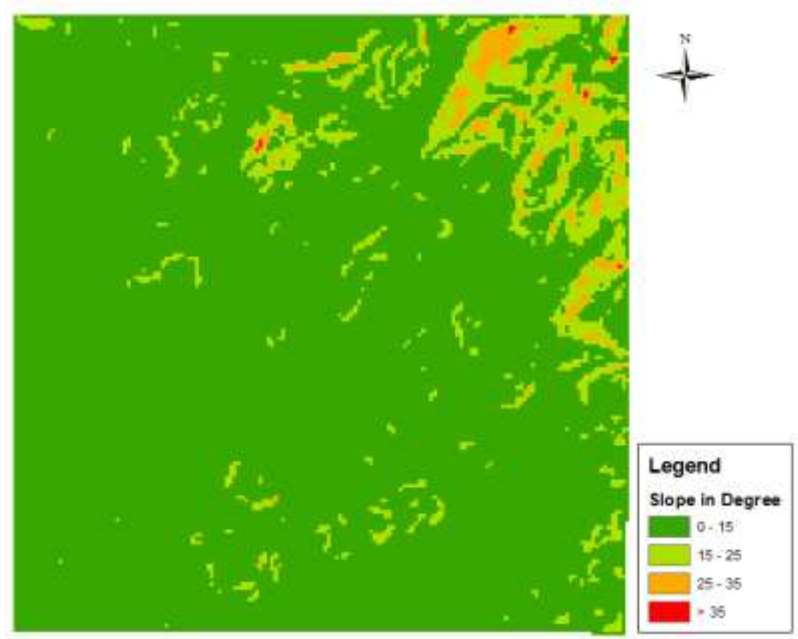


Orthoimage of Study Area



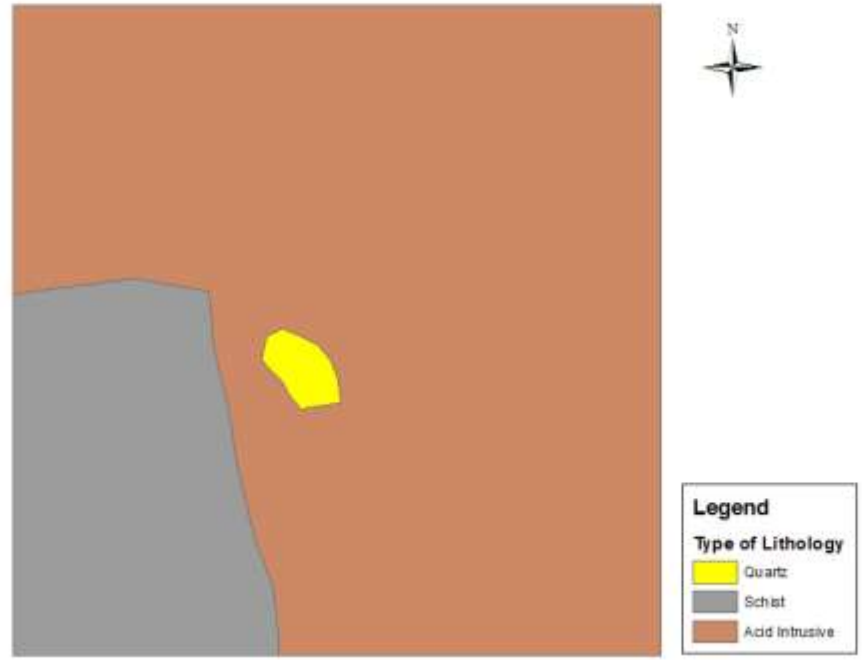


Slope map derived from_LiDAR

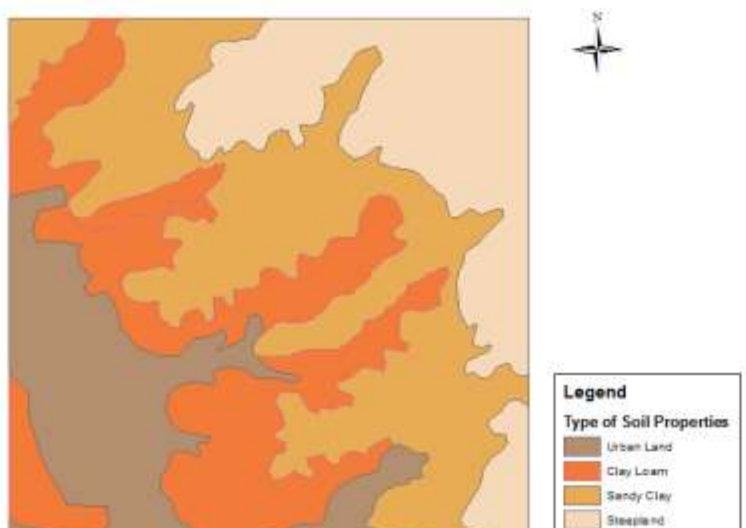


Slope map derived from_SRTM

Land use map

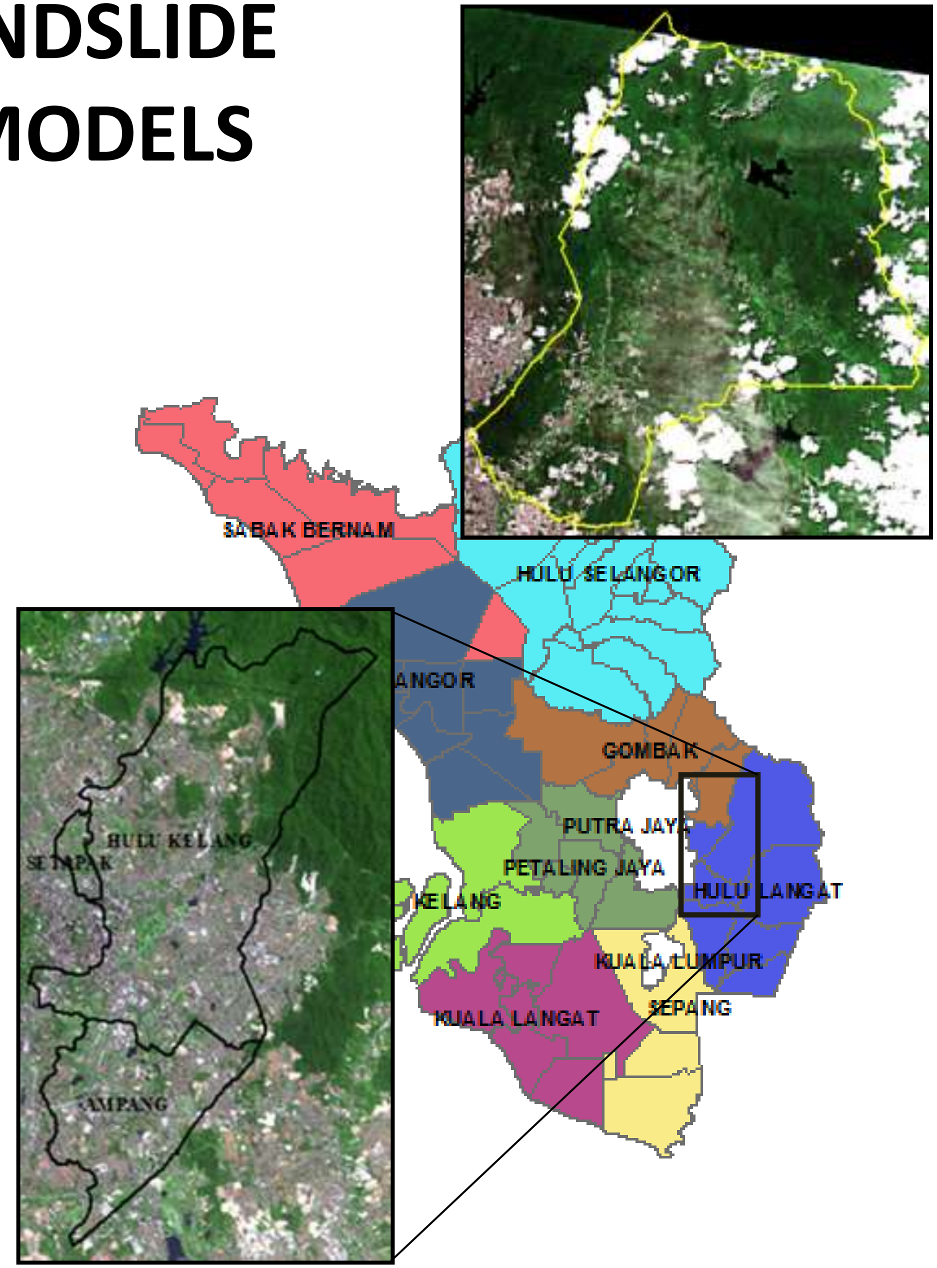


Lithology map



DEVELOPMENT OF LANDSLIDE HAZARD ZONATION MODELS

- Based on earlier studies by Ainon Nisa, Wan Mohd and Noraini Surip
- Study Areas - Ampang Jaya and Hulu Langat
- Technique used – GIS-based Multicriteria Decision Making (MCDM)



Landslide Hazard Models Tested

Model No	Technique/ Criteria	Slp	Lu	Litho	SP	Geomor	Asp	Elev	Rf	Priv	Prd	Facc	Drg
1	Ranking (Rank Sum)	0.333	0.133	0.267	0.2	0.067							
2	Ranking (Rank Reciprocal)	0.438	0.109	0.219	0.146	0.088							
3	Ranking (Rank Exponential)	0.454	0.073	0.291	0.164	0.018							
4	Rating	0.335	0.168	0.252	0.211	0.034							
5	AHP (Expert Opinion)	0.162	0.082	0.116	0.277		0.023	0.061	0.21	0.041	0.032		
6	Pairwise Comparison (Expert Opinion)	0.5	0.036	0.143	0.214		0.107						
7	Pairwise Comparison (Expert Opinion)	0.294	0.088	0.236	0.265	0.029						0.088	
8	AHP (Expert Opinion)	0.361	0.113	0.091	0.199		0.141			0.051	0.044		
9	AHP (Expert Opinion)	0.[illegible]	[illegible]	[illegible]	[illegible]		0.108			0.045	0.037		0.195

FACTORS CONSIDERED :

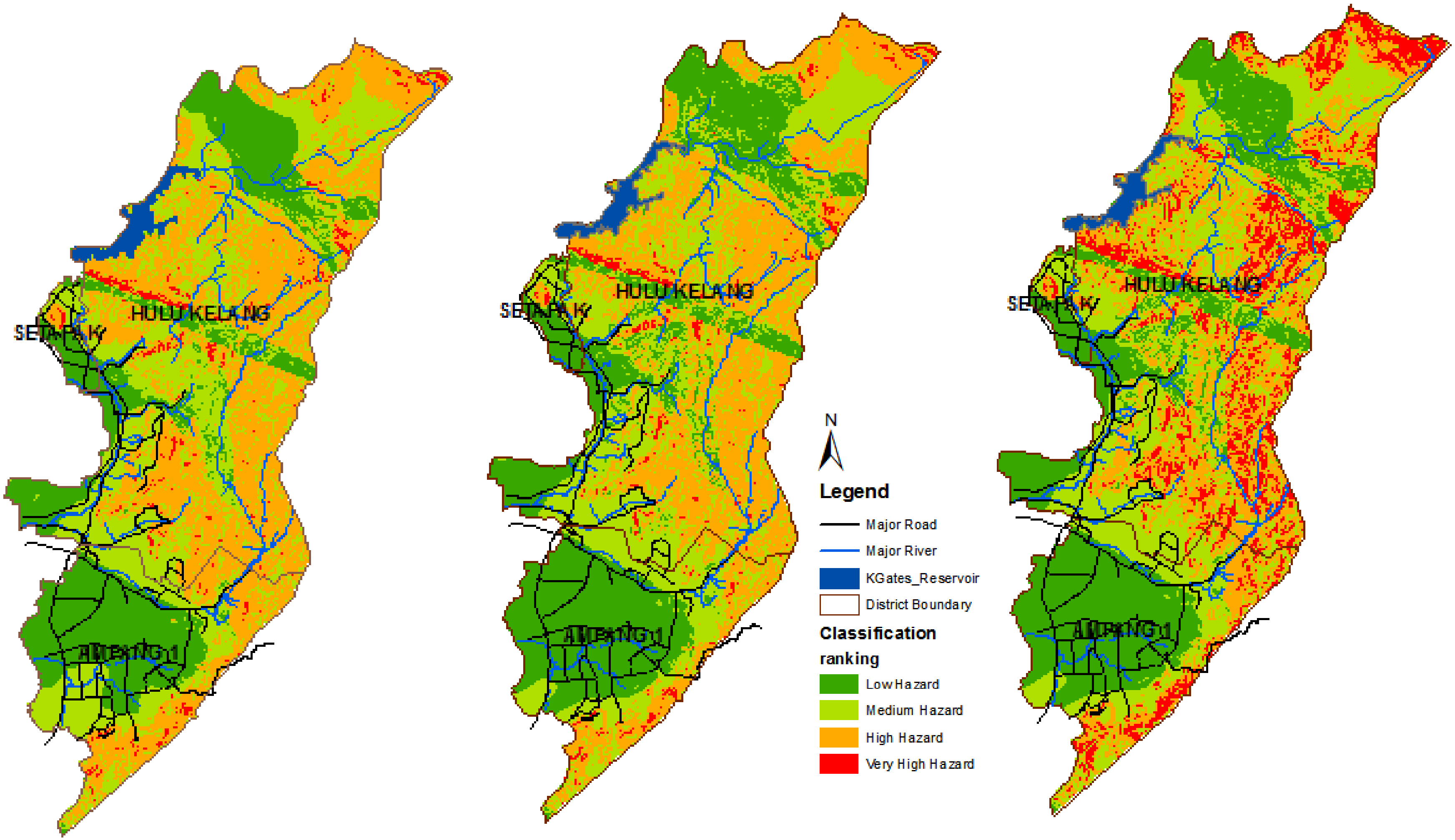
Slope (slp)
Land use (Lu)
Lithology (Litho)
Soil Properties (SP)

Geomorphology (Geomor)
Aspect (Asp)
Elevation (Elev)
Rainfall (Rf)

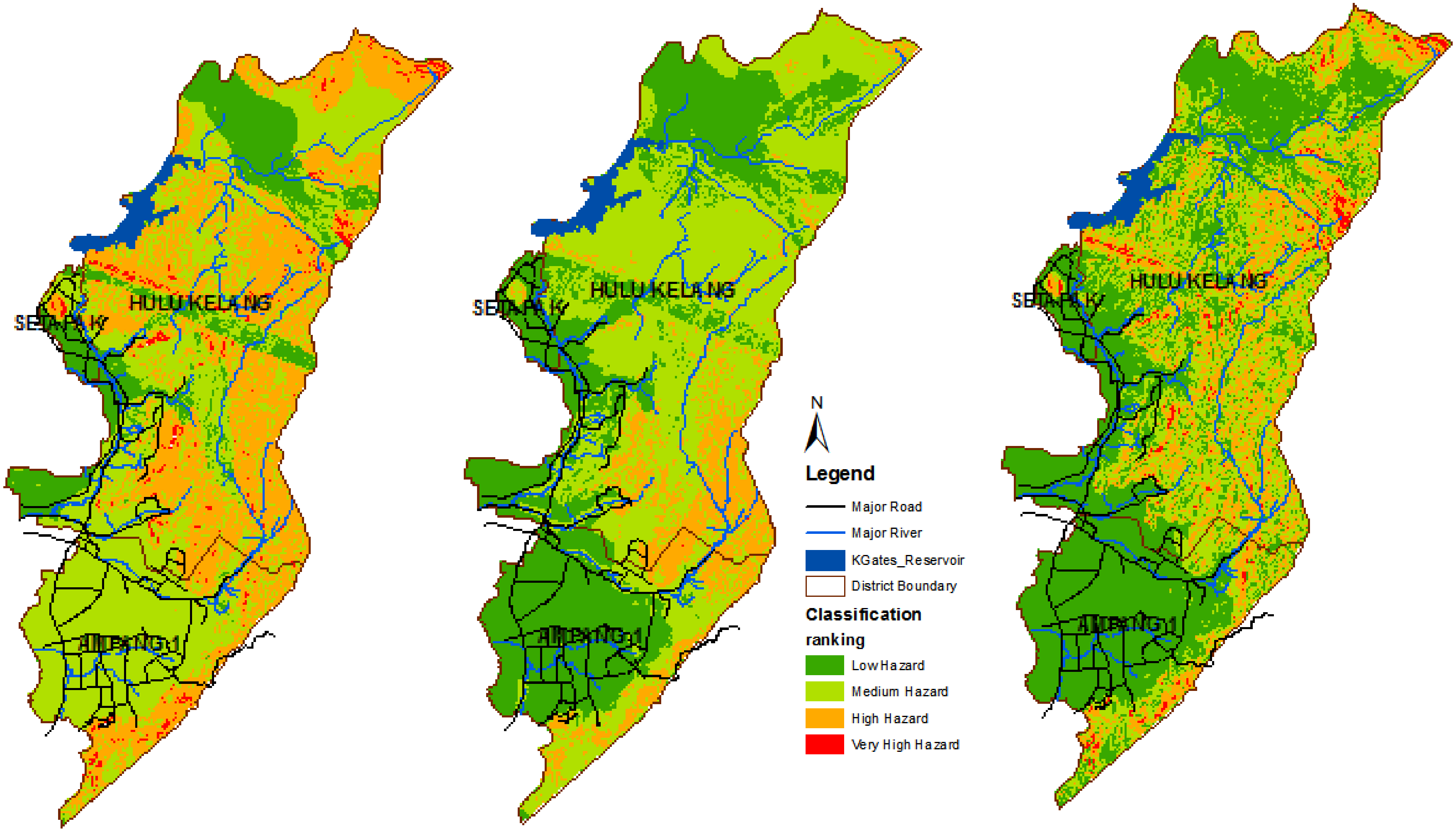
Proximity to river (Priv)
Proximity to road (Prd)
Flow Accumulation (Facc)
Drainage Pattern (Drg)

Developed Models

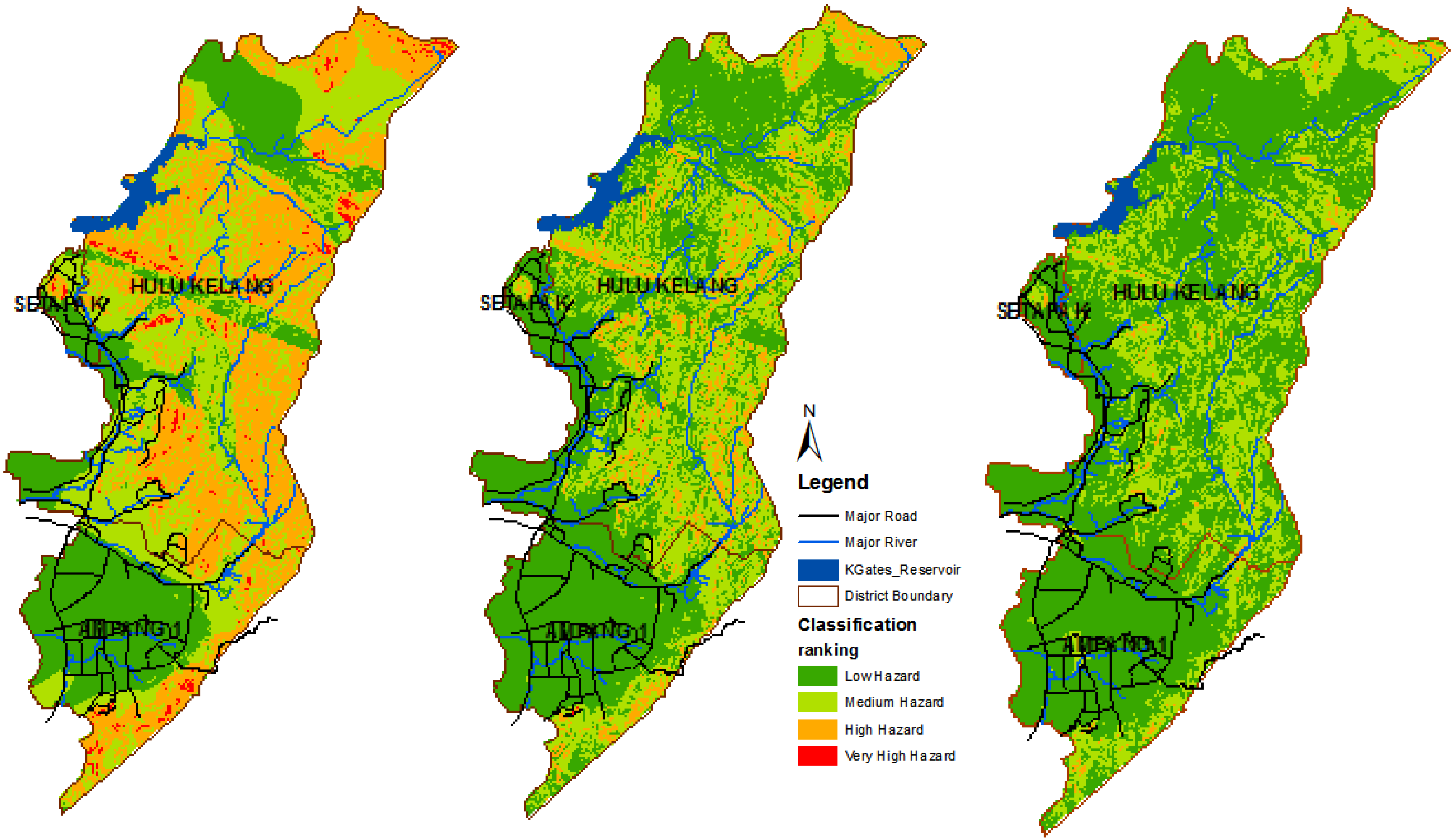
Model No	Technique	Formula
1	Rank Sum	0.333(s_slp) + 0.133(s_lu) + 0.267(s_lit) + 0.2(s_sp) +0.067(s_geomorf)
2	Rank Reciprocal	0.438(s_slp) + 0.109(s_lu) + 0.219(s_lit) + 0.146(s_sp) + 0.088(s_geomorf)
3	Rank Exponent	0.454(s_slp) + 0.073(s_lu) + 0.291(s_lit) + 0.164(s_sp) + 0.018(s_geomorf)
4	Rating	0.335(s_slp) + 0.168(s_lu) + 0.252(s_lit) + 0.211(s_sp) + 0.034(s_geomorf)
5	AHP	0.162(s_slp) + 0.082(s_lu) + 0.116(s_lit) + 0.277(s_sp) + 0.023(s_asp) + 0.061(s_elev) + 0.207(s_rfal) + 0.041 (s_priv) + 0.032(s_prd)
6	Pairwise Comparison	0.5(s_slp) + 0.036(s_lu) +0.143(s_lit) + 0.214(s_sp) + 0.107(s_asp)
7	Pairwise Comparison	0.294(s_slp) + 0.088(s_lu) + 0.029(s_geomorf) + 0.265(s_sp) + 0.236(s_lit) + 0.088(s_flowacc)
8	AHP	0.361(s_slp) + 0.141(s_asp) + 0.091(s_lit) + 0.113(s_lu) + 0.199(s_sp) + 0.051(s_priv)+0.044(s_prd)
9	AHP	0.301(s_slp) + 0.108(s_asp) + 0.073(s_lit) + 0.089(s_lu) +0.152(s_sp) + 0.045(s_priv) + 0.037(s_prd) + 0.195(s_drg)



Landslide Hazard Zonation Maps Generated from Model 1, 2 and 3

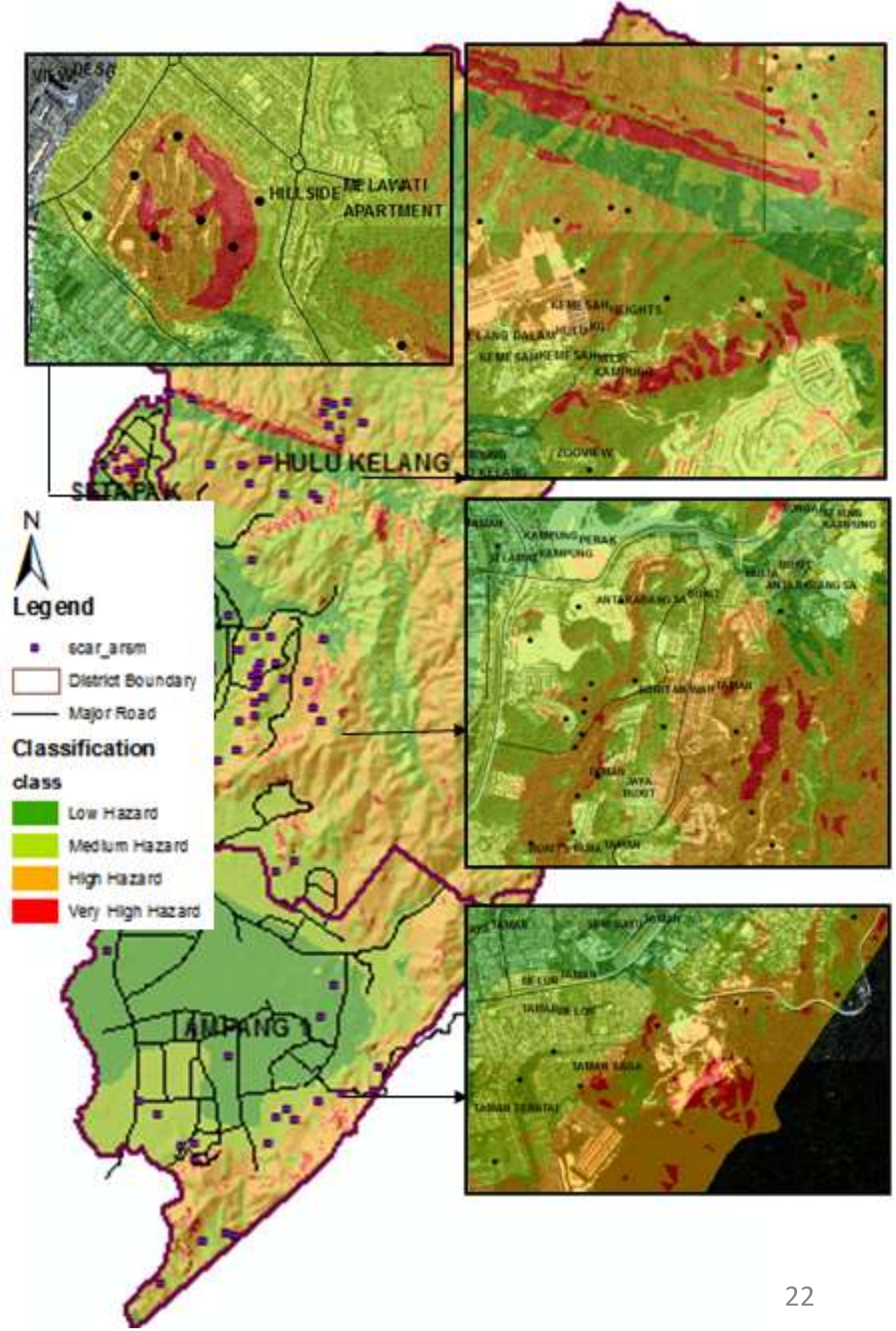


Landslide Hazard Maps Generated from Model 1, 2 and 3



Landslide Hazard Maps Generated from Model 7, 8 and 9

Comparison between landslide hazard class and landslide historical data – Area Hulu Kelang



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Models Used – For this study

Criteria Considered

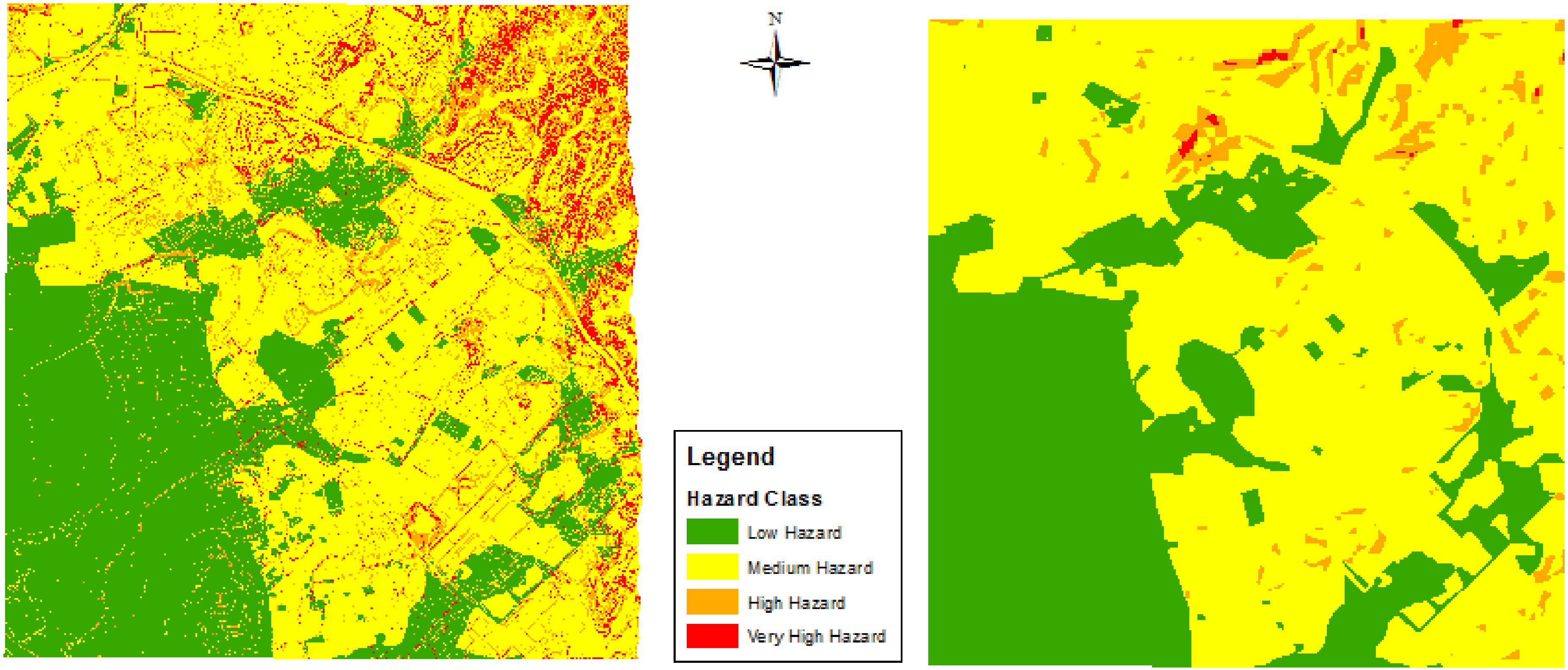
- Slope
- Lithology
- Land use
- Soil Properties

LHZ (Model 1) = (0.400 x s_slp) + (0.100 x s_lu) + (0.300 x s_litho) + (0.200 x s_sp) ------------(1)

LHZ (Model 2) = (0.347 x s_slp) + (0.219 x s_lu) + (0.218 x s_litho) + (0.174 x s_sp) -----------------------(2)

LHZ (Model 3) = (0.481 x s_slp) + (0.240 x s_lu) + (0.159 x s_litho) + (0.120 x s_sp) ----------------------------------(3)

RESULT – LHZ MAP BASED ON MODEL 1



LHZ based on LiDAR data

LHZ based on SRTM data

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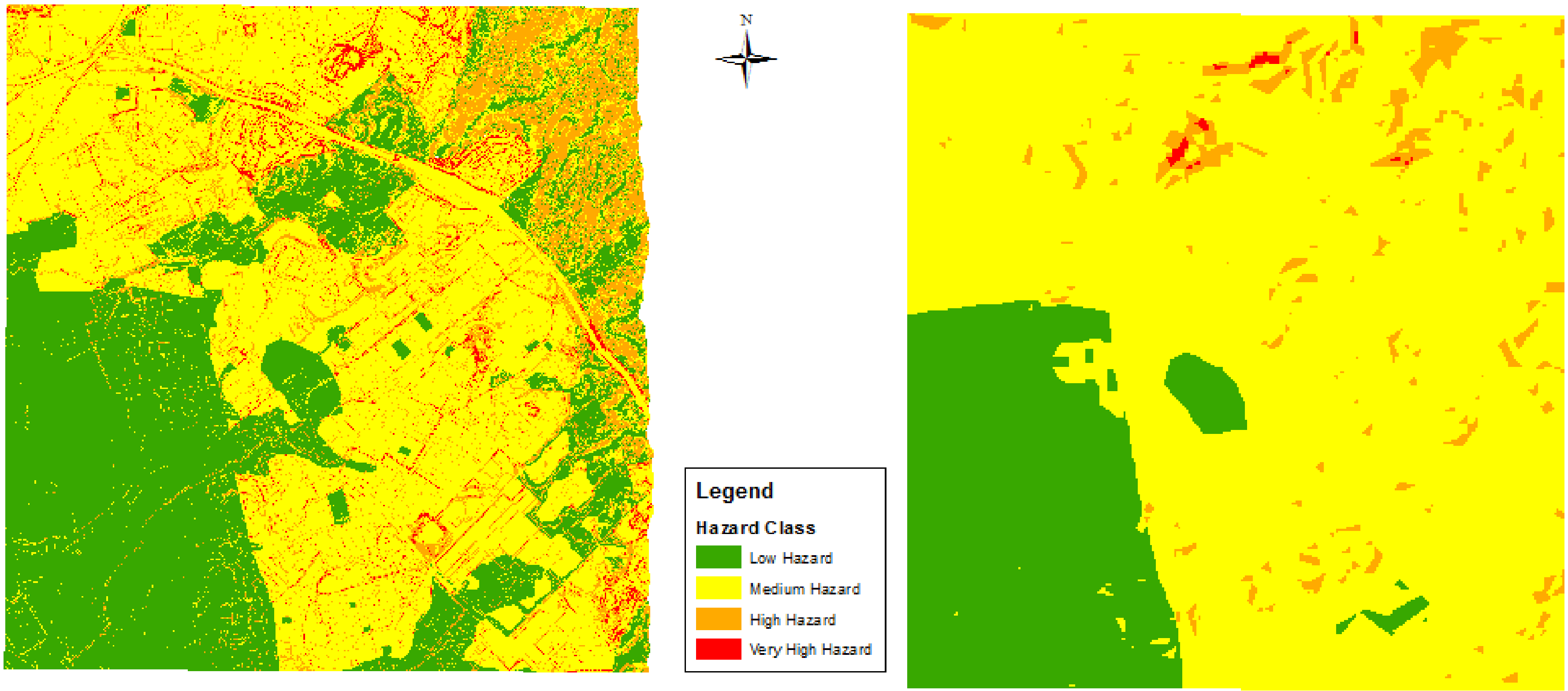
RESULT – LHZ MAP BASED ON MODEL 2

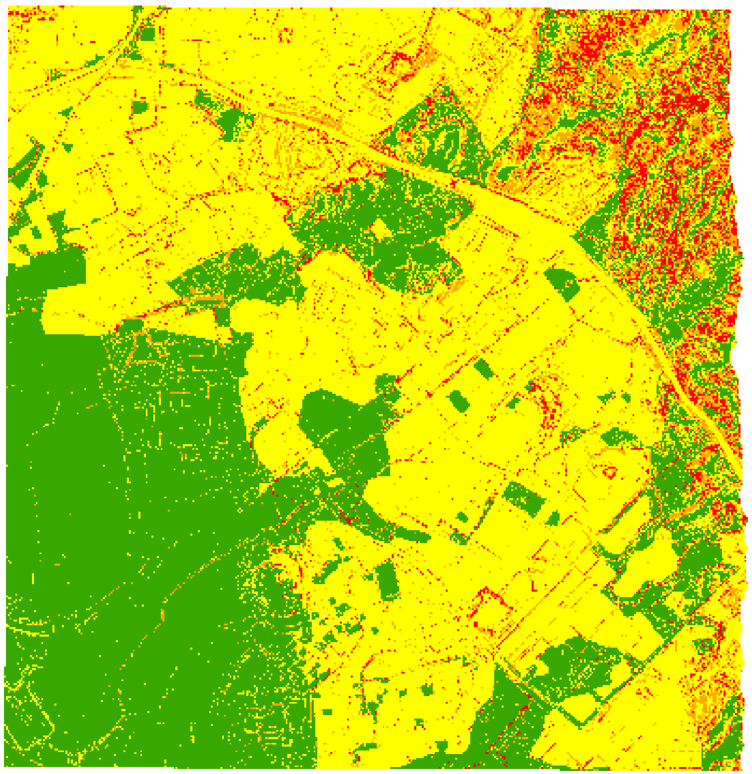


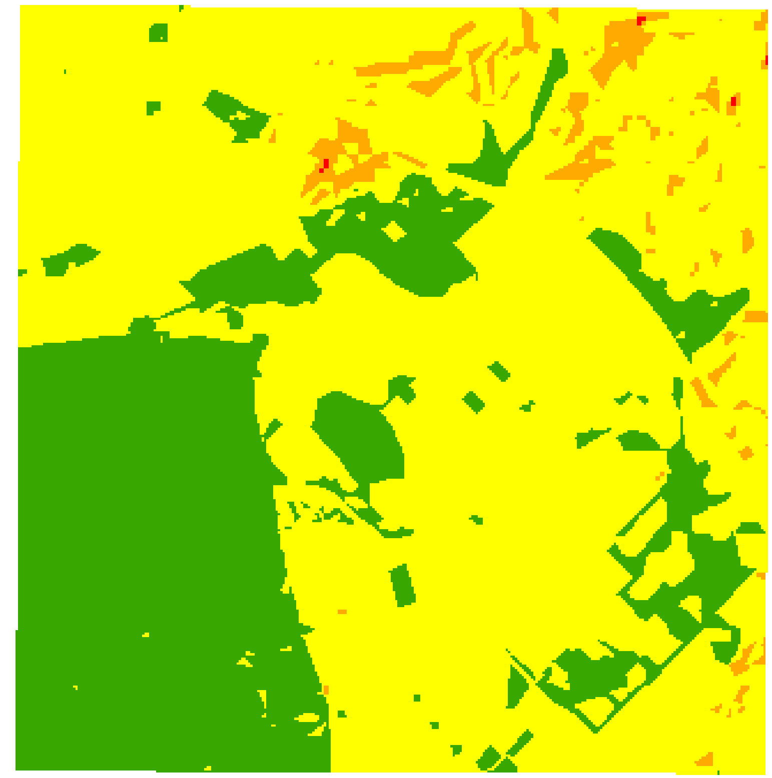
LHZ based on LiDAR data

LHZ based on SRTM data

DTM_Model 2

RESULT – LHZ MAP BASED ON MODEL 3

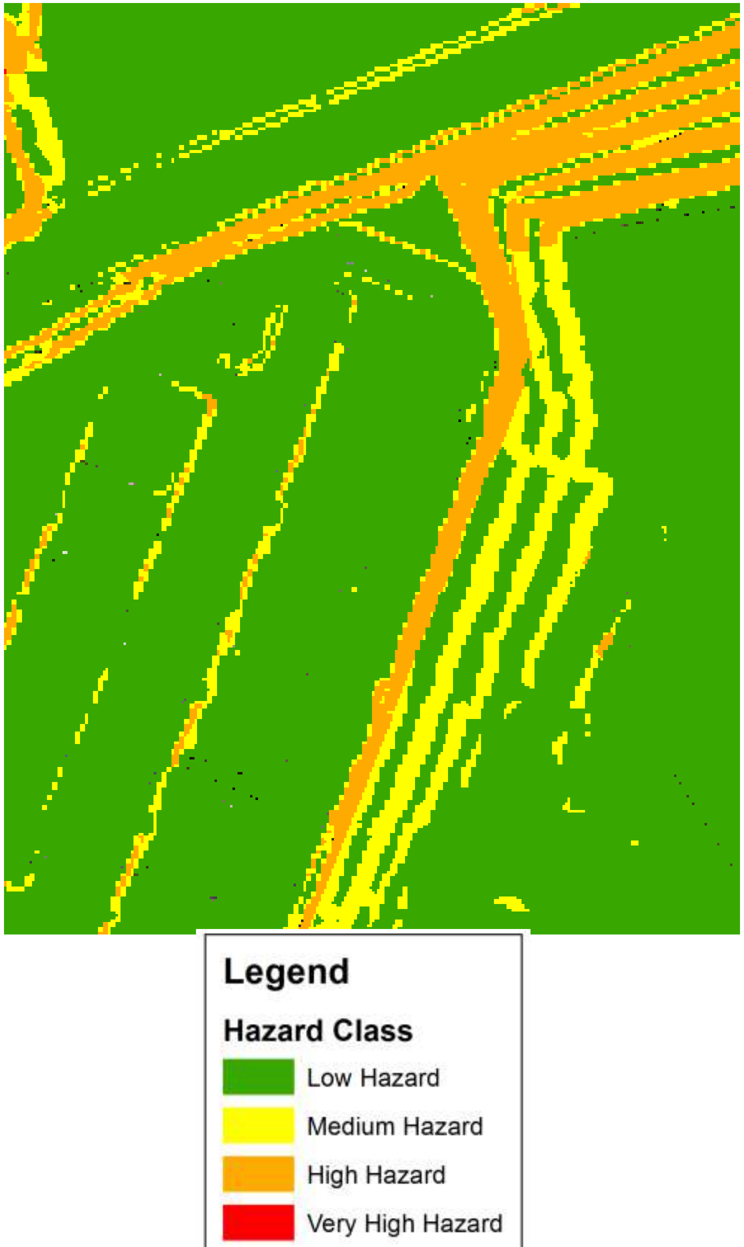




LHZ based on LiDAR data

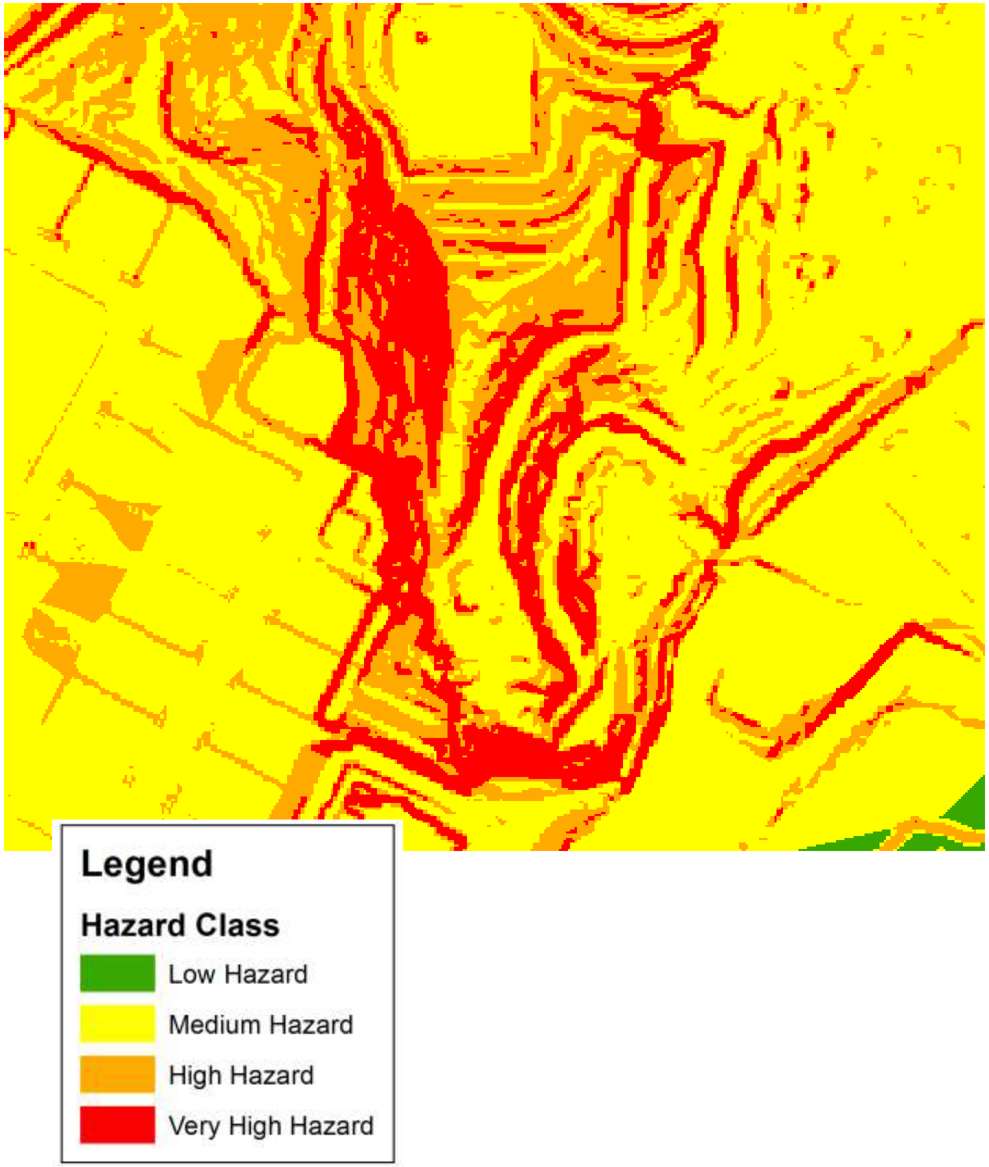
LHZ based on SRTM data

SITE 1

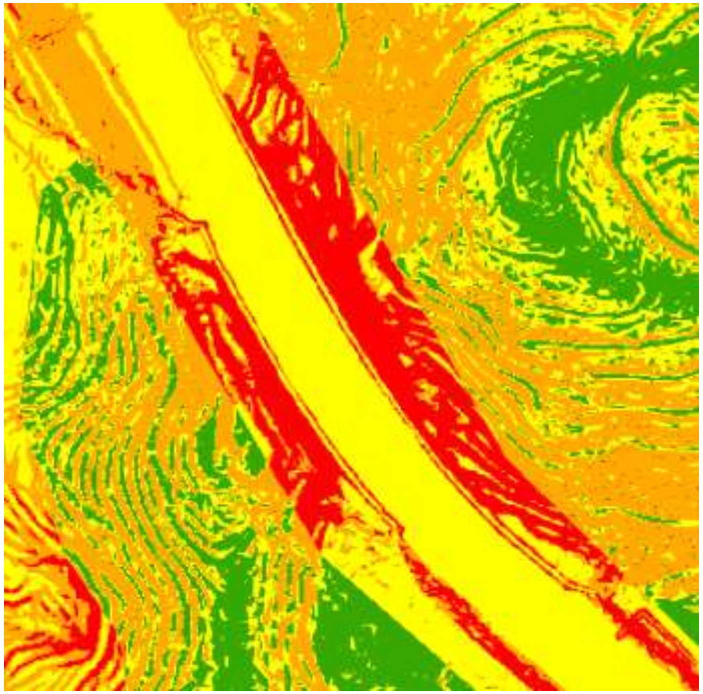


Legend
Hazard Class
Low Hazard
Medium Hazard
High Hazard
Very High Hazard

SITE 2


Legend
Hazard Class
Low Hazard
Medium Hazard
High Hazard
Very High Hazard

SITE 3

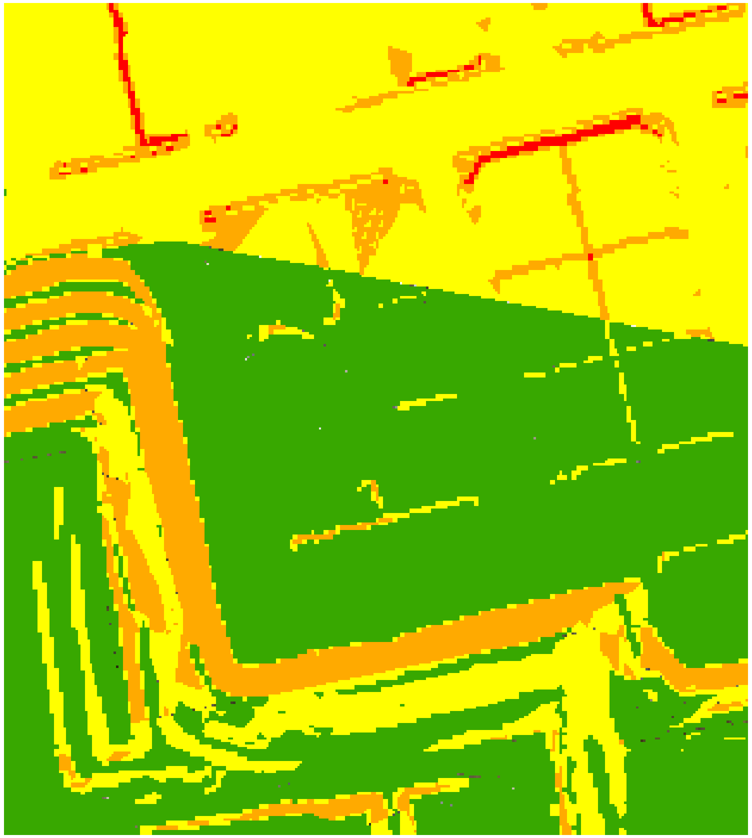


Legend

Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard

SITE 4

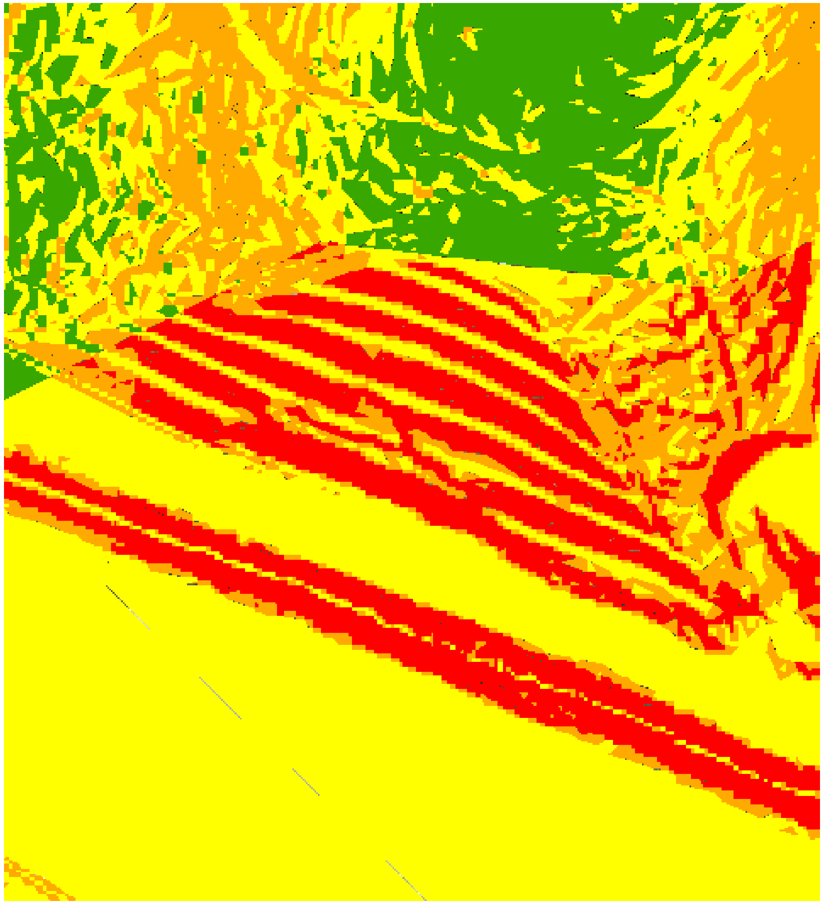


Legend

Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard

SITE 5

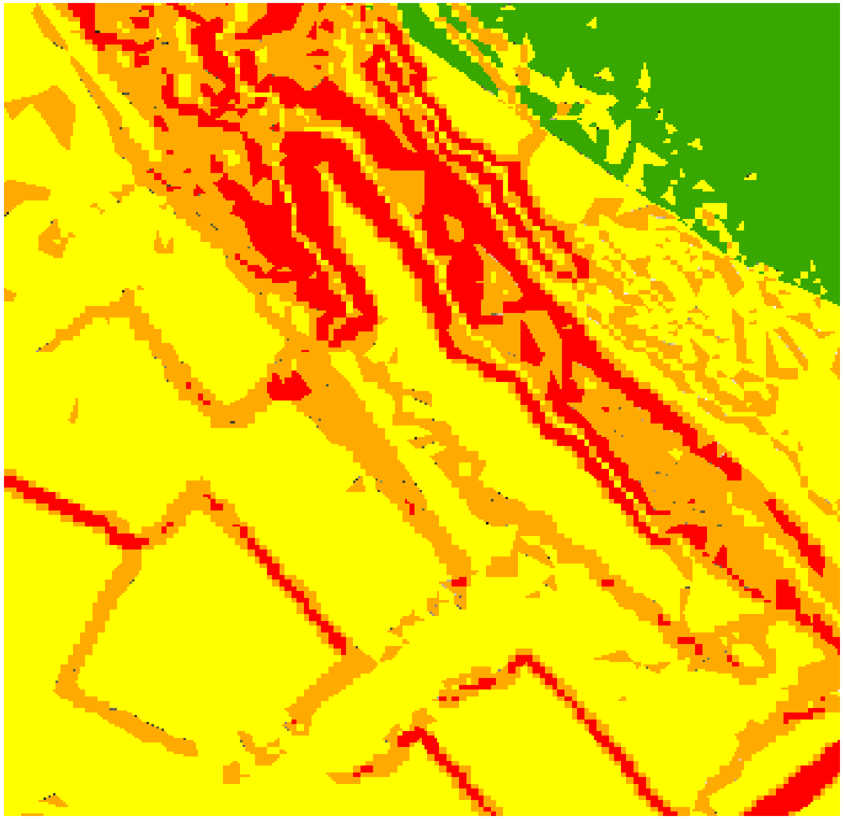


Legend

Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard

SITE 6



Legend

Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard

SITE 7

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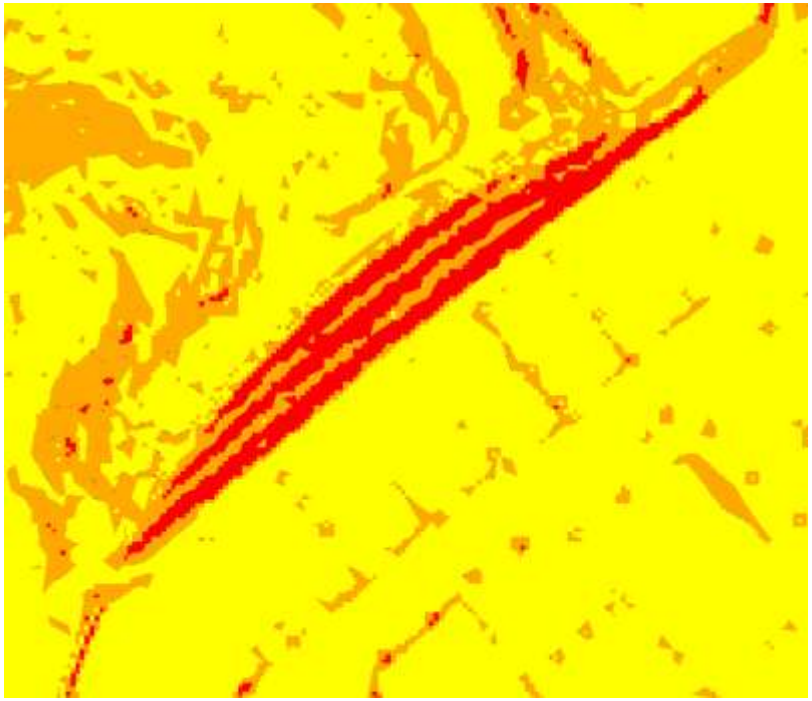

Legend

Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard

CONCLUSIONS

- MCDM techniques is used to calculate the relative importance of the factors
- Accuracy of model largely depend on the quality and resolution of DTM
- LiDAR provide high resolution/high accuracy height information
- GIS is an important tools to integrate and model landslide hazard zones