COMMONWEALTH SCHOLARSHIPS

Welcome

To the presentation on

UCL

Landslide Susceptibility Mapping Using Multicriteria Evaluation Techniques in Chittagong Metropolitan Area, Bangladesh

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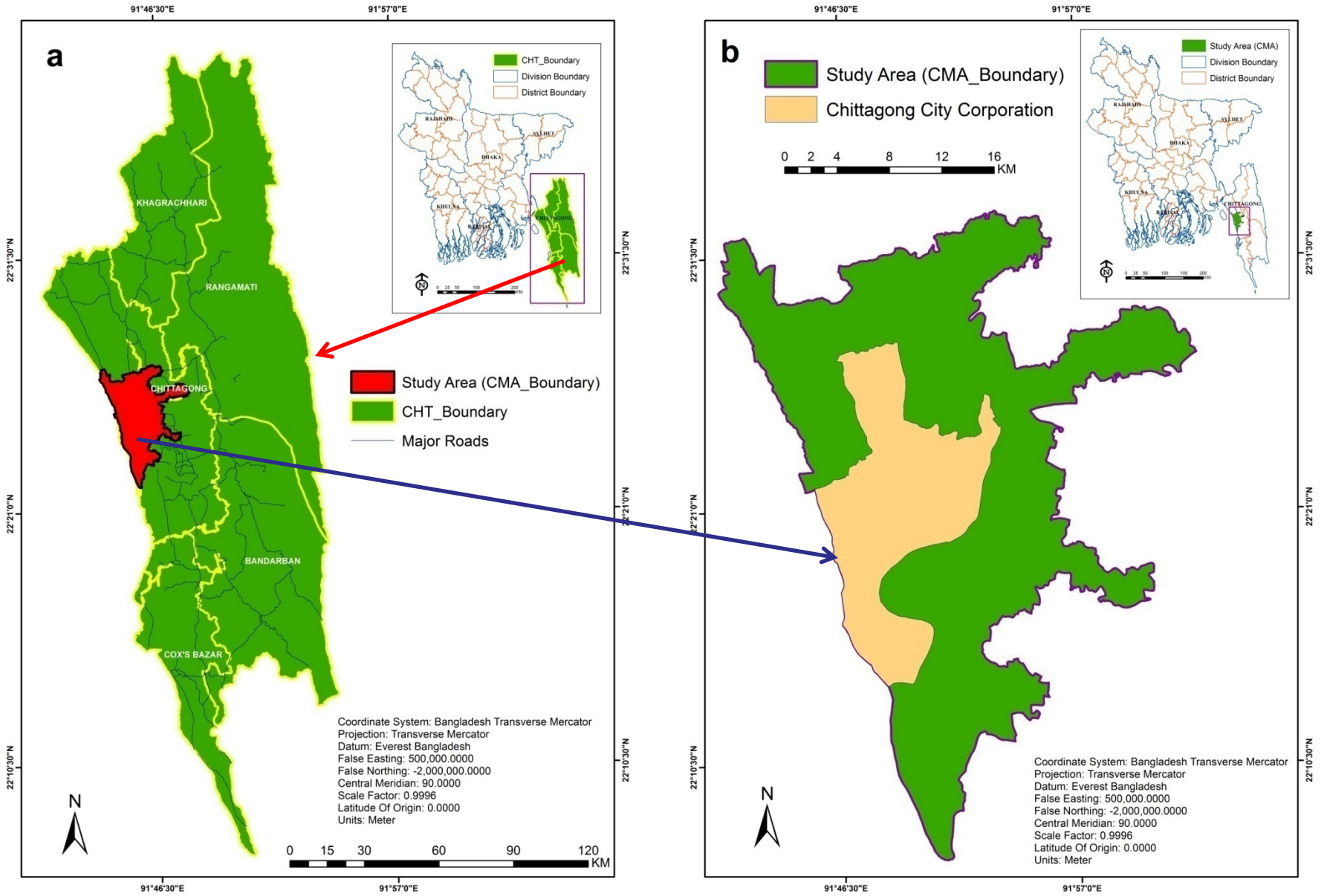
Background of the Research

1. Chittagong Metropolitan Area (**CMA**) is highly **vulnerable to landslide hazards**, with an increasing trend of frequency and damage

2. It is therefore essential to **determine the landslide prone areas** of CMA so that appropriate landslide risk reduction strategies can be developed

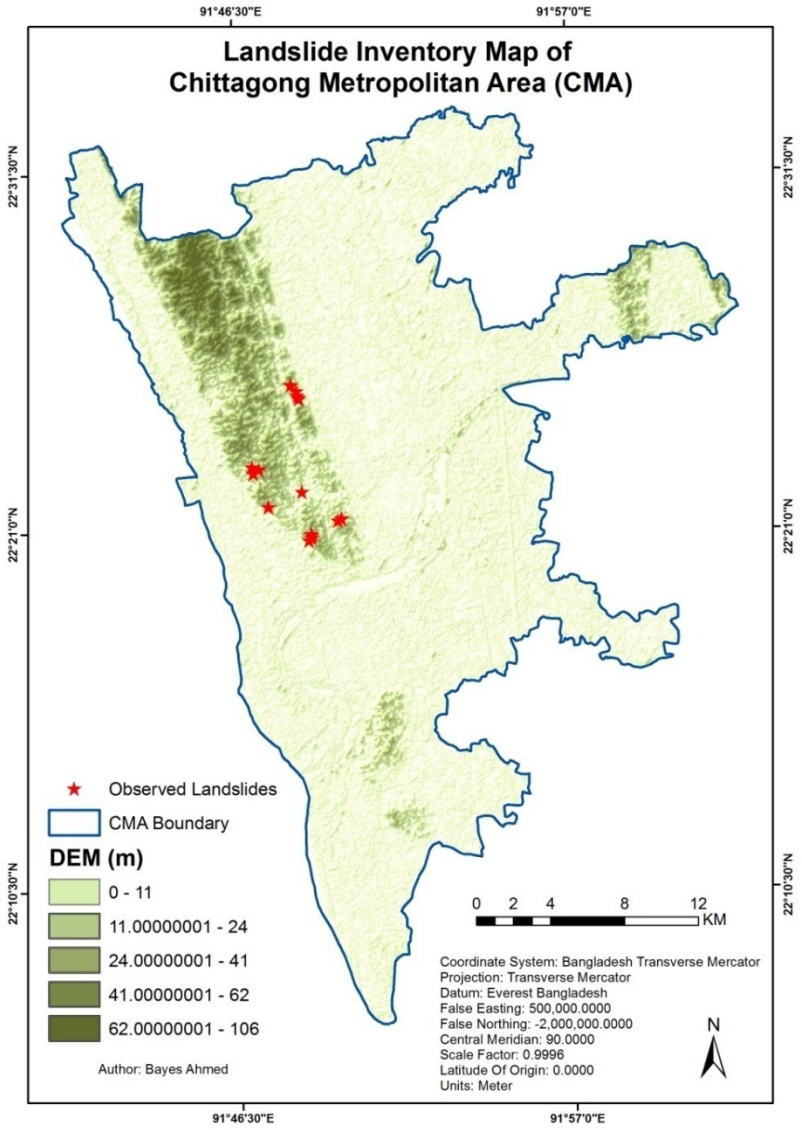
3. Producing **up-to-date** and **accurate** landslide susceptibility maps can ensure **safety to people, property at risk and avoid extensive economic loss**

Study Area



Data source: Geological Survey of Bangladesh, 2000 and Chittagong Development Authority (CDA), 2013

Landslide Inventory Map



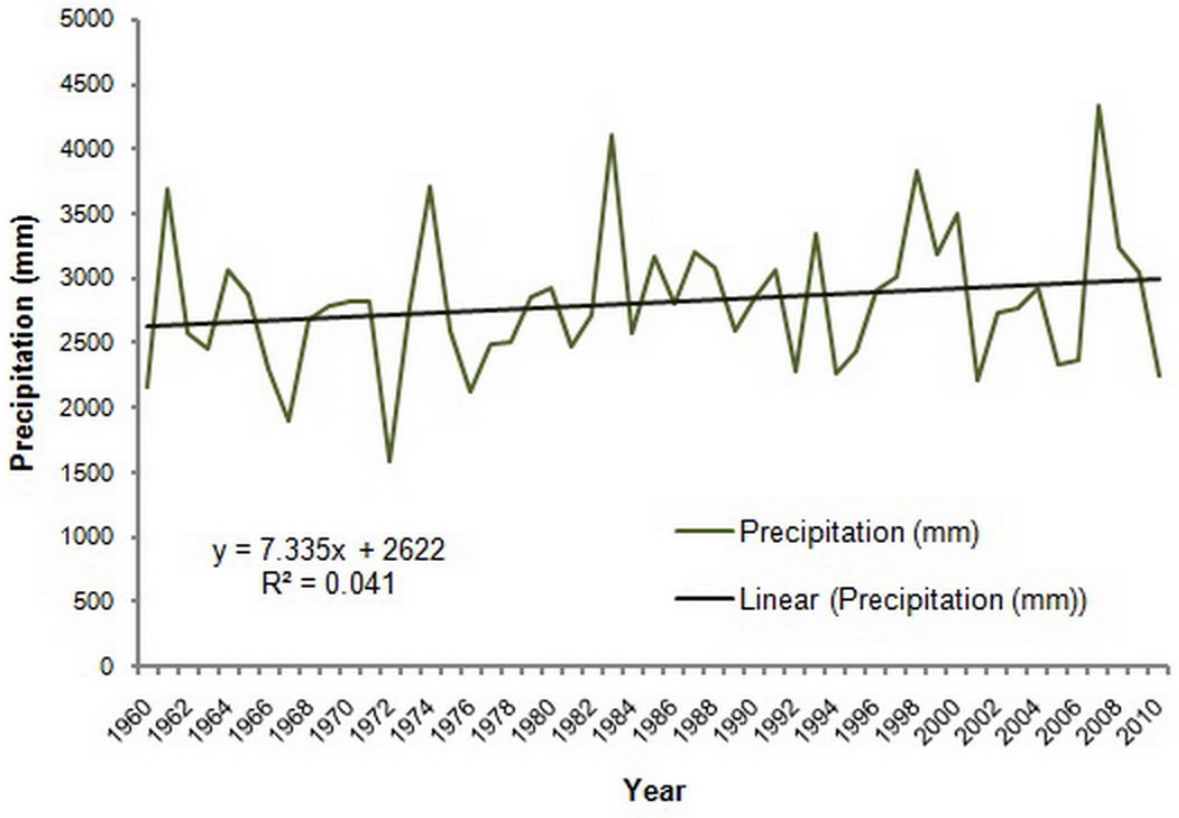
20 landslide locations were identified through GPS survey in CMA

Source: Field Visit, March & September, 2013

DEM Data source: ASTER Global Digital Elevation Model (ASTER GDEM), 2013

Precipitation Pattern (In-situ Data)

Mean annual rainfall is **2540 - 3810 mm** in CMA. The monsoon season is from **June to October**, which is warm, cloudy and wet. A **gradual upward shift in precipitation** has been noted in the last five decades (1960-2010)



Data source: Bangladesh Meteorological Department, 2013

Landslide Susceptibility Mapping (LSM)

In this research, three GIS based Multi Criteria Decision Analysis (GIS-MCDA) methods have been used for LSM. These are:

1. Analytical Hierarchy Process (AHP)

2. Weighted Linear Combination (WLC)

3. Ordered Weighted Averaging (OWA)

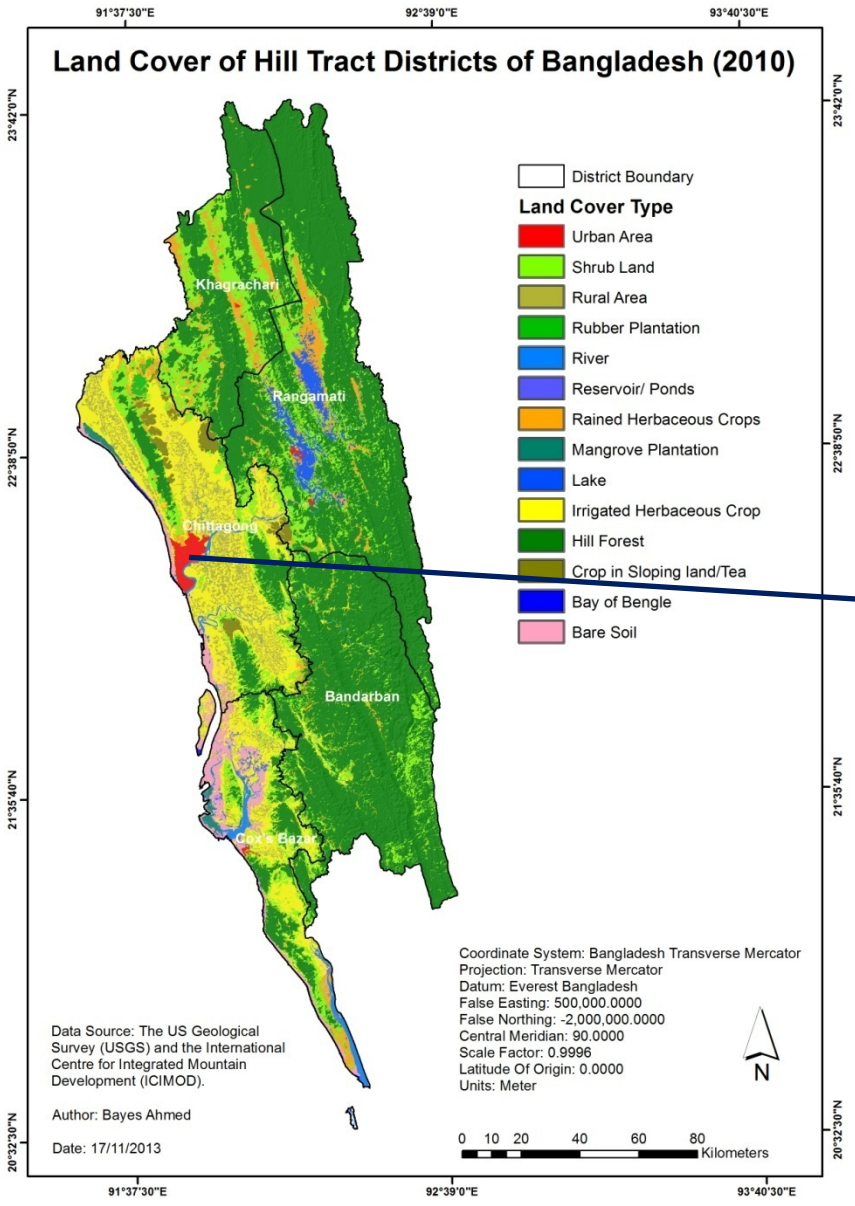
Landslide Susceptibility Mapping (LSM)

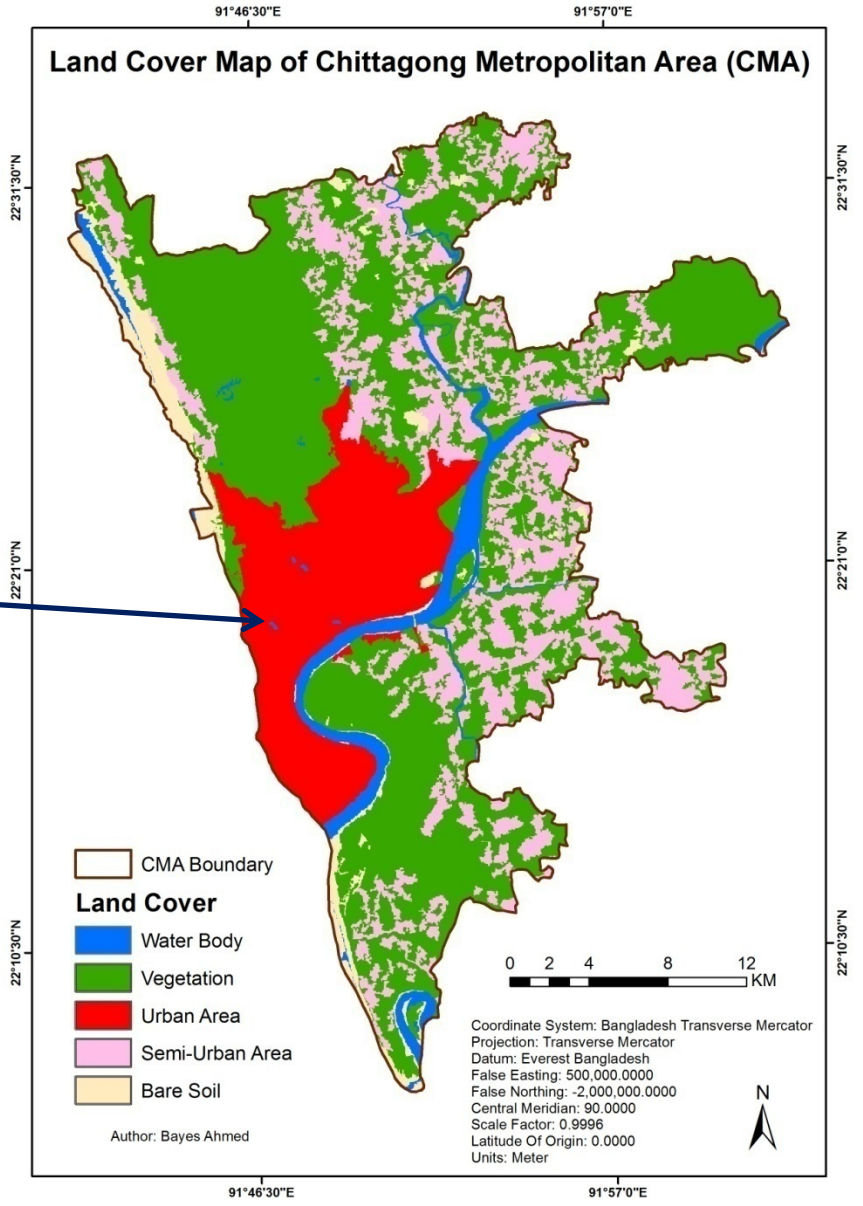
MCDA is basically a **GIS based overlaying method** used to to **combine a set of criteria** to achieve a single composite basis for **a decision** according to a **specific objective**

MCDA is a **knowledge-based method**. The **people's, expert's or decision maker's** preferences get importance

The main drawback of MCDA is only **failing to choose appropriate assumptions**/criteria for suitability analysis

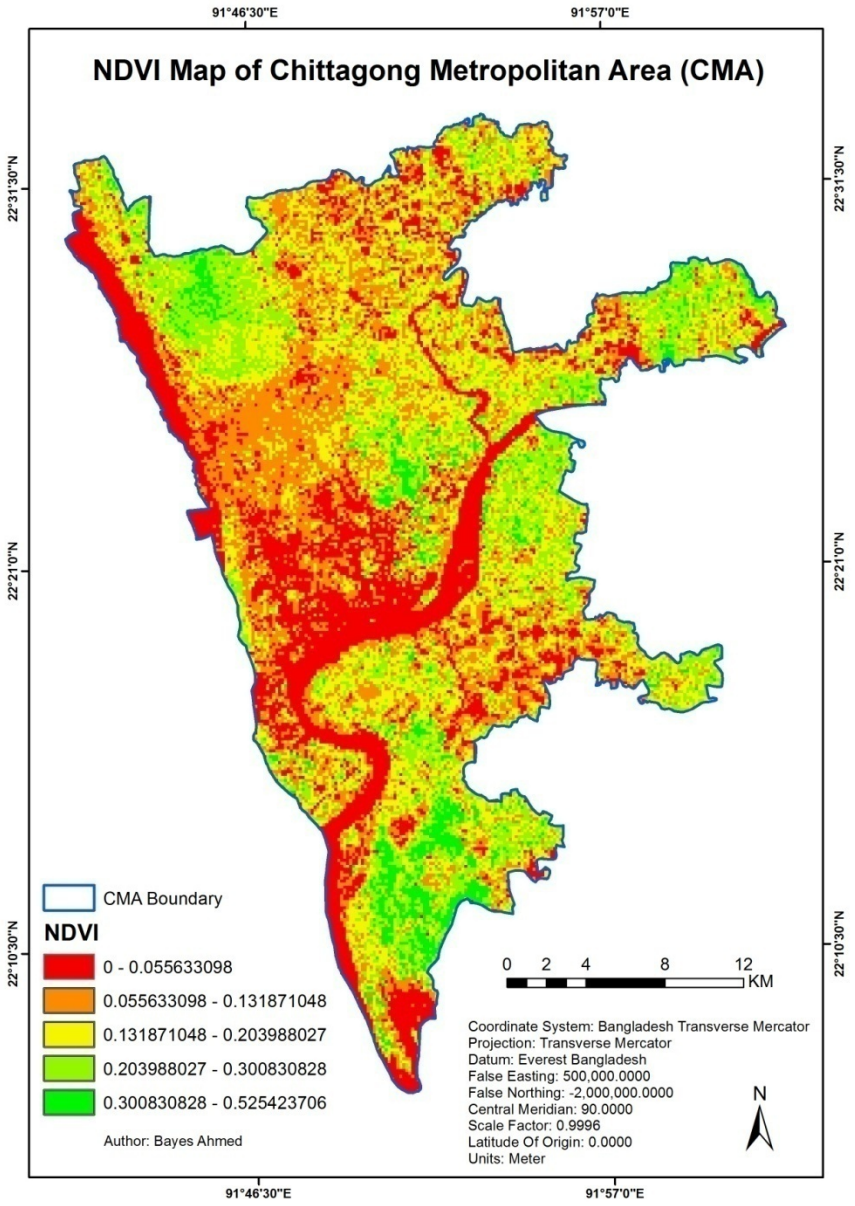
Land Cover Mapping



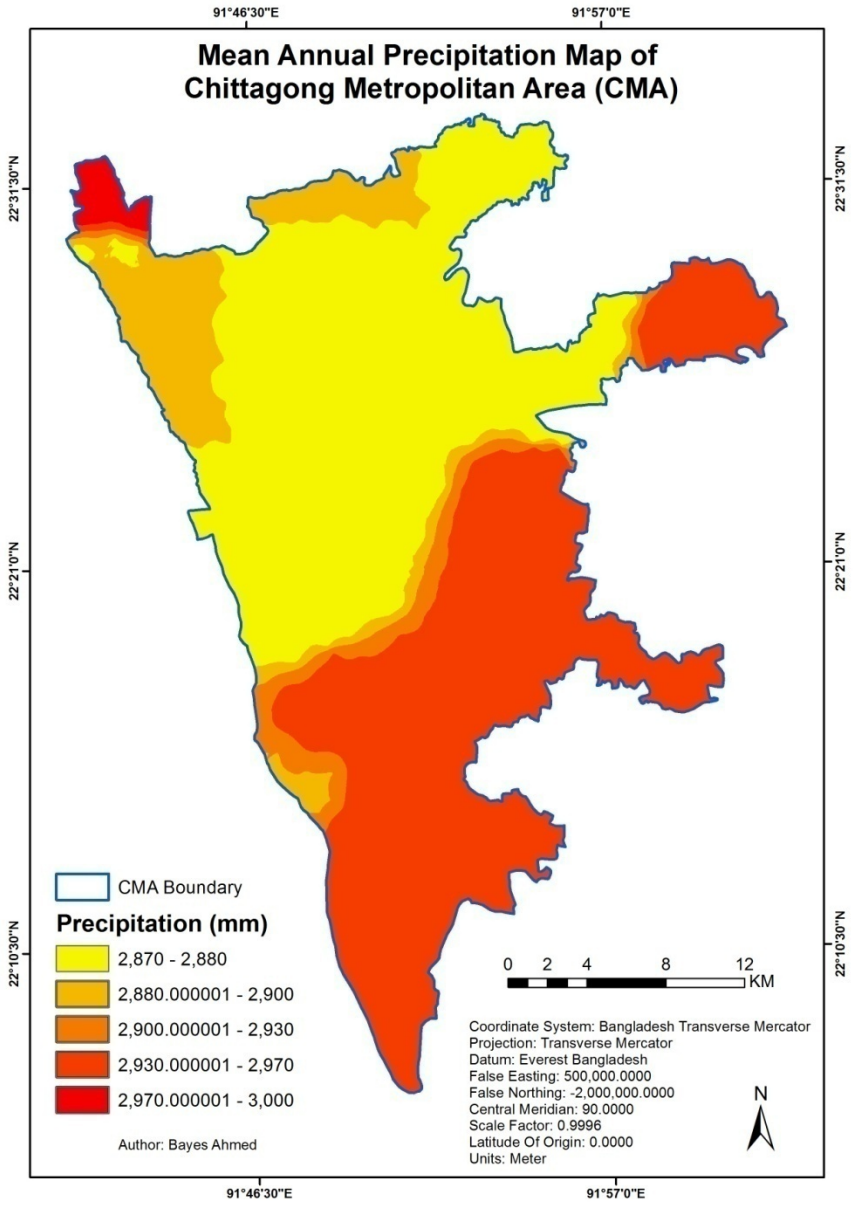


Data source: United States Geological Survey (USGS), 2012

Other Thematic Layers



Data source: United States Geological Survey (USGS), 2012



Data source: Geological Survey of Bangladesh, 2000

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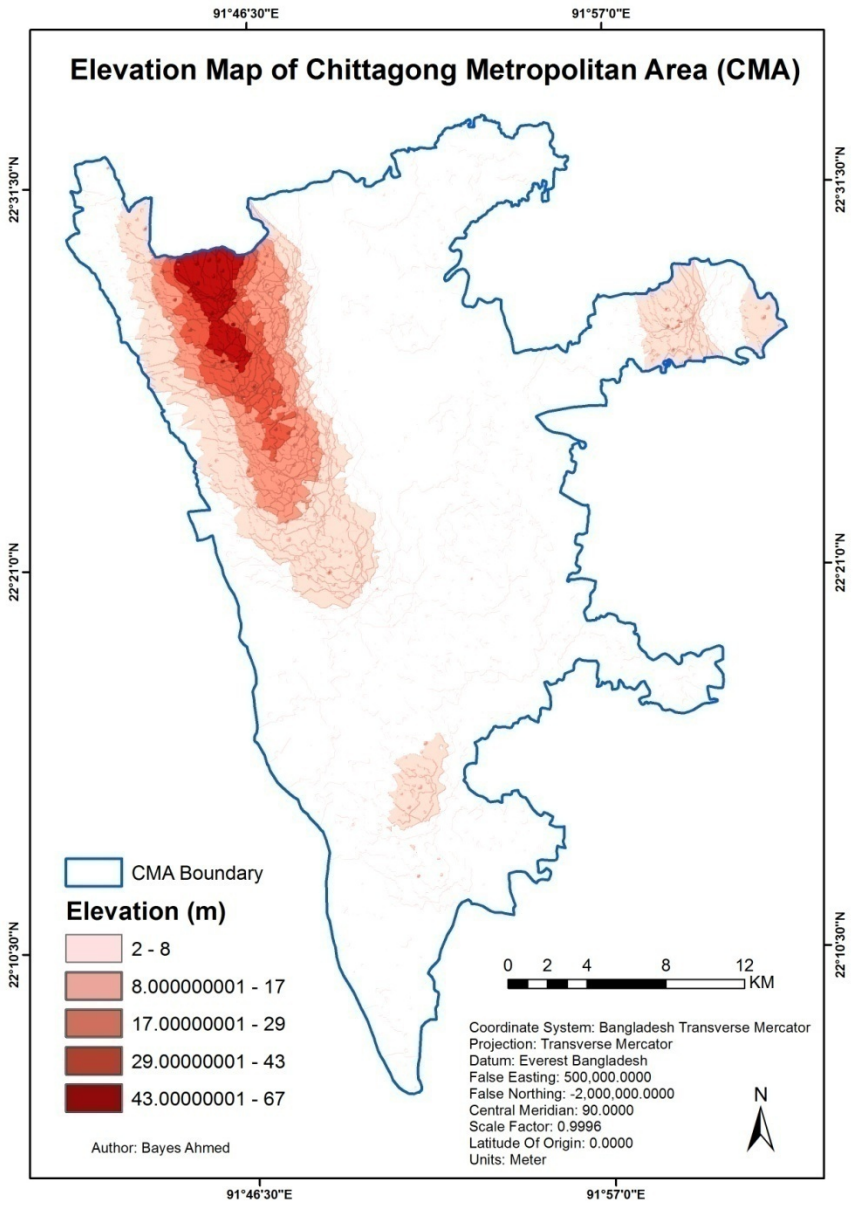

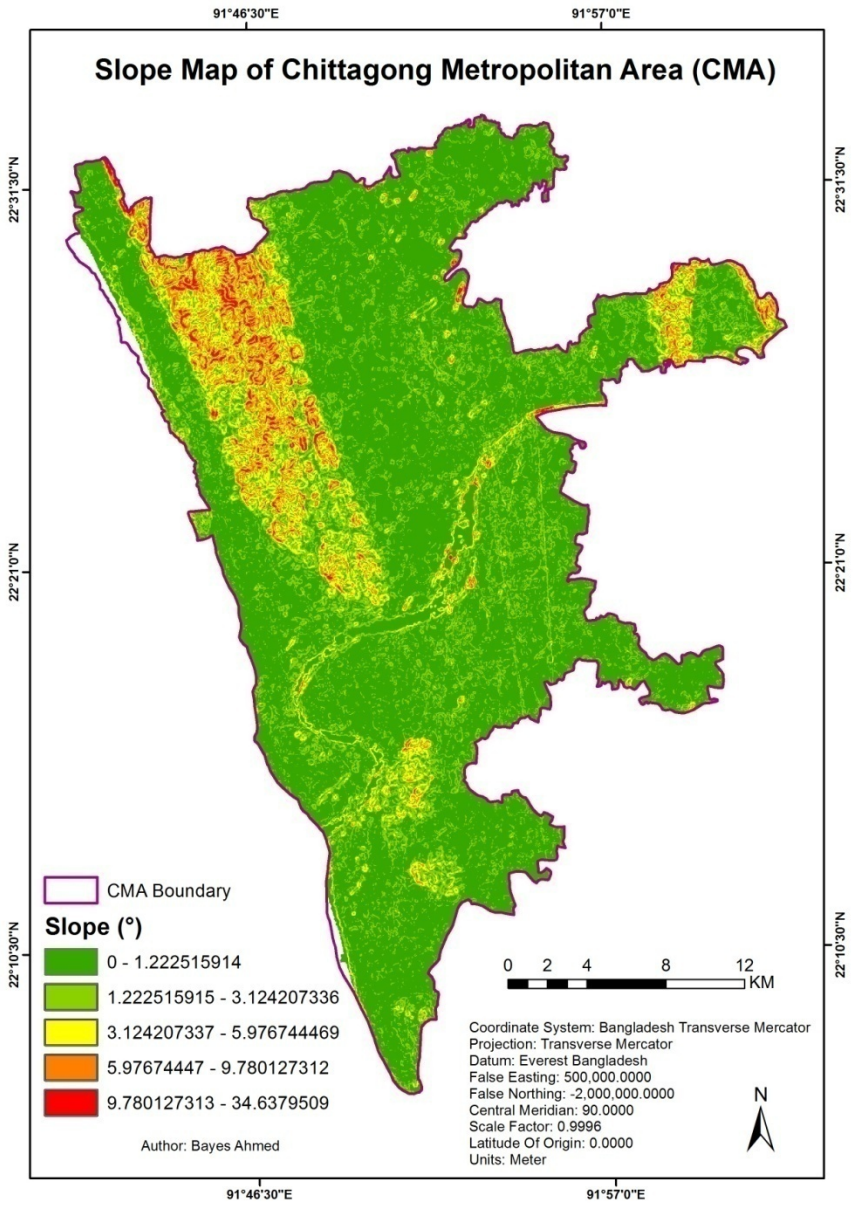

Data source: Geological Survey of Bangladesh, 2000

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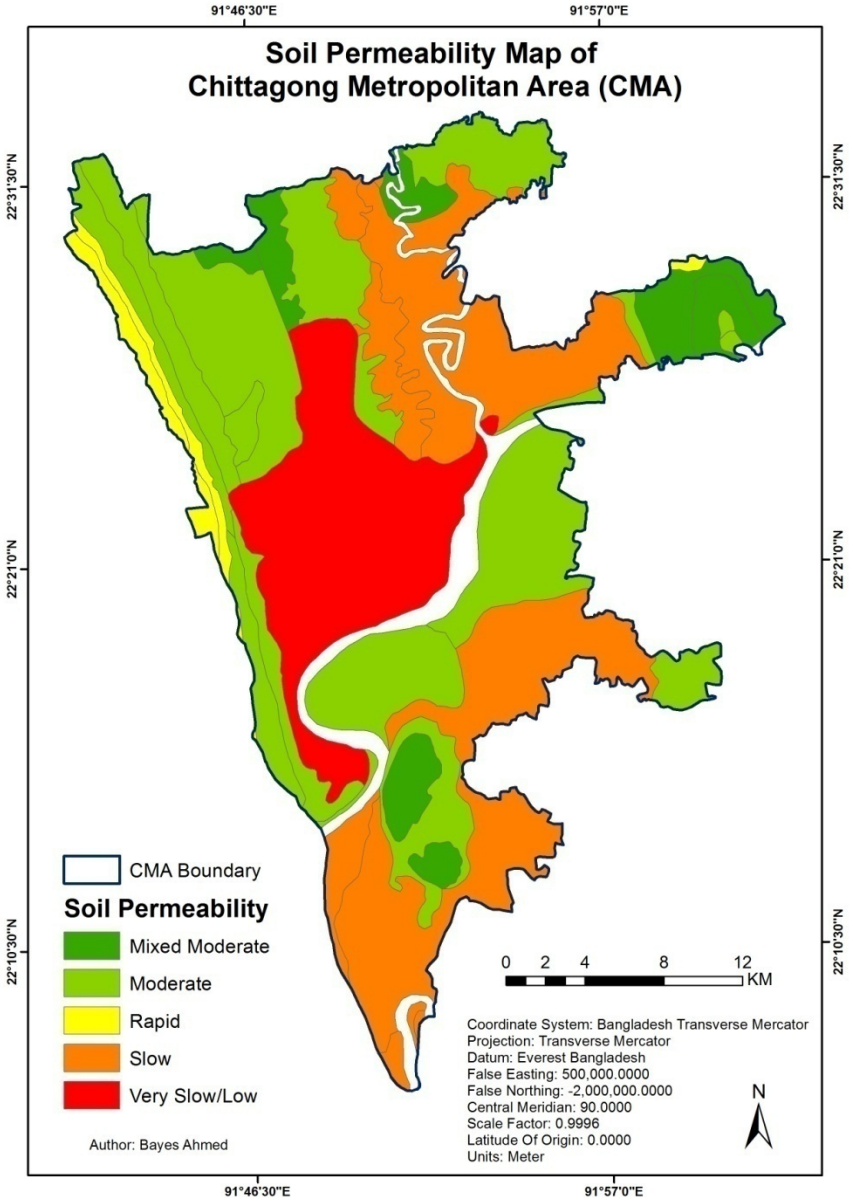
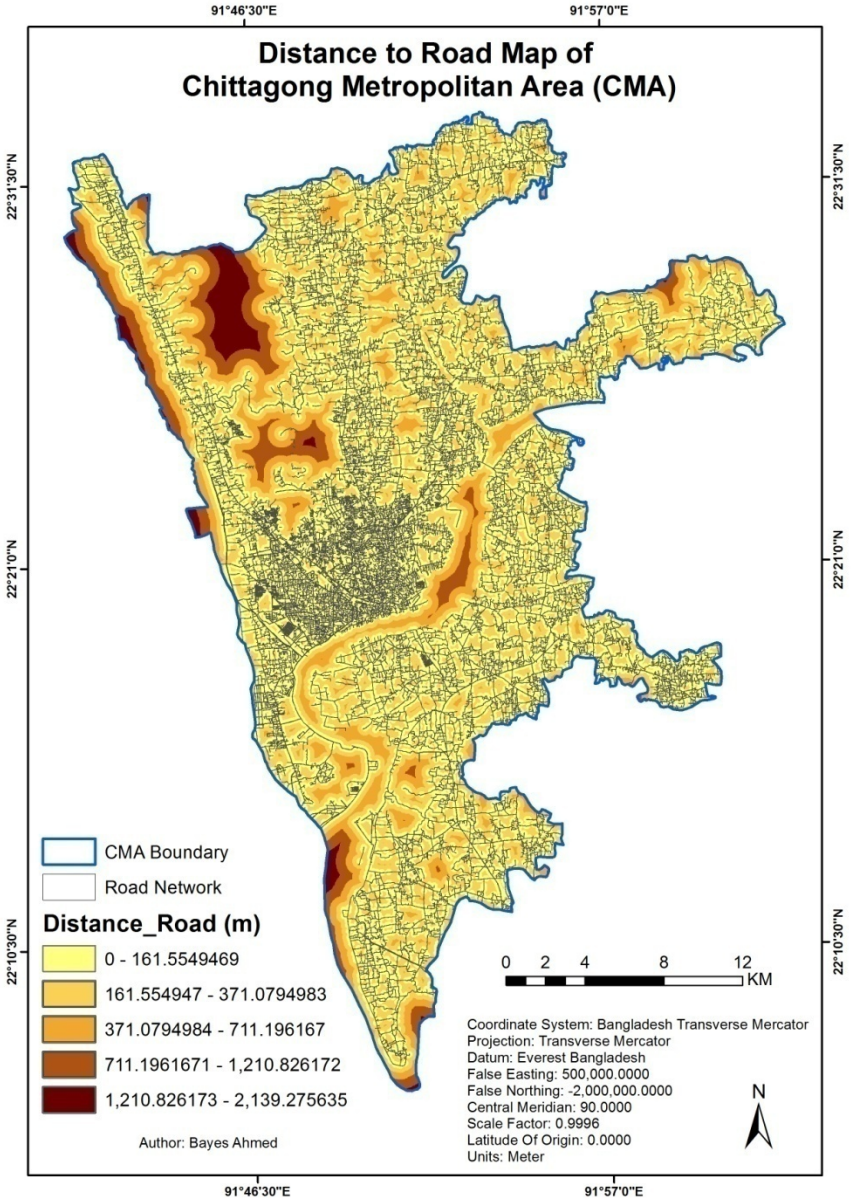
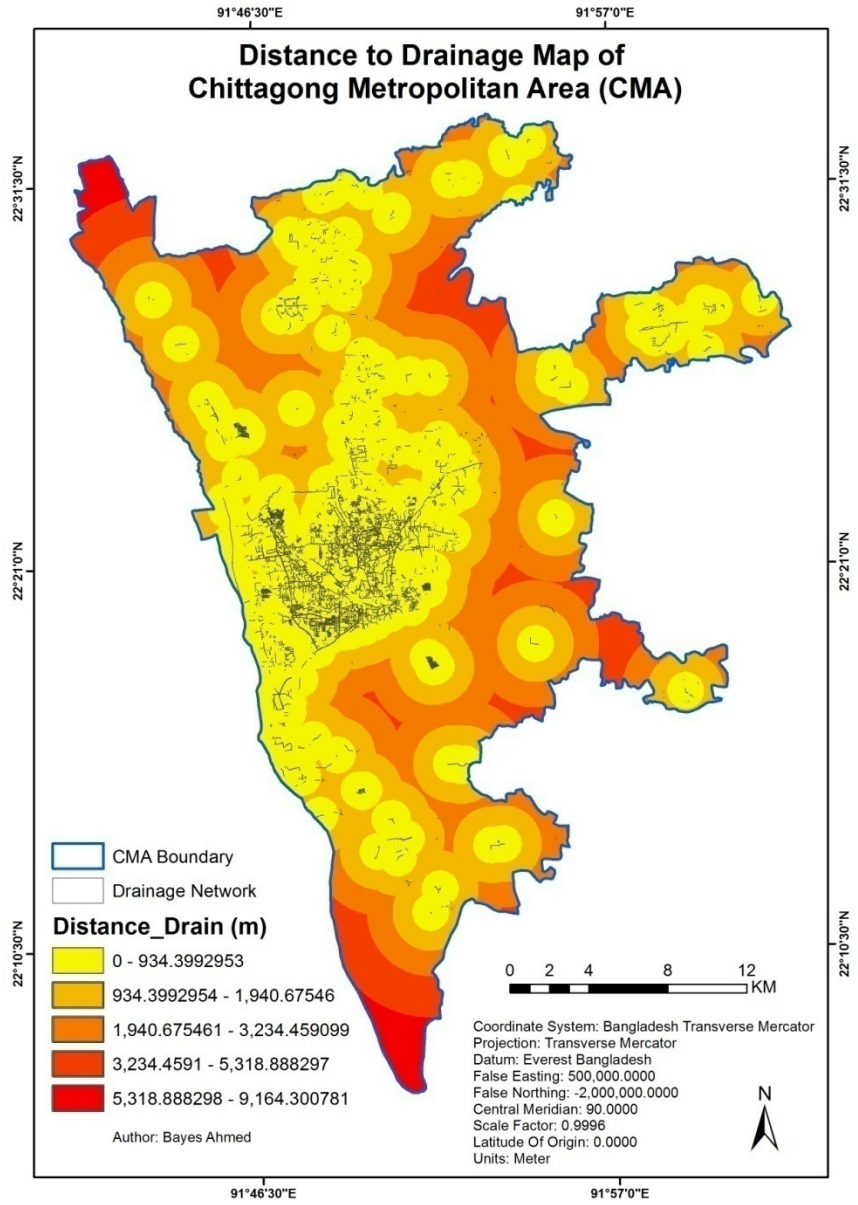


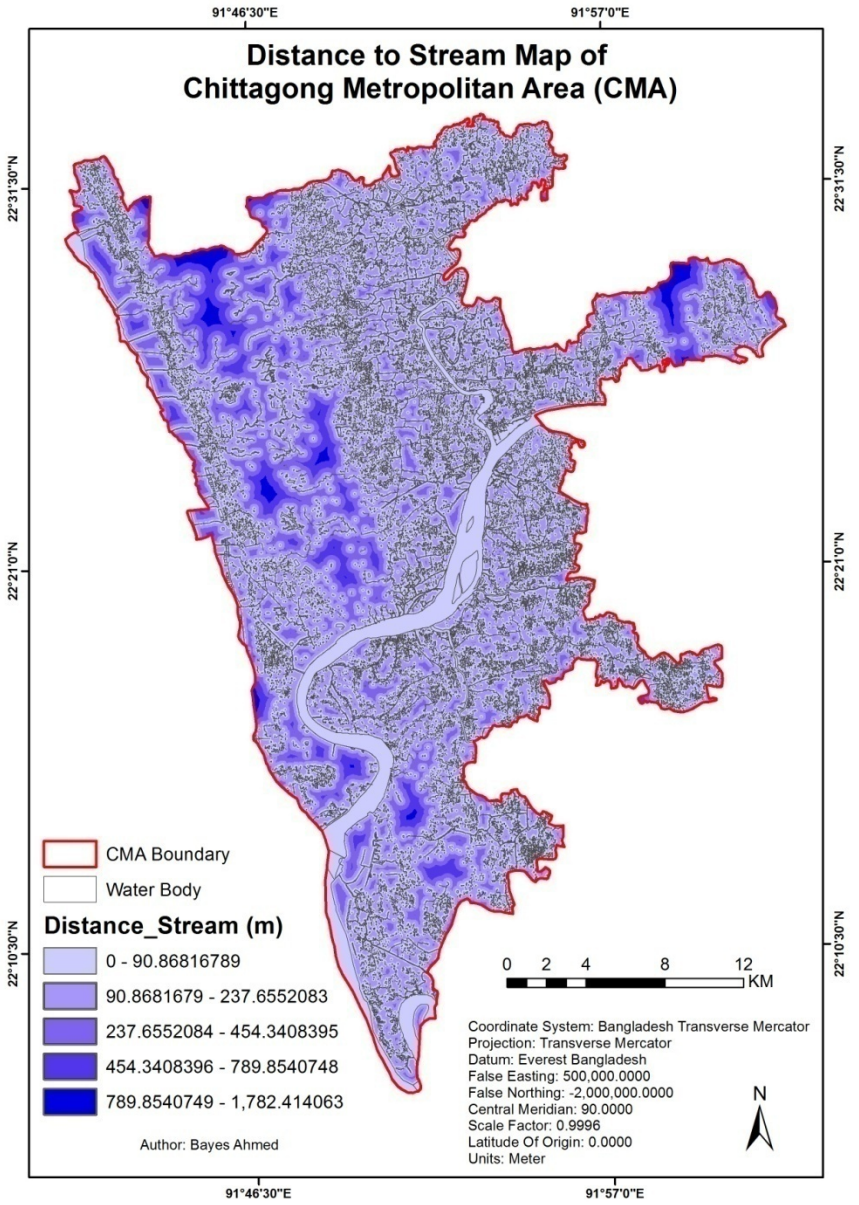


Data source: Geological Survey of Bangladesh, 2000

Data source: Chittagong Development Authority (CDA), 2013

Other Thematic Layers





Data source: Chittagong Development Authority (CDA), 2013

LSM using AHP Method

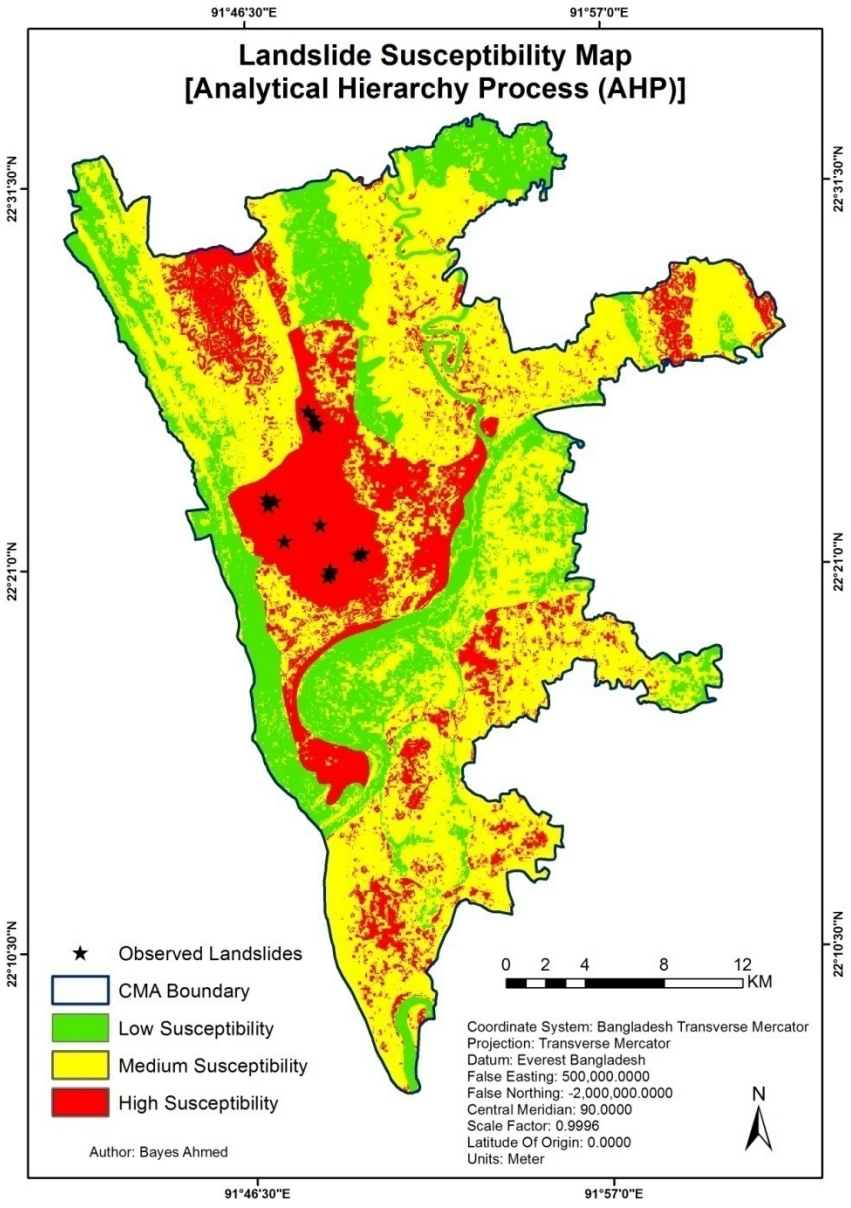
Factors	(1)	(2)	(3)	(4)	(5)	Eigen values
Distance to drain (m)						
(1) 0 – 934.3992953	1					0.0448
(2) 934.3992954 – 1,940.67546	2	1				0.0699
(3) 1,940.675461 – 3,234.459099	3	2	1			0.1098
(4) 3,234.4591 – 5,318.888297	6	4	3	1		0.2408
(5) 5,318.888298 – 9,164.300781	7	6	5	4	1	0.5346
Consistency ratio: **0.04**						
Elevation (m)						
(1) 2 – 8	1					0.0501
(2) 8.000000001 - 17	3	1				0.0964
(3) 17.00000001 - 29	4	2	1			0.1521
(4) 29.00000001 – 43	6	5	4	1		0.4548
(5) 43.00000001 – 67	4	3	2	1/2	1	0.2465
Consistency ratio: **0.03**						
Land cover						
(1) Water body	1					0.0434
(2) Vegetation	3	1				0.1196
(3) Urban area	7	6	1			0.5019
(4) Semi-urban area	5	4	1/3	1		0.2537
(5) Bare soil	3	1/3	1/5	1/3	1	0.0814
Consistency ratio: **0.08**						

LSM using AHP Method

Ratings are provided on a 9-point continuous scale: (1/9, 1/8, 1/7, 1/6, 1/5, 1/4, 1/3, 1/2, 1, 2, 3, 4, 5, 6, 7, 8, 9)

Factors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	Eigen values
(1) Distance to drain	1									0.0469
(2) Elevation	5	1								0.1989
(3) Land cover	3	1/3	1							0.0975
(4) NDVI	2	1/4	1/2	1						0.0706
(5) Precipitation	1/3	1/7	1/4	1/3	1					0.0366
(6) Distance to road	1/3	1/8	1/6	1/5	1/2	1				0.0243
(7) Slope	5	1	5	4	3	6	1			0.1989
(8) Soil permeability	7	2	5	6	8	9	2	1		0.3074
(9) Distance to stream	1/2	1/7	1/6	1/5	1/4	1/3	1/7	1/8	1	0.0190
Consistency ratio: 0.07										

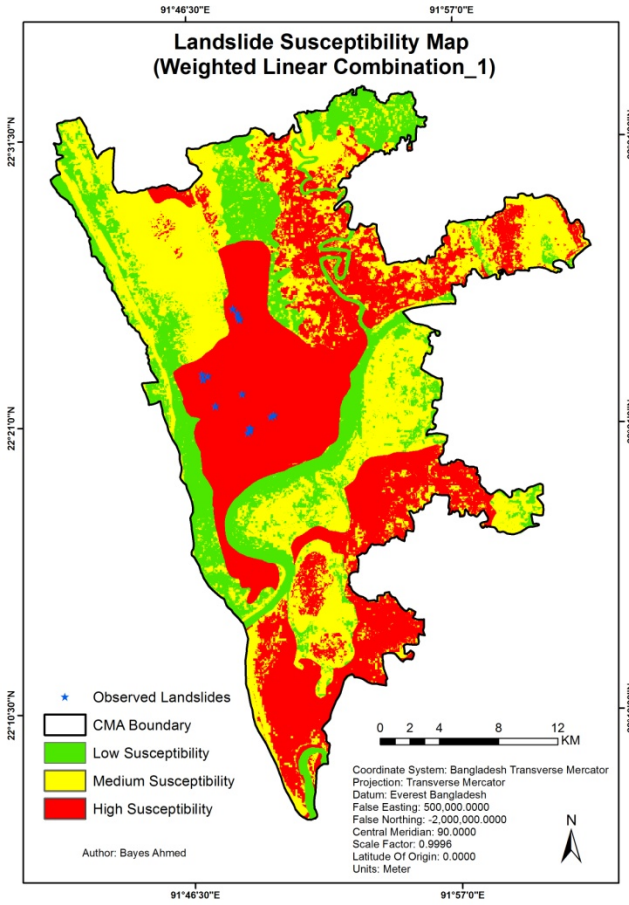
LSM using AHP Method

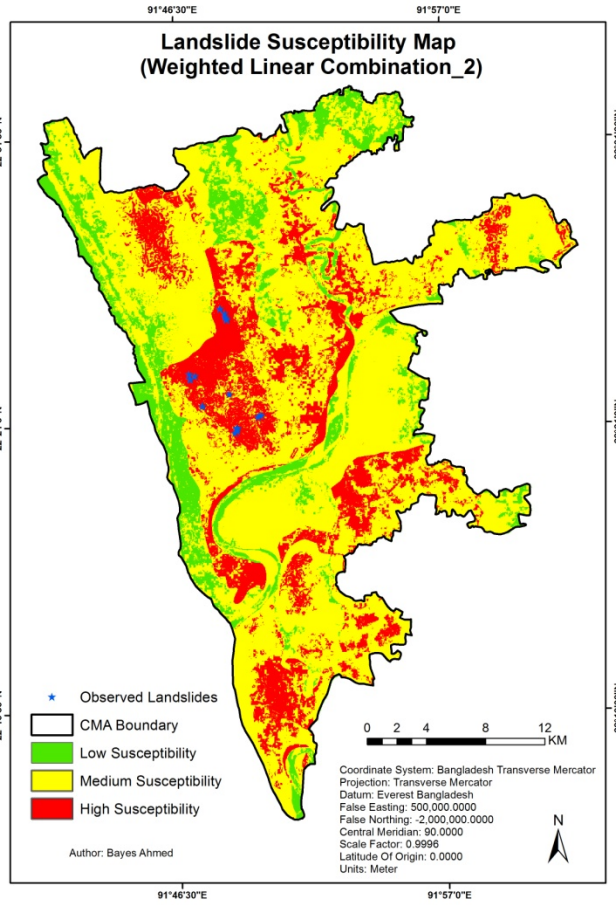


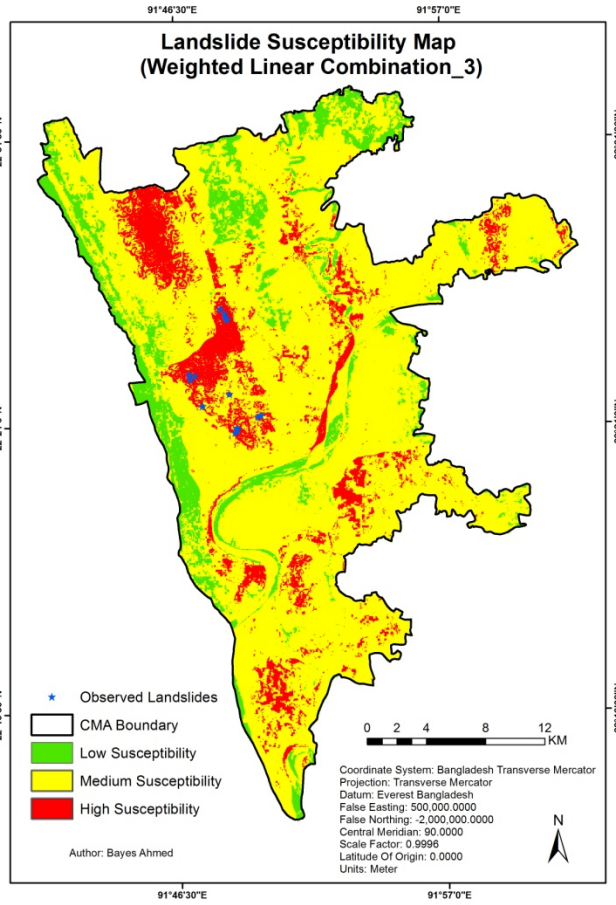
LSM using WLC Method

Factors	Weight_1	Weight_2	Weight_3
Distance to drain	0.05	0.10	0.10
Elevation	0.10	0.10	0.15
Land cover	0.10	0.15	0.15
NDVI	0.10	0.10	0.10
Precipitation	0.05	0.05	0.05
Distance to road	0.05	0.05	0.05
Slope	0.10	0.15	0.15
Soil permeability	0.40	0.25	0.20
Distance to stream	0.05	0.05	0.05
Total	1.00	1.00	1.00

LSM using WLC Method





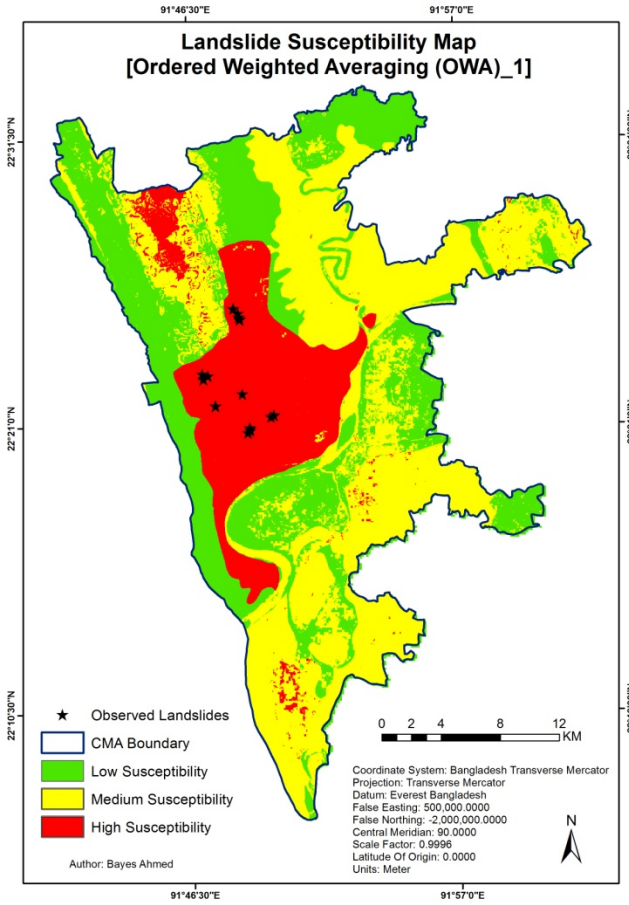


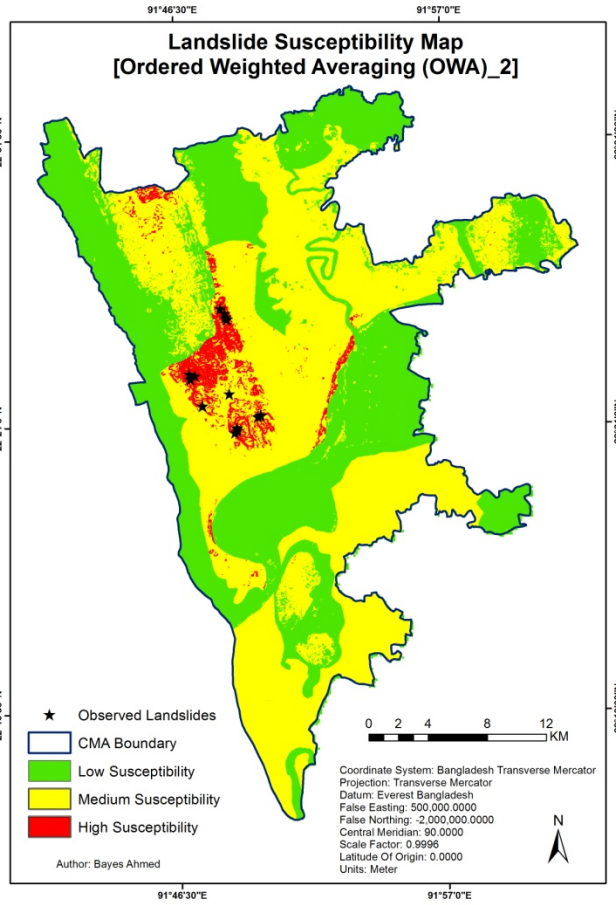
LSM using OWA Method

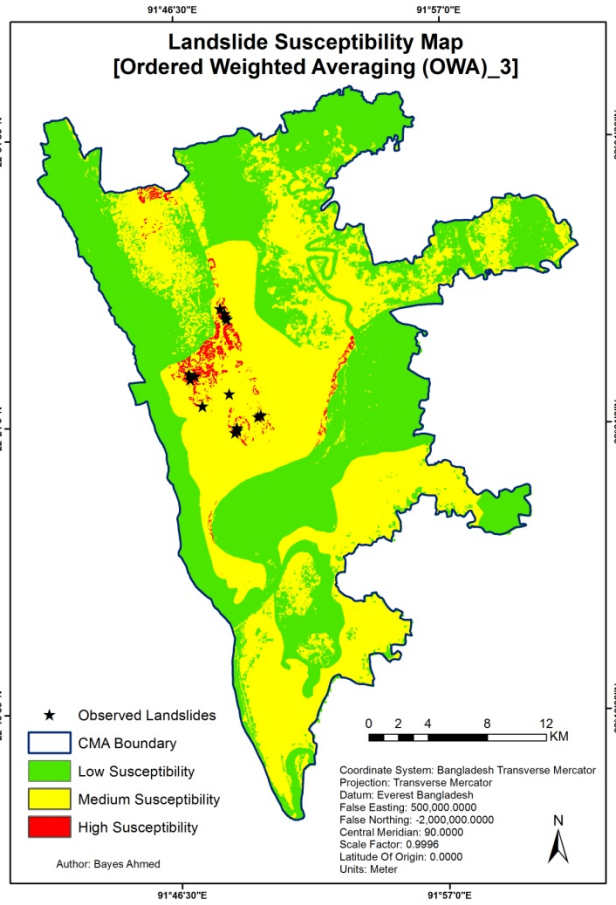
Factors	Factor weight
(1) Distance to stream	0.0190
(2) Distance to road	0.0243
(3) Precipitation	0.0366
(4) Distance to drain	0.0469
(5) NDVI	0.0706
(6) Land cover	0.0975
(7) Elevation	0.1989
(8) Slope	0.1989
(9) Soil permeability	0.3074

Order weight	Weight 1	Weight 2	Weight 3	Weight 4	Weight 5	Weight 6	Weight 7	Weight 8	Weight 9
OWA_1	0.05	0.05	0.05	0.05	0.10	0.10	0.10	0.10	0.40
OWA_2	0.05	0.05	0.05	0.10	0.10	0.15	0.10	0.15	0.25
OWA_3	0.05	0.05	0.05	0.10	0.10	0.15	0.15	0.15	0.20

LSM using OWA Method



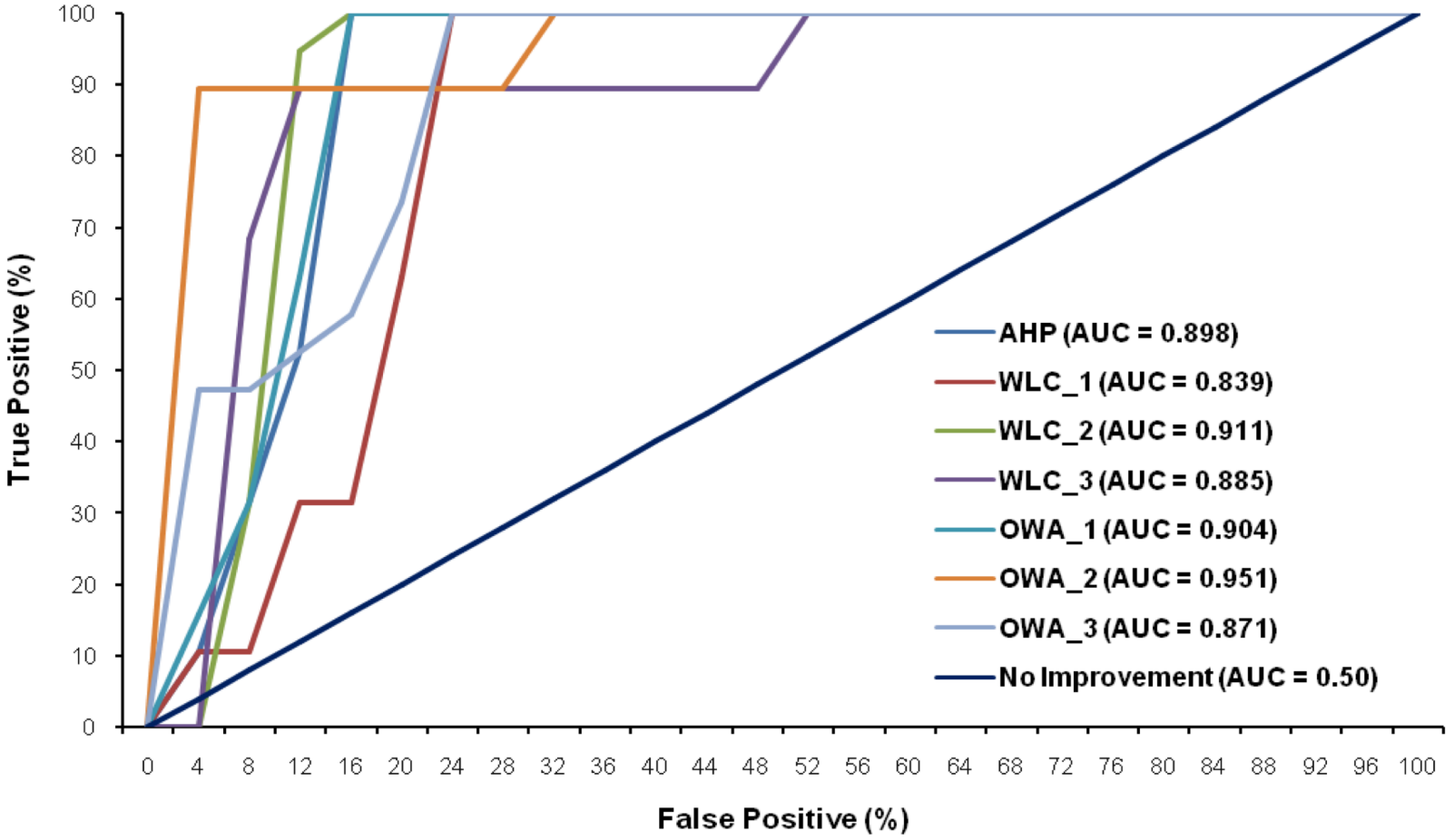


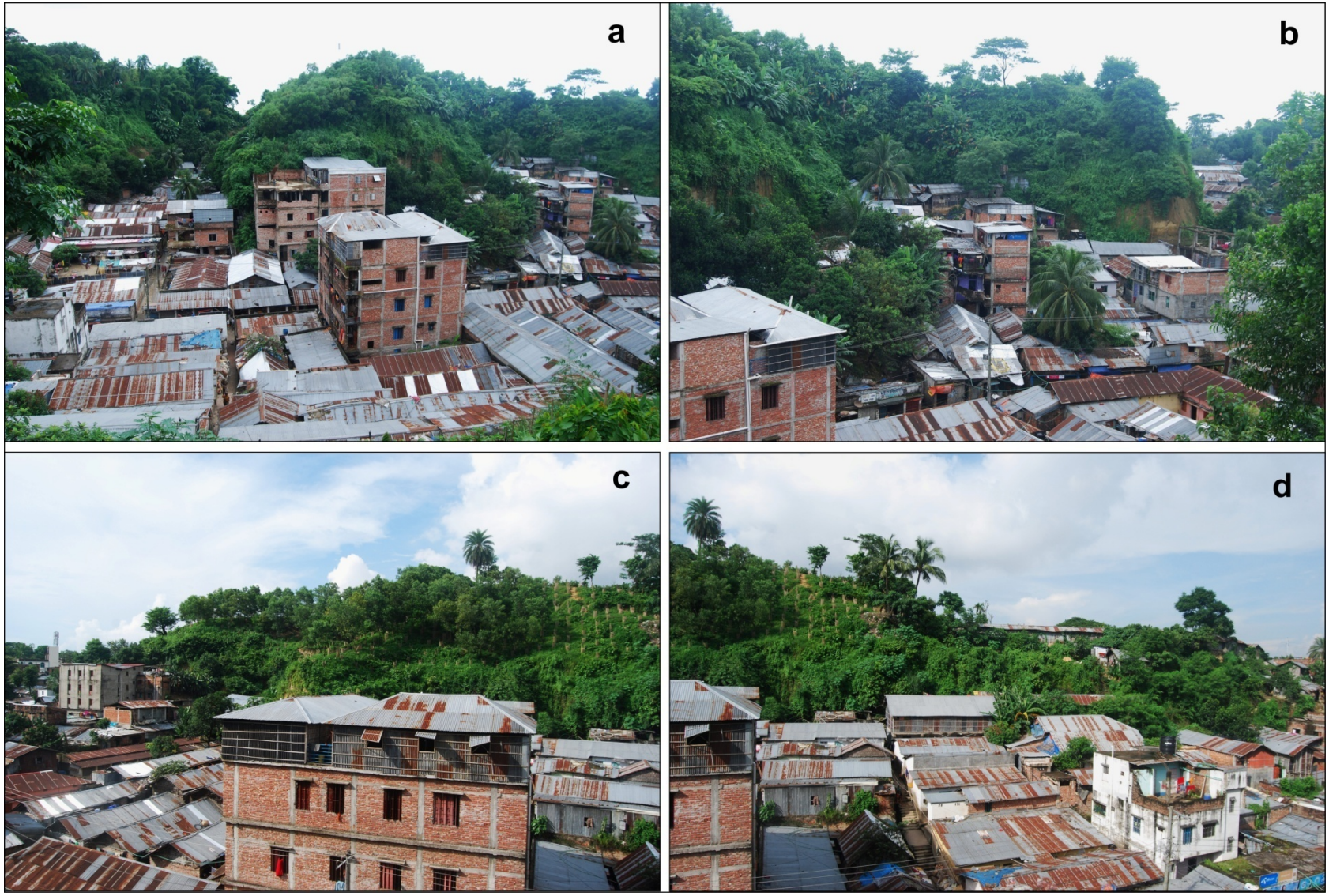


Analysis of the Results

Methods	Susceptible zones	Area under category (%)	Number of landslides	Comparison with landslide area (%)
	High susceptibility	22.713	20	100
AHP	Medium susceptibility	53.609	0	0
	Low susceptibility	23.677	0	0
	High susceptibility	41.890	20	100
WLC_1	Medium susceptibility	36.791	0	0
	Low susceptibility	21.319	0	0
	High susceptibility	20.365	20	100
WLC_2	Medium susceptibility	66.079	0	0
	Low susceptibility	13.556	0	0
	High susceptibility	1.5520	18	90
WLC_3	Medium susceptibility	96.911	2	10
	Low susceptibility	1.5370	0	0
	High susceptibility	19.565	20	100
OWA_1	Medium susceptibility	46.149	0	0
	Low susceptibility	34.286	0	0
	High susceptibility	3.4750	18	90
OWA_2	Medium susceptibility	52.381	2	10
	Low susceptibility	44.144	0	0
	High susceptibility	1.3410	9	45
OWA_3	Medium susceptibility	46.115	11	55
	Low susceptibility	52.544	0	0

Validation of the Methods (Relative Operating Characteristic)



The AUC values of the AHP, WLC_1, WLC_2, WLC_3, OWA_1, **OWA_2**; and OWA_3 methods were calculated as 0.898, 0.839, 0.911, 0.885, 0.904, **0.951**, and 0.871; respectively

Thank You All, QUESTIONS?