

**Ministry of Megapolis and Western Development
Urban Development Authority
Government of the Democratic Socialist Republic of Sri Lanka**

**PROJECT FOR
FORMULATION OF GREATER KANDY
URBAN PLAN (GKUP)**

Final Report

**Volume 3: Geographic Information System
(GIS) Technical Report**

September 2018

Japan International Cooperation Agency (JICA)

**Oriental Consultants Global Co., Ltd.
NIKKEN SEKKEI Research Institute
ALMEC Corporation**

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CHAPTER 1 INTRODUCTION

1.1 Preparation of Spatial Database

Geographic Information System (GIS) is utilized in this project as one of the fundamental tools for spatial data analysis by using a great variety of basic data for natural and social conditions at the stages of Strategic Environmental Assessment. All the spatial data collected for the assessment and proposal was stored in the spatial database. Spatial database of Greater Kandy Urban Plan are mainly collected by two methods:

1. Primary Data: Site Survey
2. Secondary Data Collection obtained from related authorities

All of the necessary spatial data for planning was organized in a structured manner compiled in the database with appropriate technical manual. Sri Lankan counterparts can utilize the spatial data in future work and update it from time to time.

1.1.1 Site Survey

Site survey was conducted by JICA team since February 2017-August 2018. The data collected for Greater Kandy area and heritage area, Kandy to develop the spatial database for fundamental analysis and assessment for strategic planning.

1.1.2 Secondary Data Collected from Relevant Authorities

Secondary data was collected from the relevant authorities and agencies included: Urban Development Authority, Department of Survey, Department of Archaeology, Kandy Municipal Council, Road Development Authority, National Building of Research Organization and other relevant authorities. A set of fundamental database was obtained from Department of Survey (Database in 2001) and it was developed by adding the additional information in spatial context for further study and assessment.

1.2 Scope of Spatial Database

Scopes of the spatial database in this project are divided into two parts by presenting the existing condition and analytical map for the areas below:

1. Greater Kandy Area
 - Coverage area of 60,000 hectares of Central Province surrounded Kandy city
 - Focus on sub-component area of cluster city
2. Heritage Area, Kandy
 - Entire heritage area of Kandy city centre
 - Four zones within heritage area: Commercial Grid Zone, Civic Hub Zone, Public Transit Zone, Lake Around Zone

CHAPTER 2 SPATIAL DATA AND THEMATIC MAPS IN THE GREATER KANDY AREA

2.1 Data Description

2.1.1 Definition of Geodetic Reference System

Projected coordinate system used in the project maps is Kandawala Sri Lanka Grid.

2.1.2 Definition of Evaluation Grid

Maps of scale 1:10,000 were obtained from several sources to produce the analytical map for Greater Kandy area. 5m pixel size was applied to create the digital evaluation model, slope and other raster set data to develop the map for environmental zoning analysis.

2.2 Category of Spatial Data Accumulated in Spatial Database

2.2.1 Fundamental Spatial Data and Thematic Maps

The thematic maps were developed by combining the datasets collected from related authorities from primary and secondary data.

Table 2.2.1 Fundamental Spatial Data for the Greater Kandy Area

Greater Kandy Area			
Category of Inventory Data		Type of Data	Source
Natural Environment	Digital Elevation	Raster	DoS, 2001
	Land Slope	Raster	DoS, 2001
	Rainfall	Raster	DoM
	Soil Condition	Polygon	Soil Science Society of Sri Lanka, Peradeniya, 1999
	Designated Land Protection in Greater Kandy Area	Polygon	Department of Forest, Department of Wildlife, Central Environmental Authority
Disaster Area	Landslide Affected Area	Polygon	NBRO, 2006
	Hazard Map	Polygon	
	Flood Affected Area	Polygon	
Population	Population Density 2001	Polygon	DoS, 2001
	Population Density 2016	Polygon	2016
	Population, AAGR, 2001-2012	Polygon	DoS, 2016
	Annual Average Population Growth Rate by GN between 2012-2035	Polygon	The JICA Team
	Major Ethnic Group by GN, 2001	Polygon	Resource Profile, 2001
	Distribution of Sinhala, 2001	Polygon	Resource Profile, 2001
Facilities	Location of Educational Facilities	Point	DoS, 2001

	Location of Medical Facilities	Point	DoS, 2001
	Locations of Government Agencies and Public Services	Point	DoS, 2001
	Location of Religious Facilities	Point	DoS, 2001
Industry	Distribution of Employed Population 10 Years Old and Over by Sector (2001) (a) Agriculture Sector	Polygon	Resource Profile, 2001
	Distribution of Employed Population 10 Years Old and Over by Sector (2001) (b) Industry Sector	Polygon	Resource Profile, 2001
	Distribution of Employed Population 10 Years Old and Over by Sector (2001) (c) Service Sector	Polygon	Resource Profile, 2001
Land Use	Land Use Distribution, 2001	Polygon	DoS, 2001
	Land Use Distribution, 2016	Polygon	Geo-view Satellite Image, The JICA Team
	Agriculture Land Use 2001	Polygon	DoS, 2001
	Land Utilization, 2001	Polygon	DoS, 2001
	Land Use in Cluster City, 2016	Polygon	Geo-view Satellite Image, The JICA Team
Cluster Cities			
Category of Inventory Data		Type of Data	Source
	Kundasale - Akurana Growth Pattern	Polygon	Geo-view Satellite Image, The JICA Team

Source: The JICA Team

DoA: Department of Archaeology

DoM: Department of Meteorology

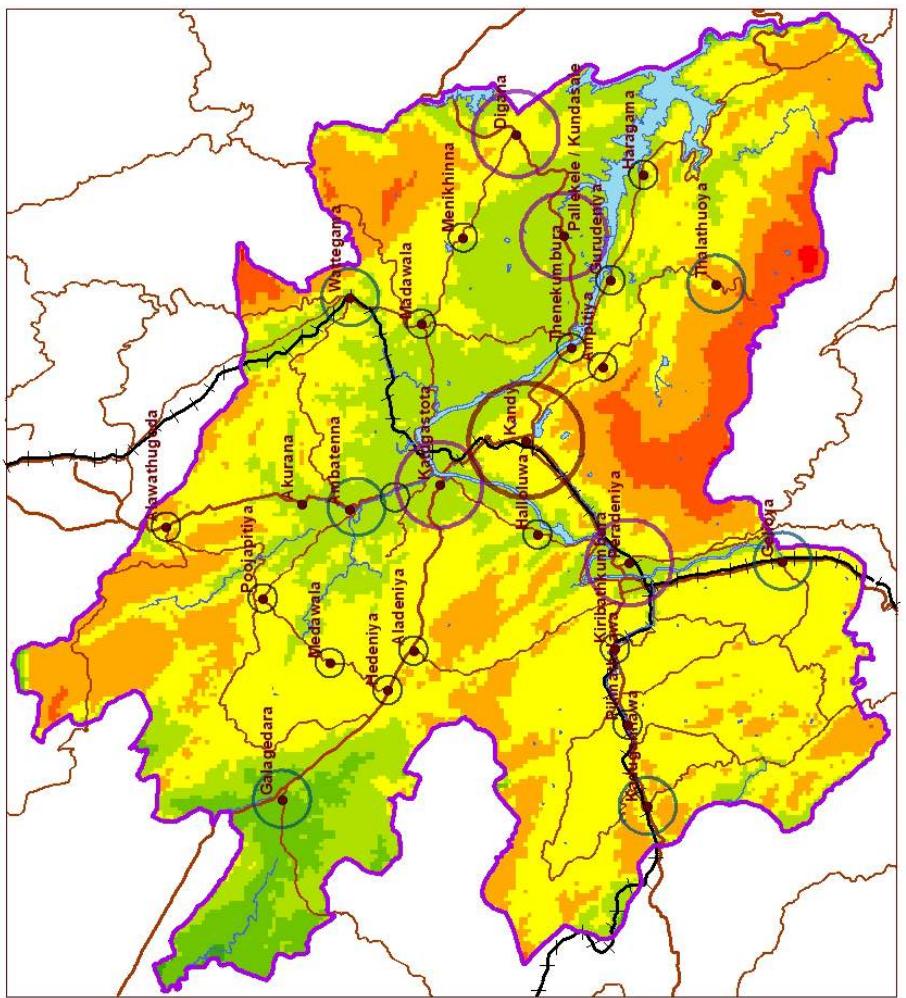
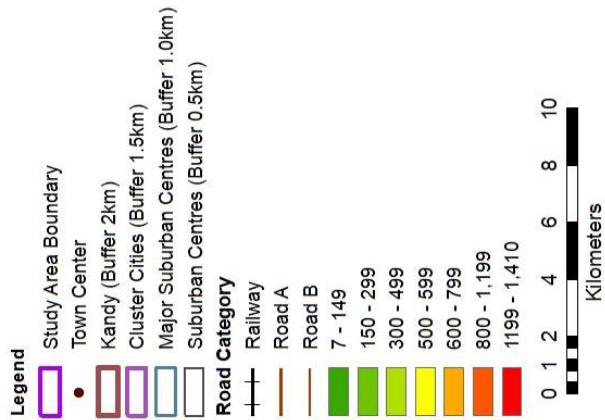
DoS: Department of Survey

NBRO: National Building Research Organisation

UDA: Urban Development Authority

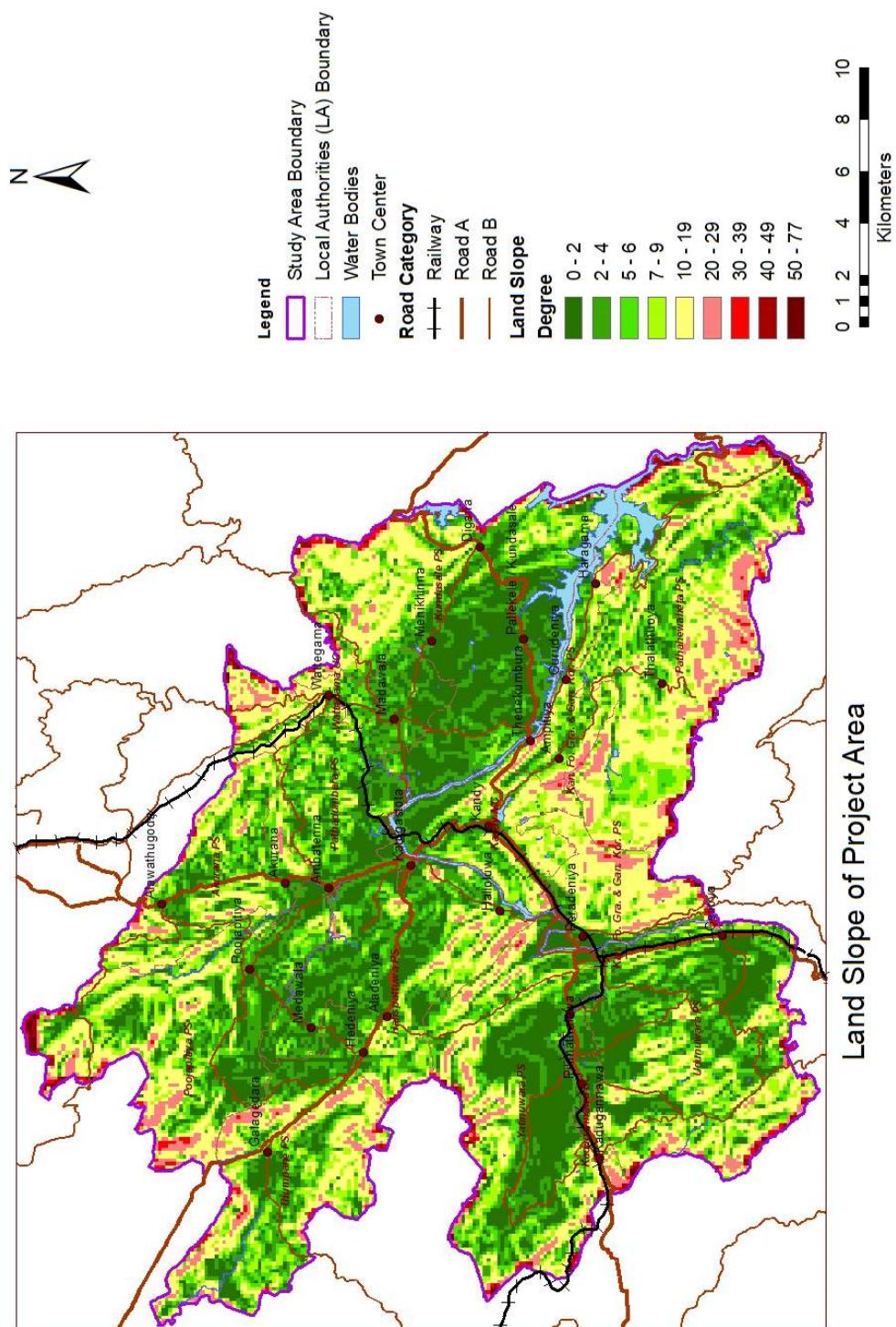
Map of Greater Kandy

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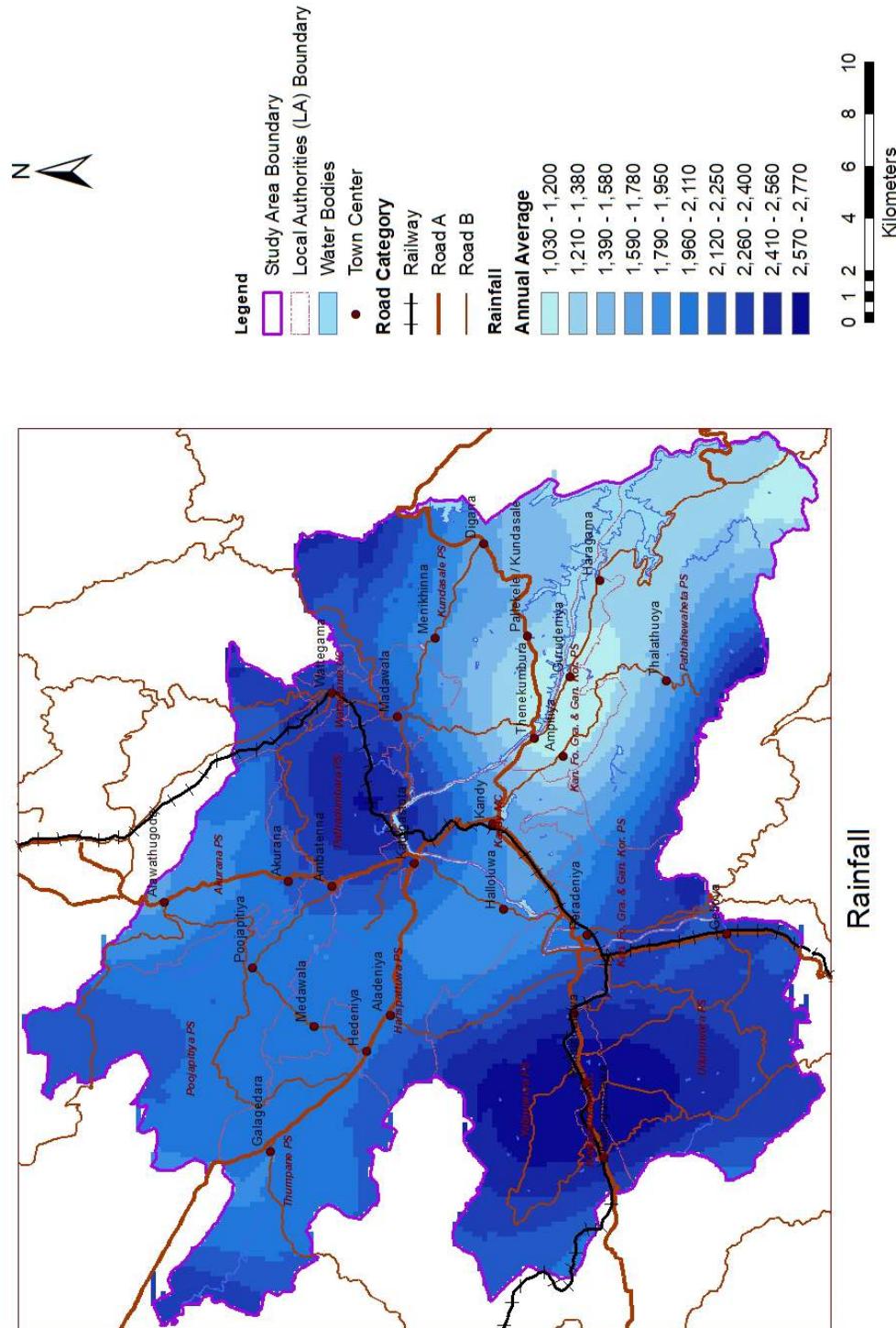
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Map of Greater Kandy



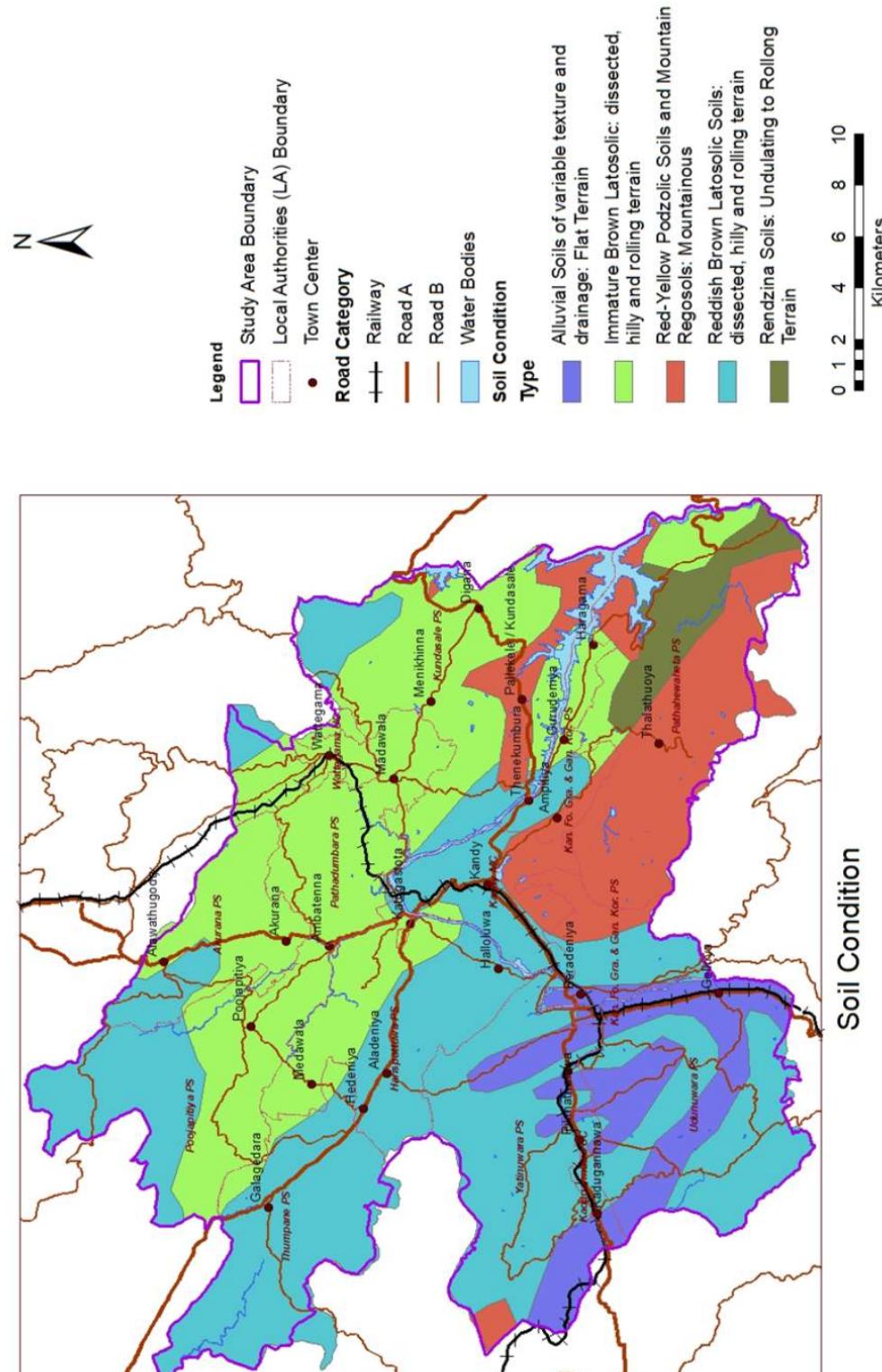
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Map of Greater Kandy



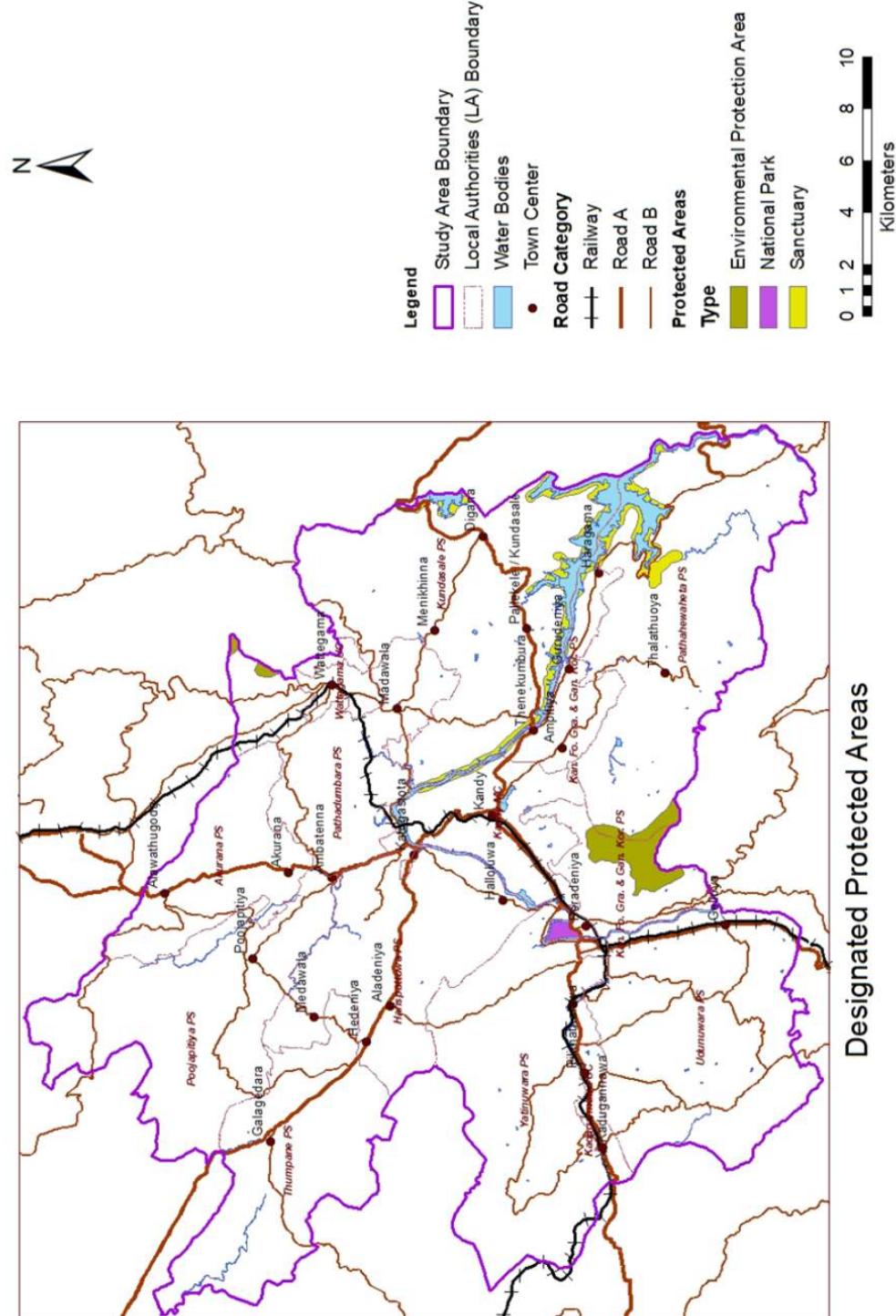
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Map of Greater Kandy



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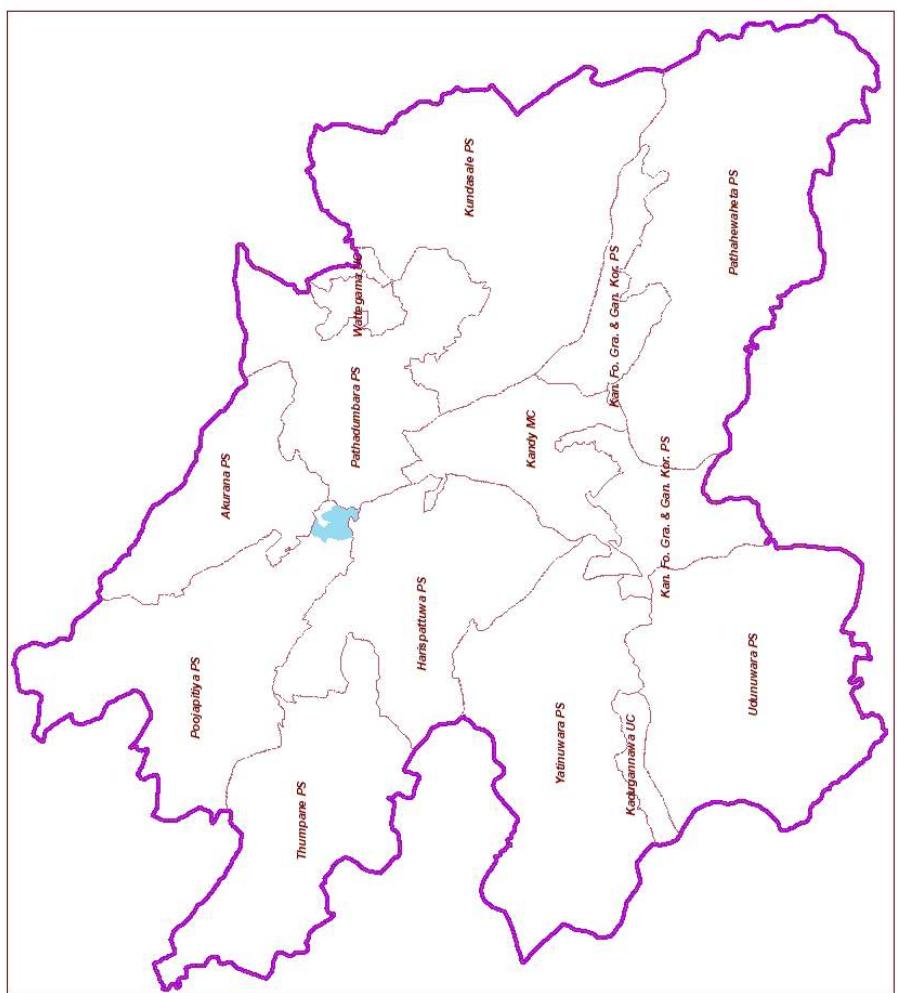
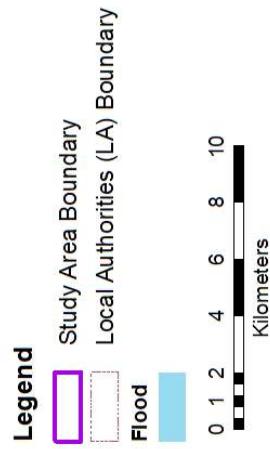
Map of Greater Kandy



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Map of Greater Kandy

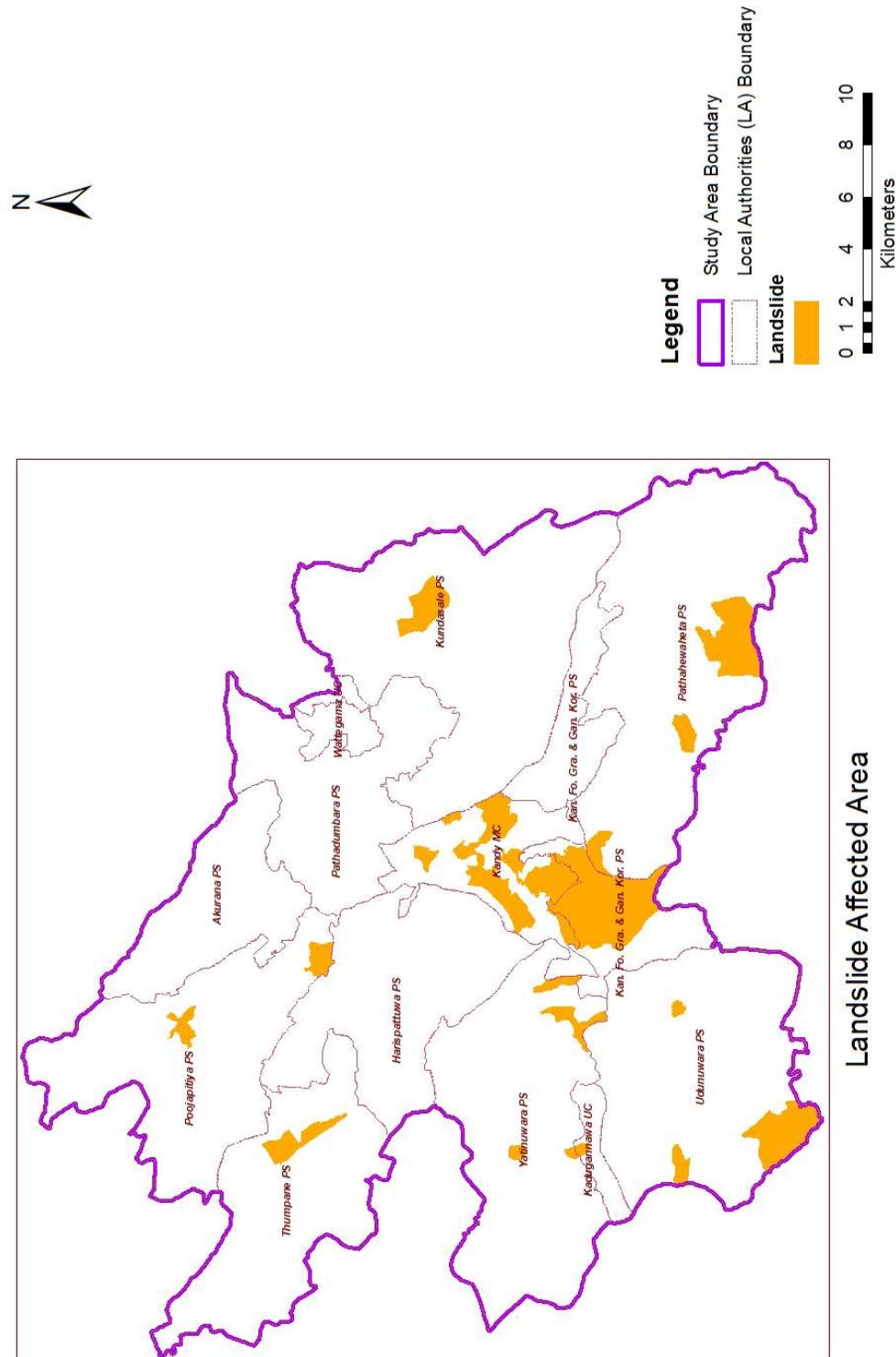
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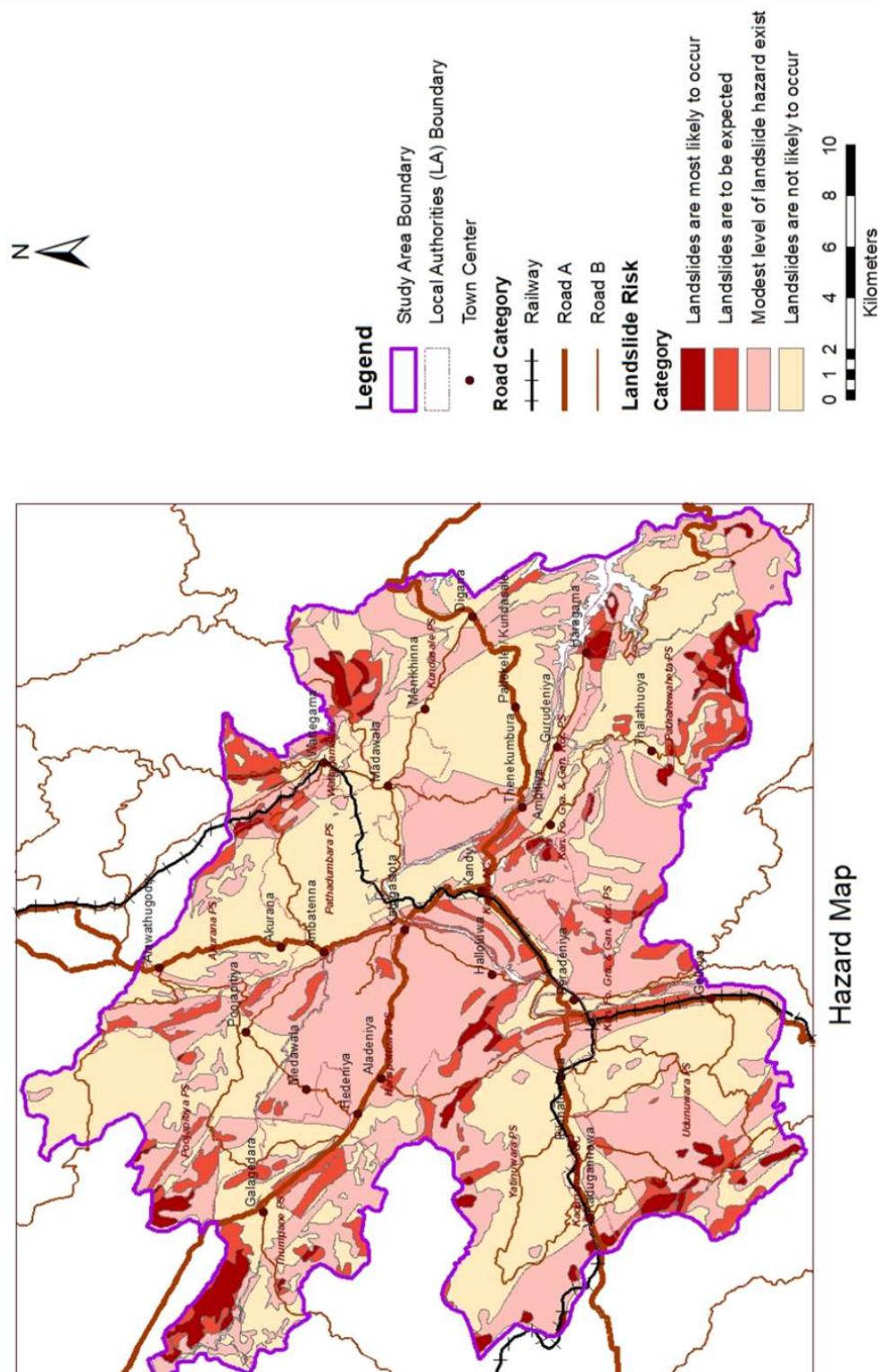
Flood Affected Area

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Map of Greater Kandy

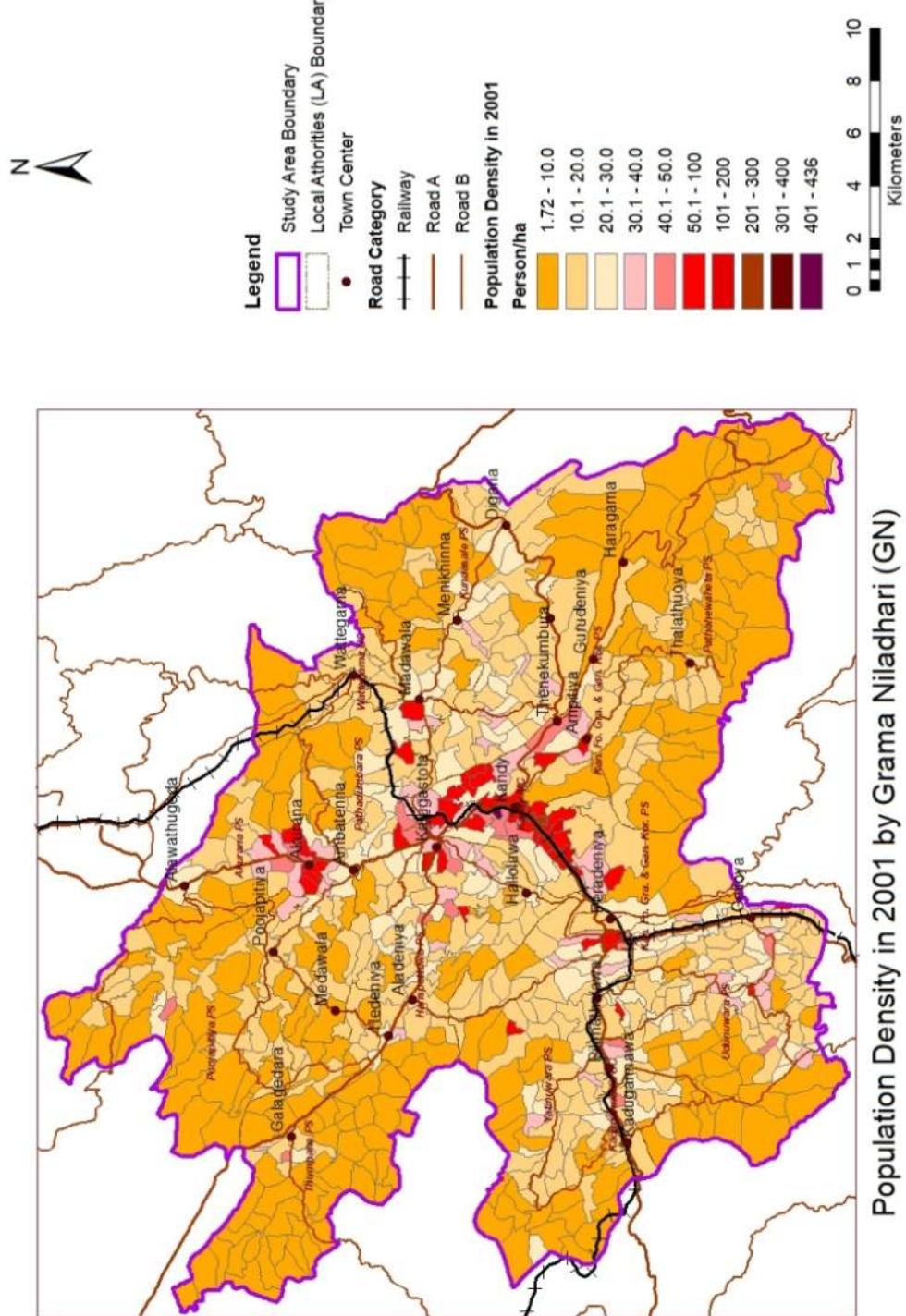


Map of Greater Kandy



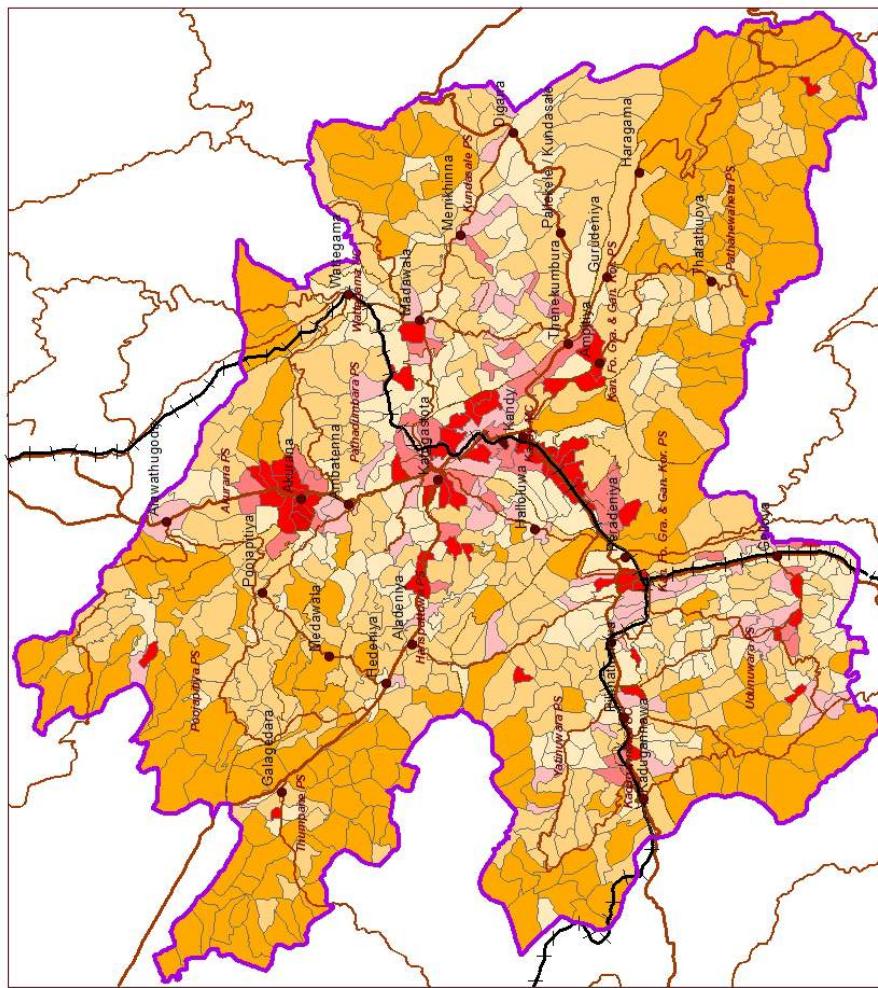
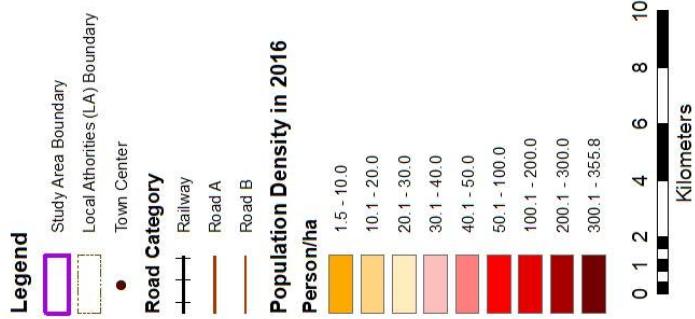
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Map of Greater Kandy



The Project for Formulation of Greater Kandy Urban Plan

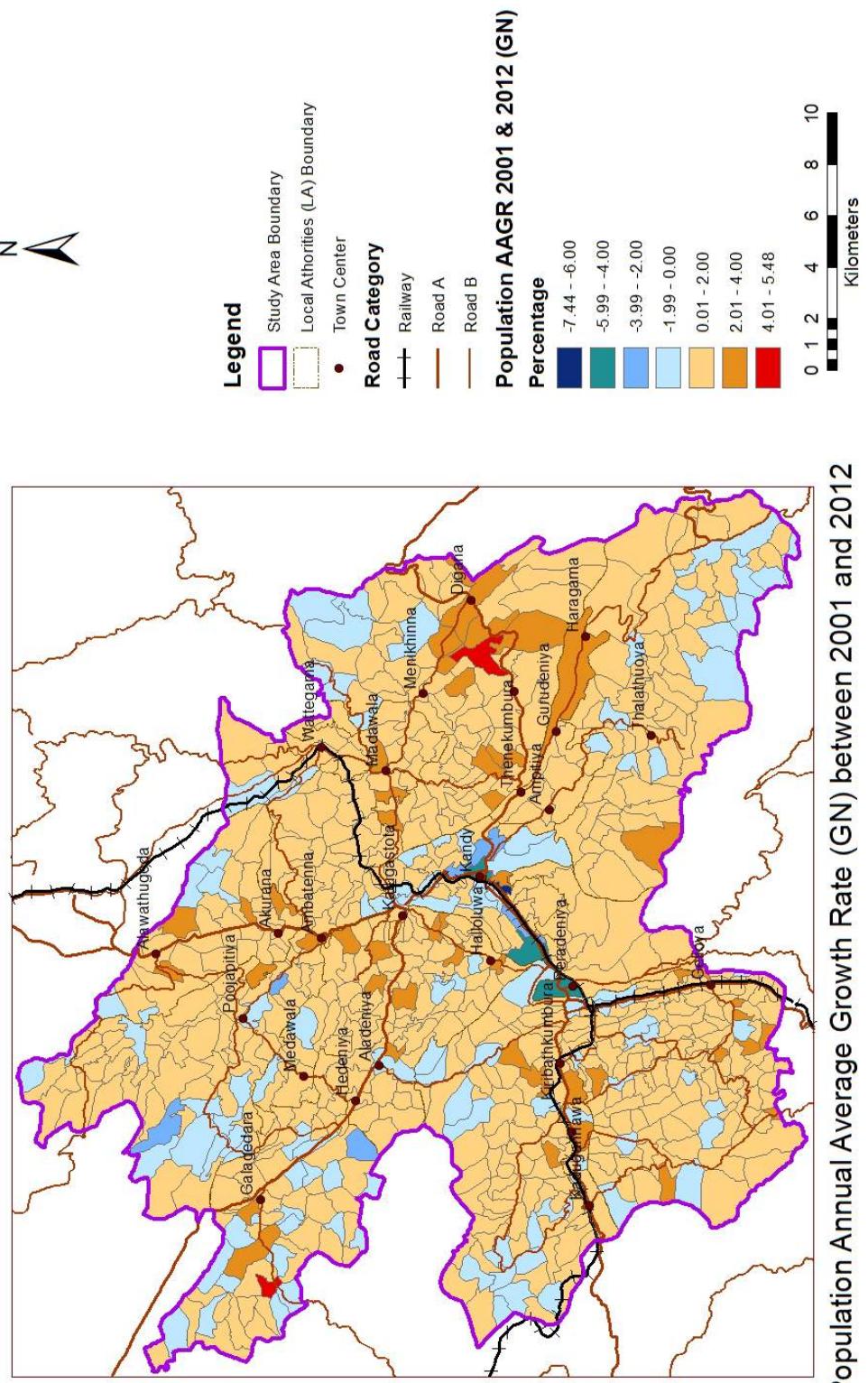
Map of Greater Kandy



Population Density in 2016 by Grama Niladhari (GN)

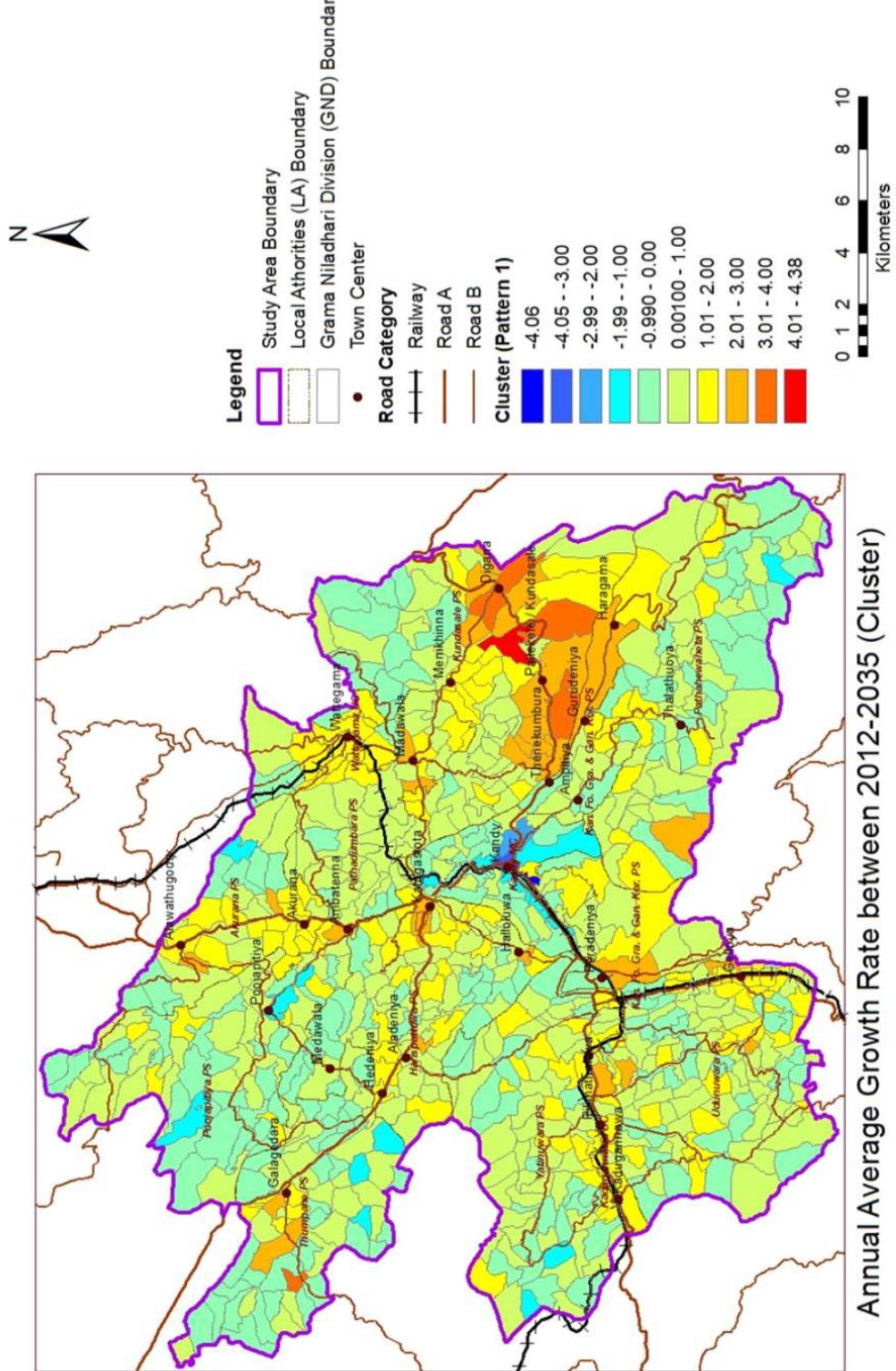
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Map of Greater Kandy



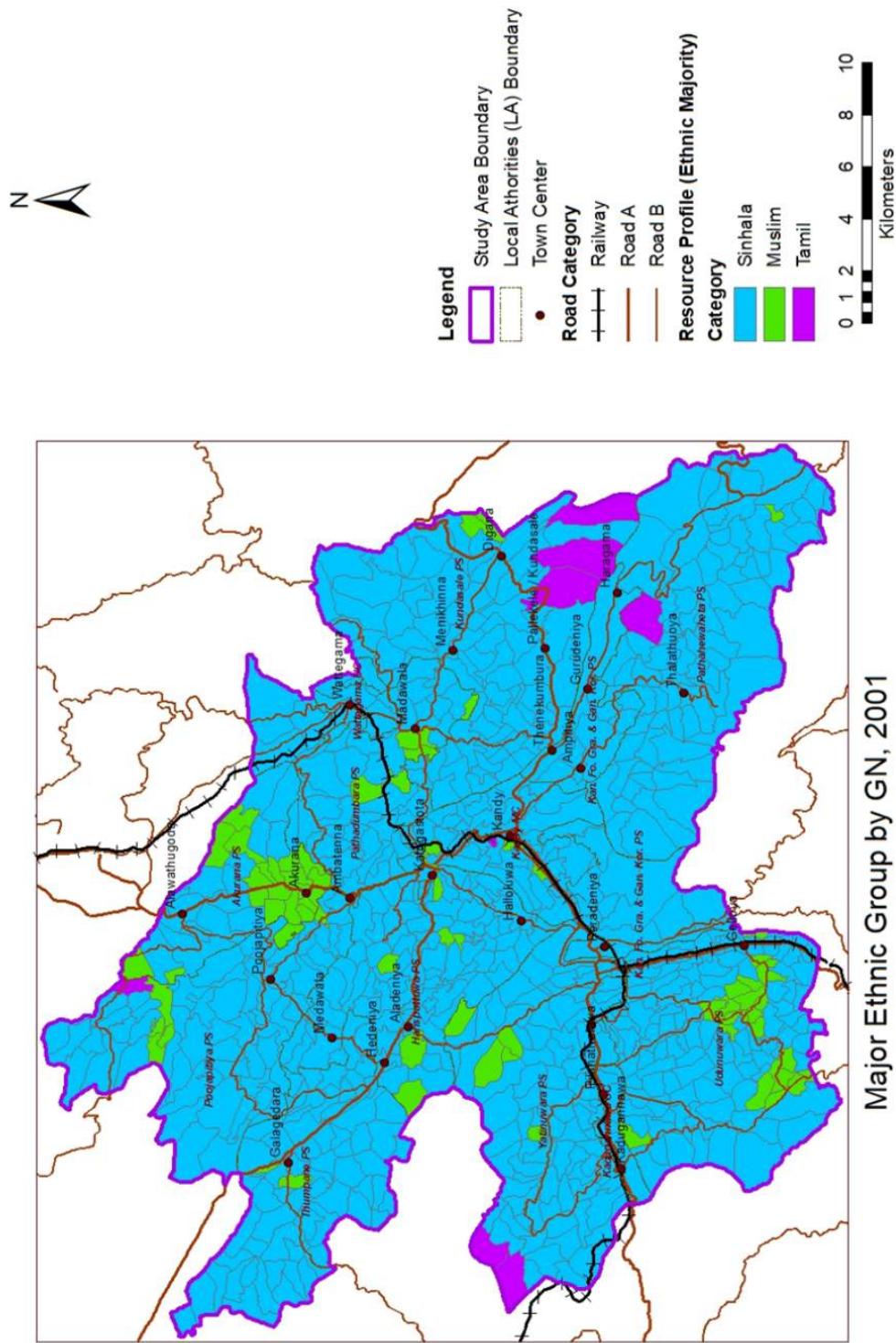
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Map of Greater Kandy



The Project for Formulation of Greater Kandy Urban Plan

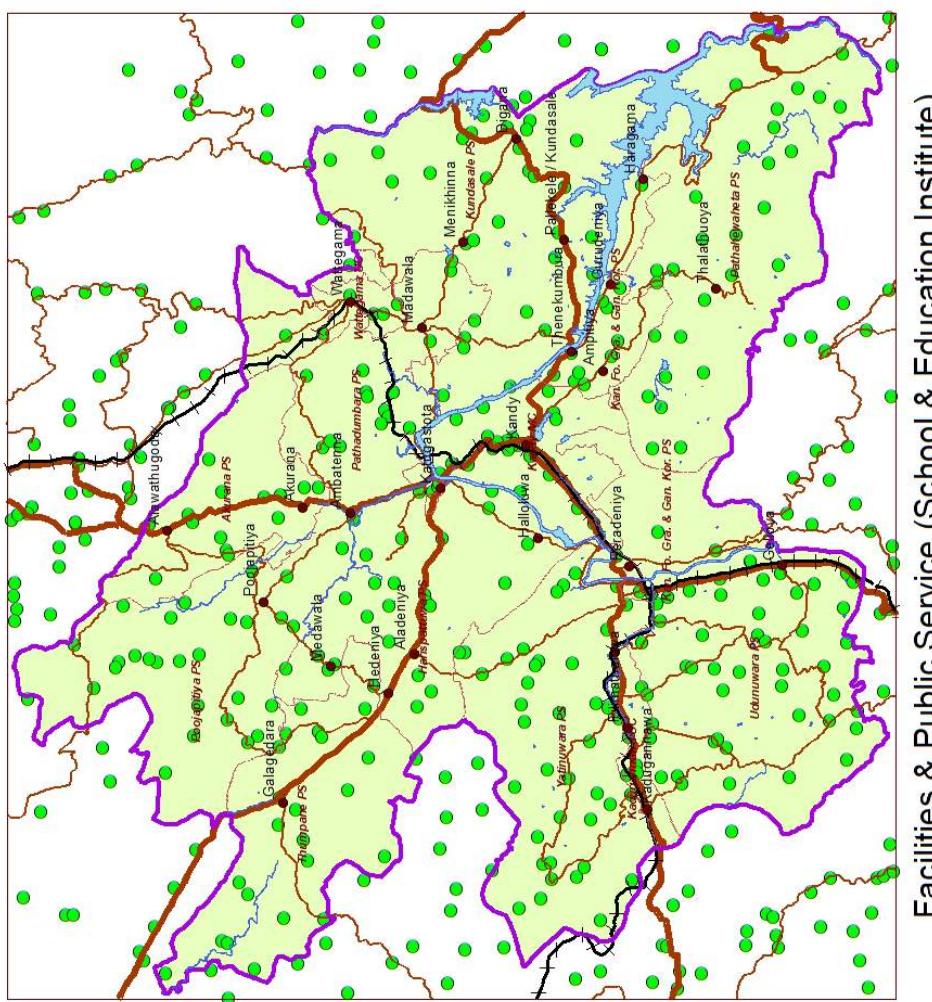
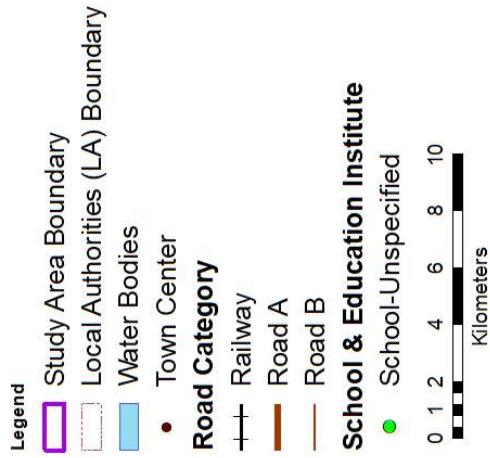
Map of Greater Kandy



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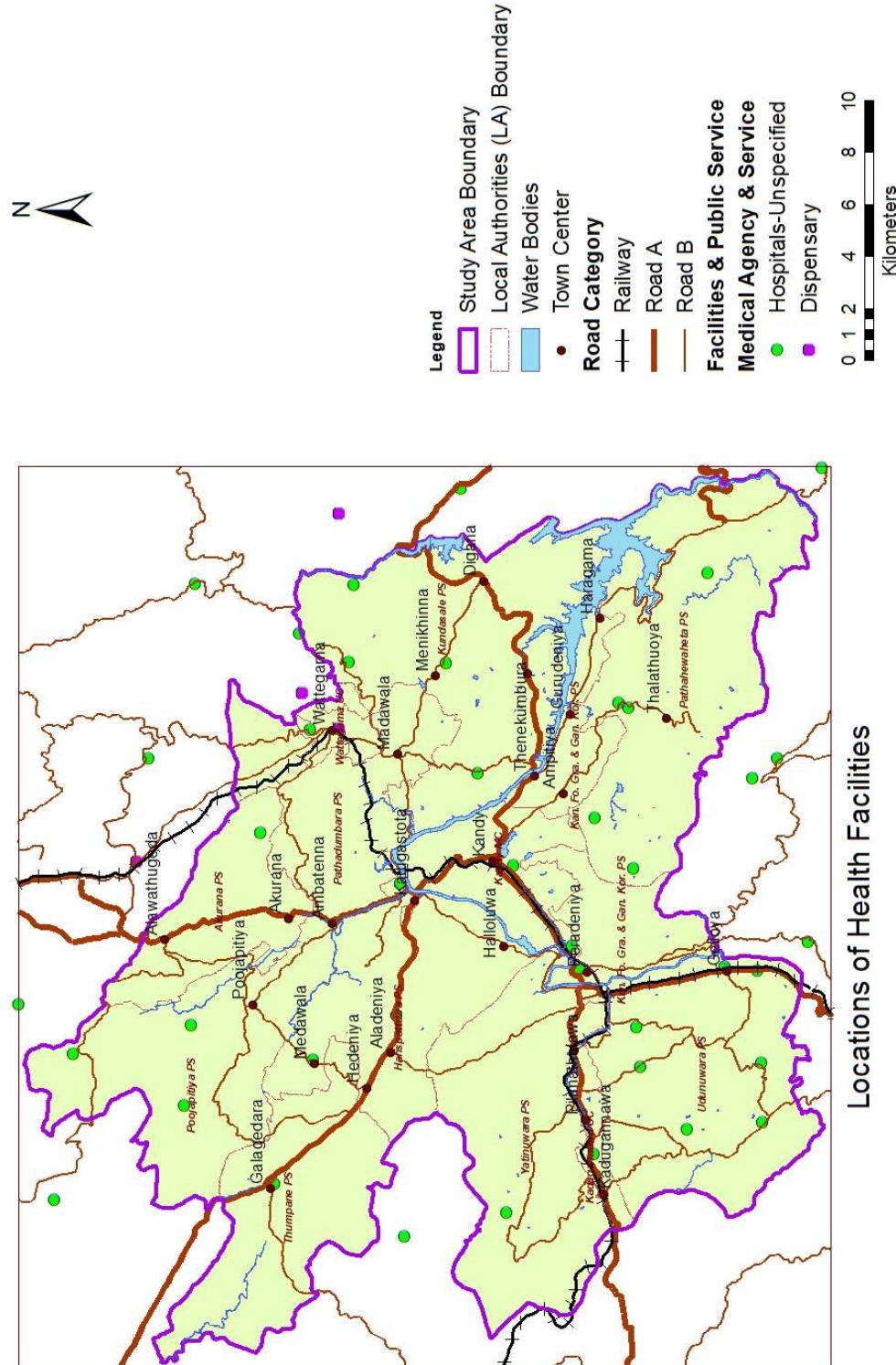
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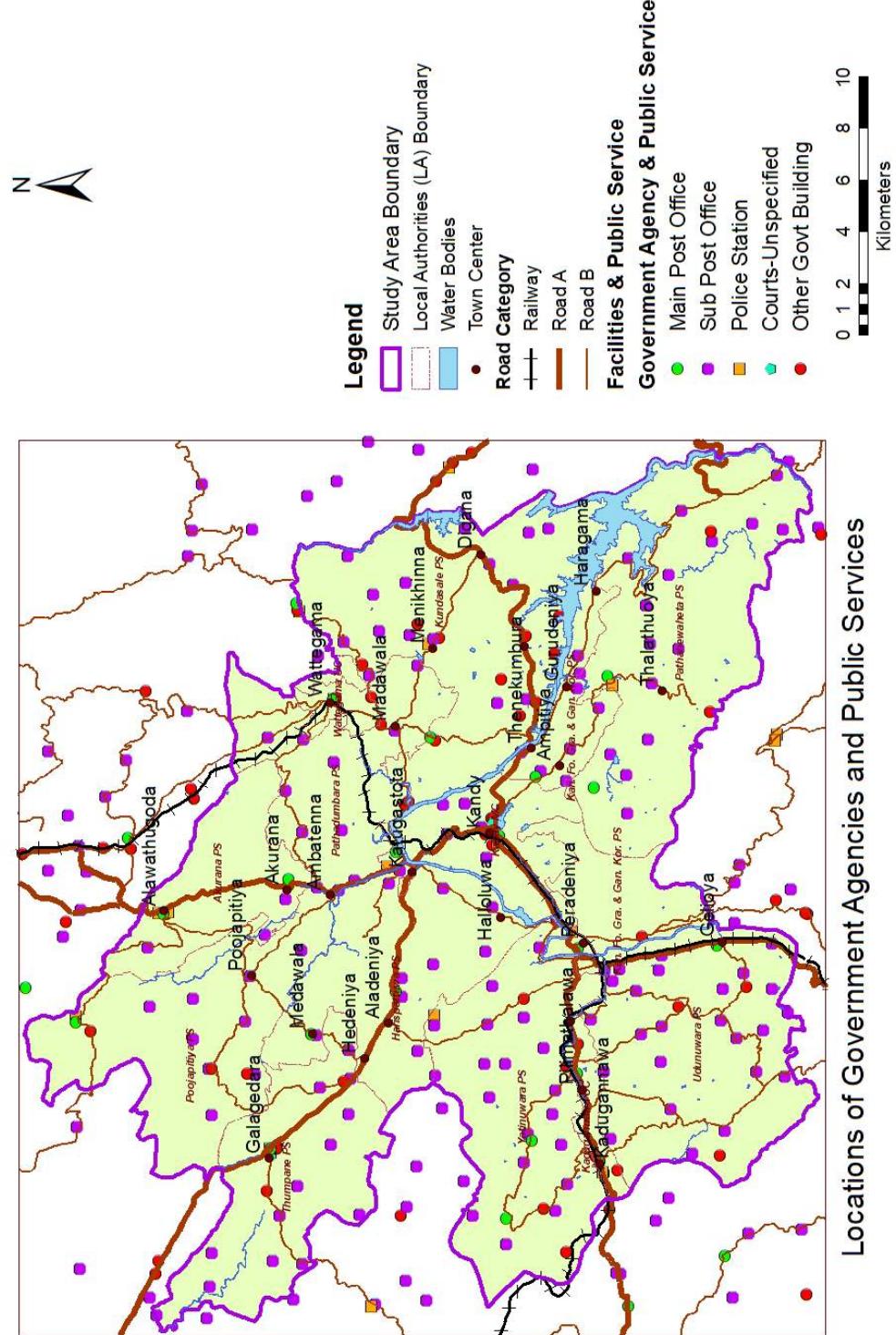
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Map of Greater Kandy



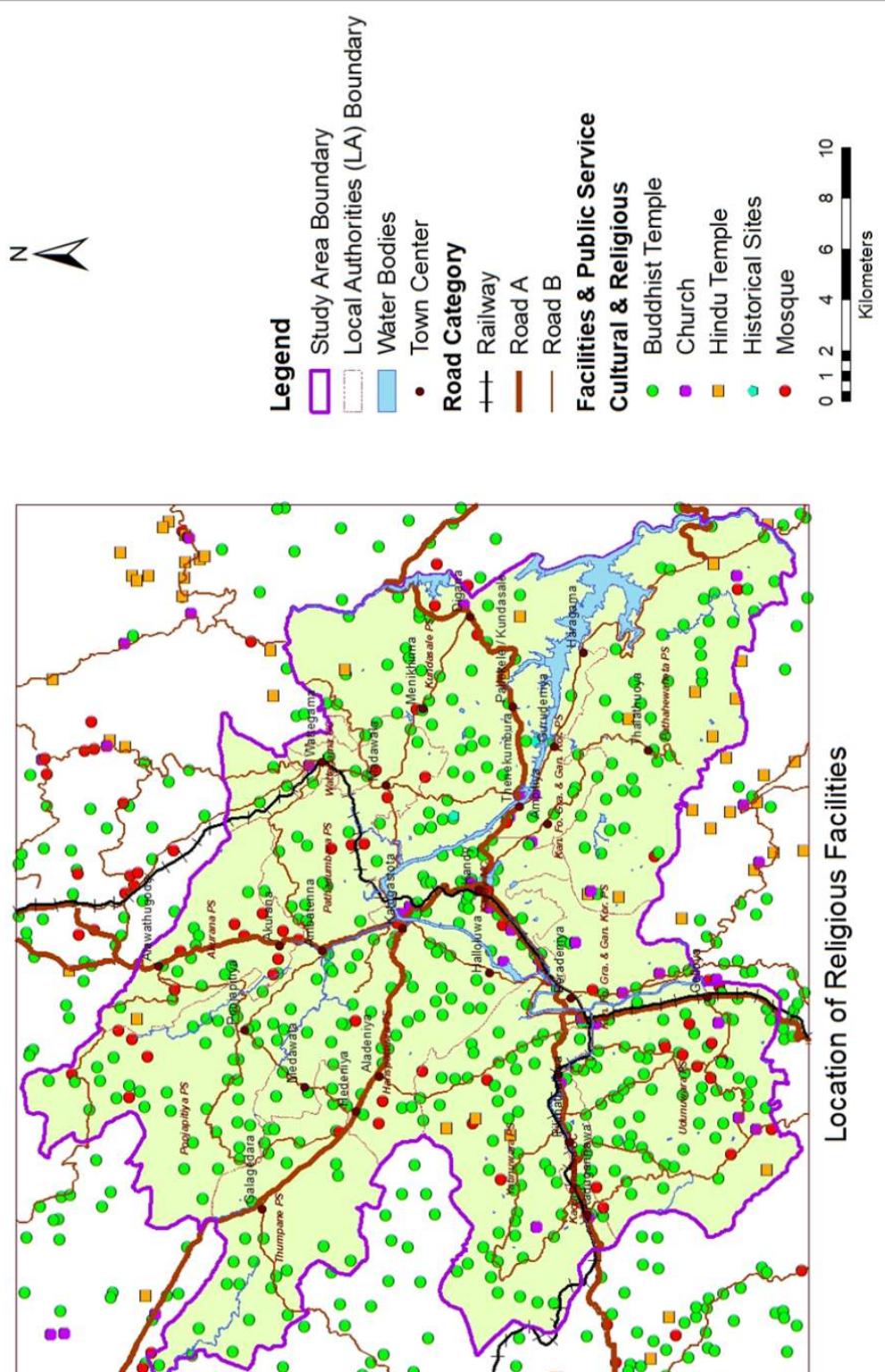
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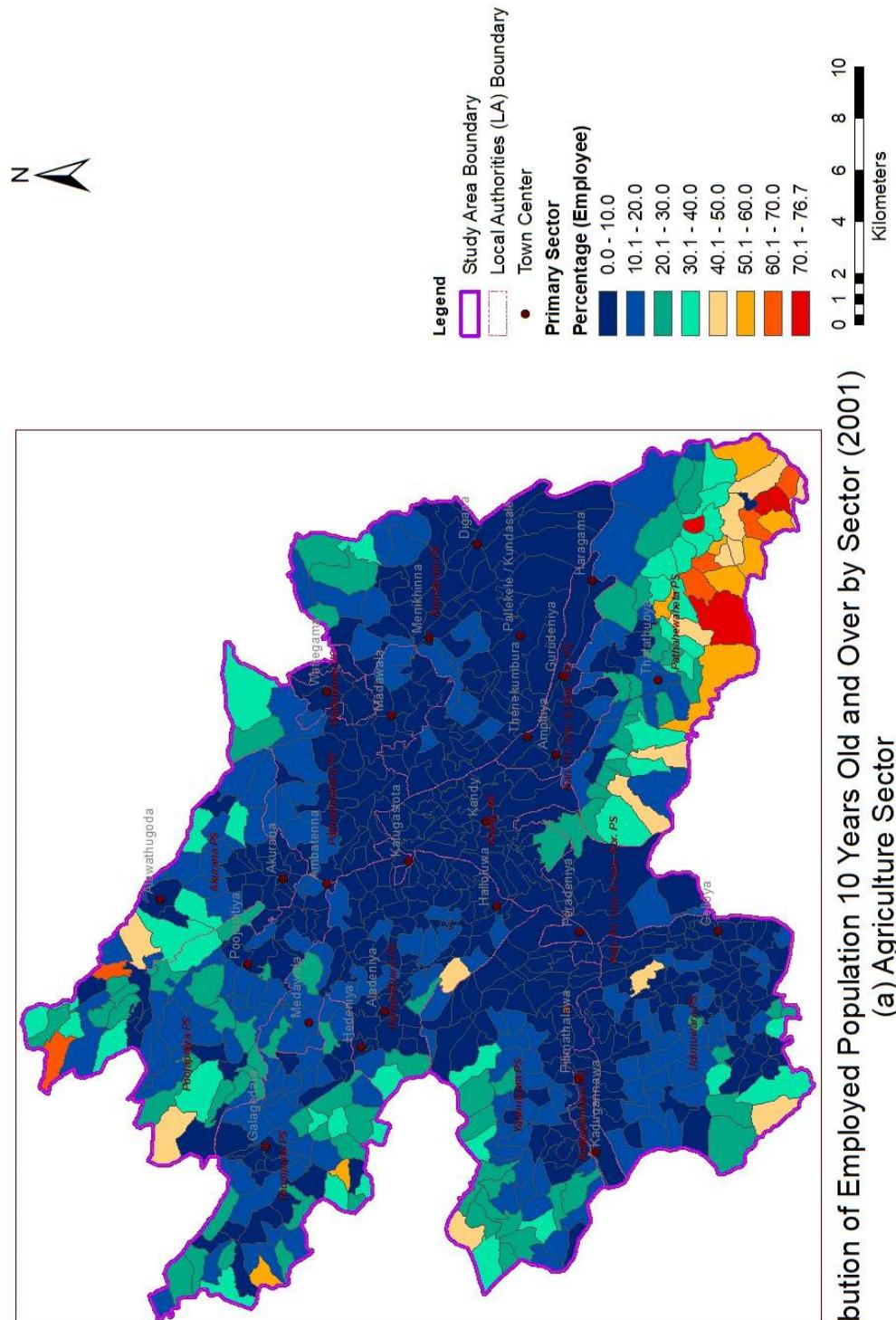
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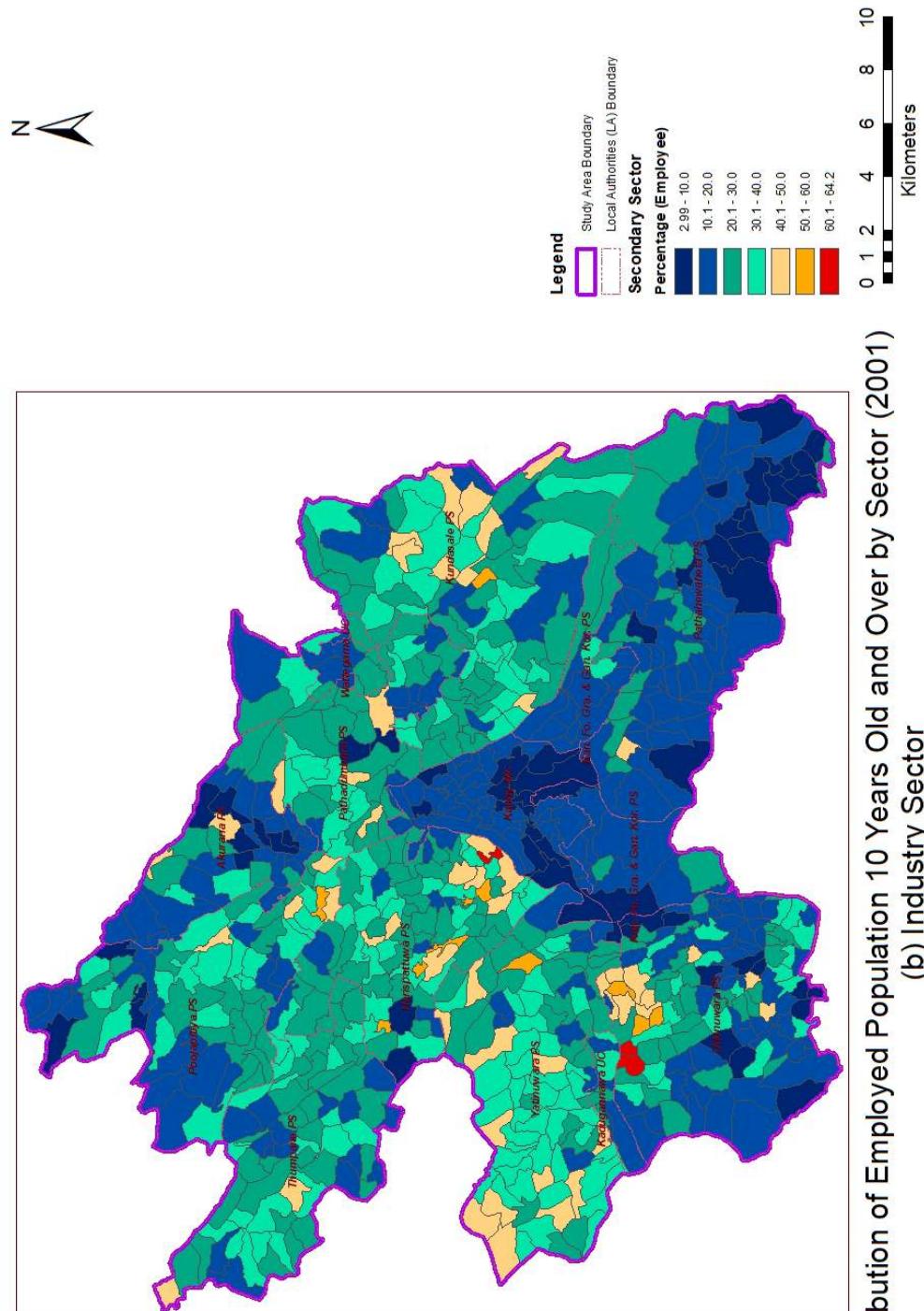
The Project for Formulation of Greater Kandy Urban Plan

Map of Greater Kandy



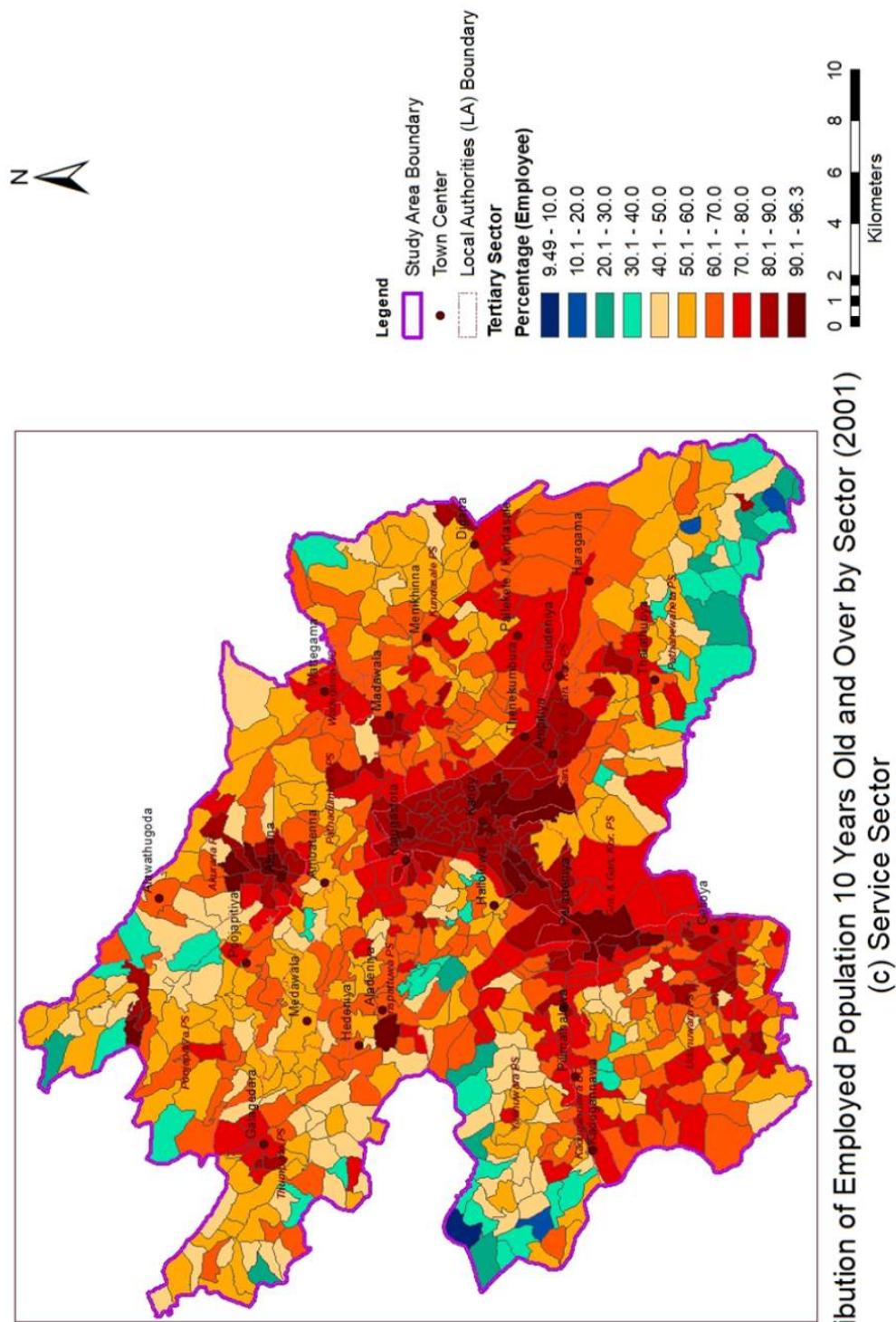
The Project for Formulation of Greater Kandy Urban Plan

Map of Greater Kandy



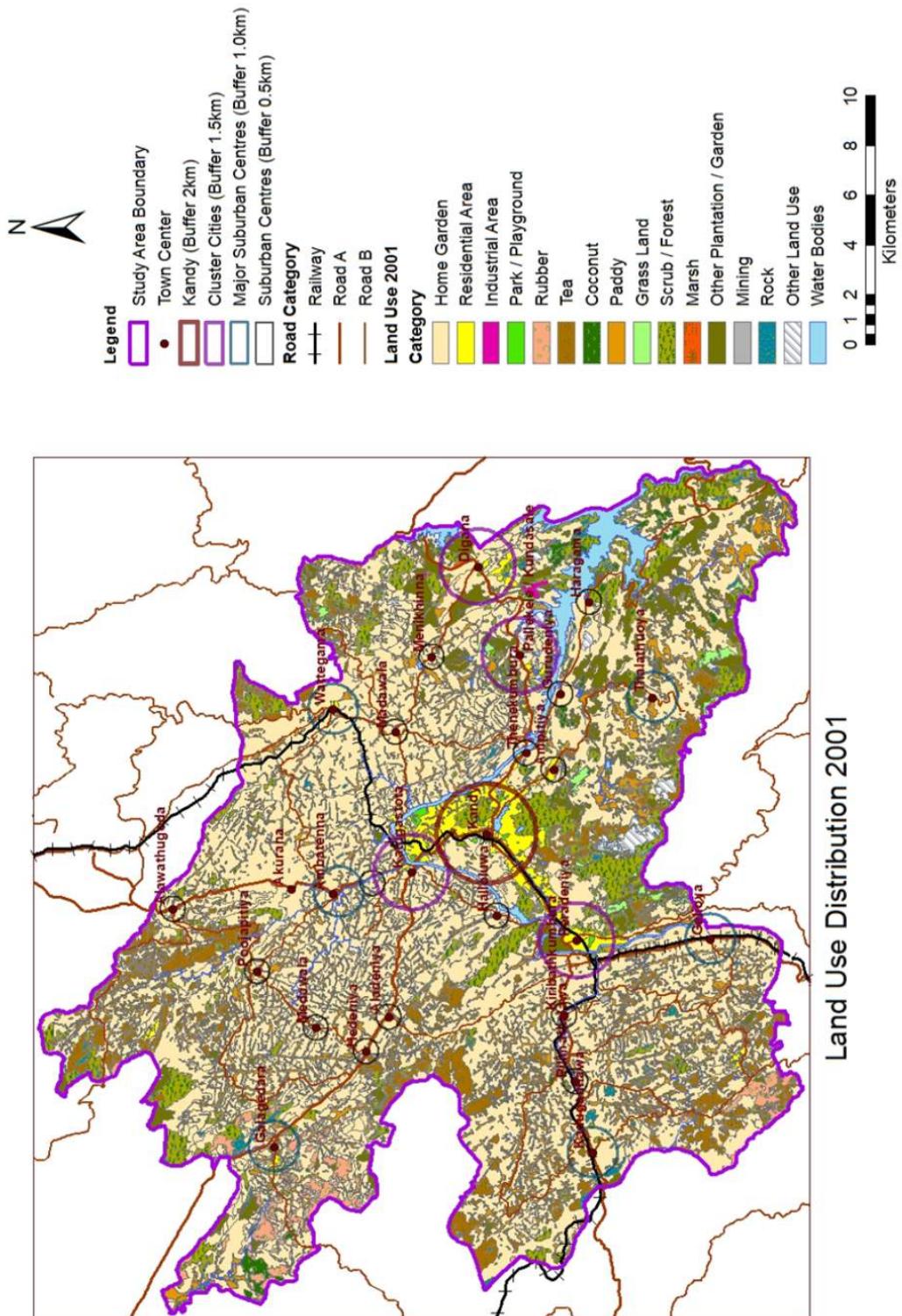
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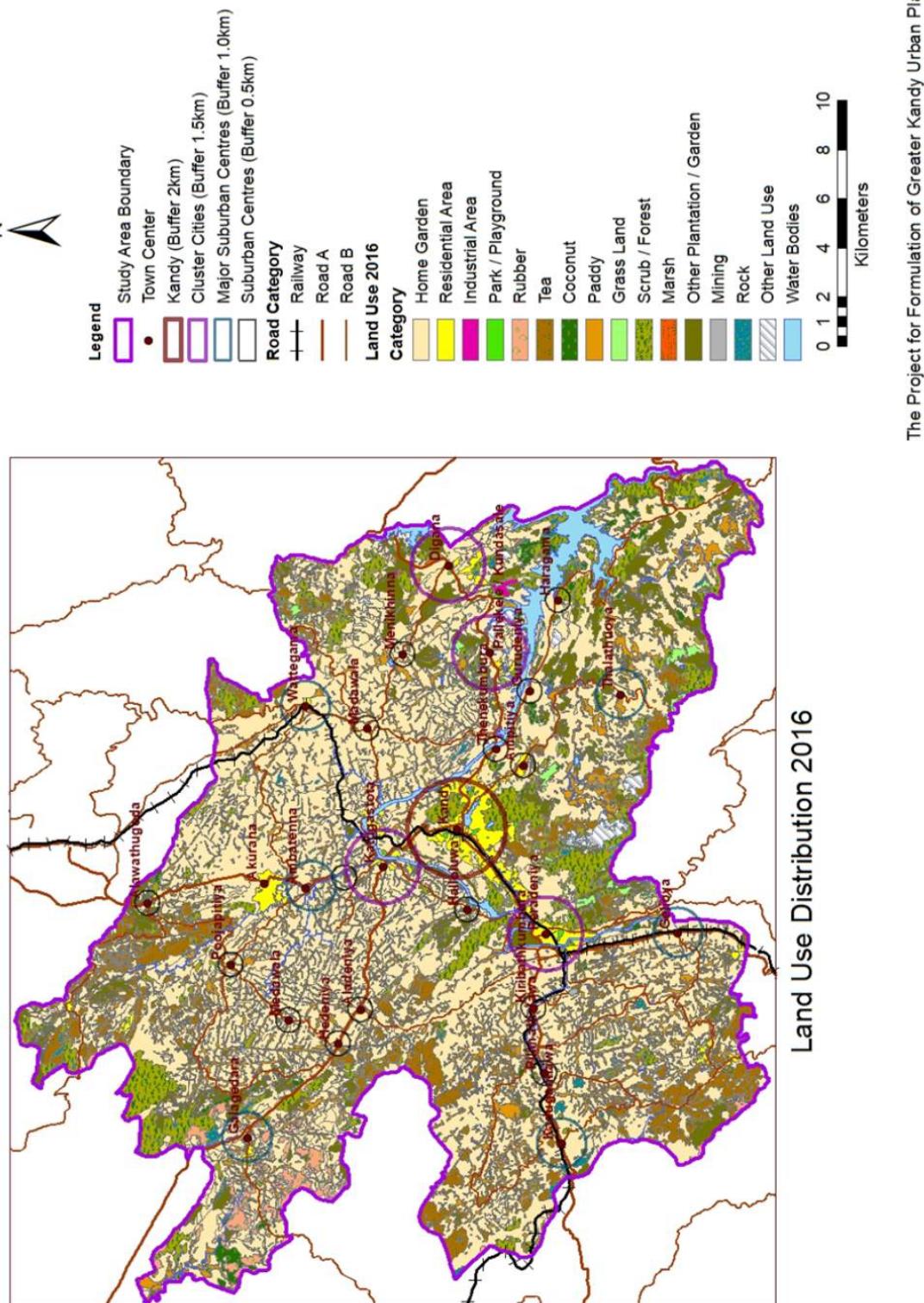
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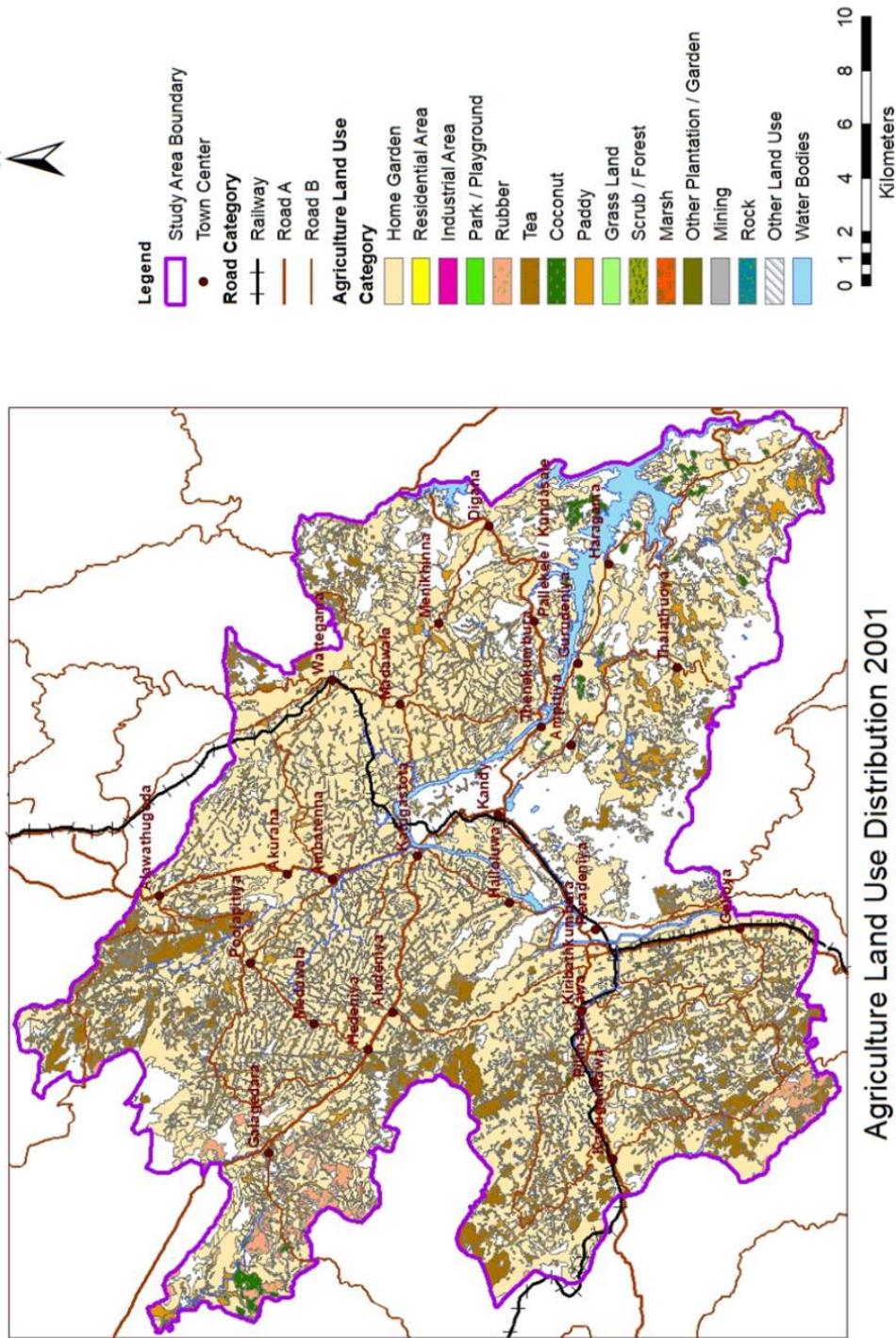


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Map of Greater Kandy



Map of Greater Kandy



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2.2.2 Environmental Assessment Spatial Data

1) Selection of Indicators

The following items were selected as constraint indicators which are likely to become major environmental constraints to urban development in the Greater Kandy (Table 2.2.2).

Table 2.2.2 Environmental indicators

Environmental Indicators	Data Source
Designated land protection <ul style="list-style-type: none"> • Conservation areas such as national parks • Forest reserve 	Department of Forest, Department of Wildlife, Central Environmental Authority
Land cover <ul style="list-style-type: none"> • Forest cover • Agricultural land 	Department of Survey, 2001
Watershed <ul style="list-style-type: none"> • River network • Water intake points 	Department of Survey, 2001
Disaster risk <ul style="list-style-type: none"> • Landslide risk • Elevation, • Slope condition 	National Building Research Organization Department of Survey 2001 Department of Survey 2001
Soil condition	Soil Science Society of Sri Lanka, Peradeniya, 1999

Source: The JICA Team

2) Evaluation Method

The evaluation indicators are scored in ranks of four levels at 0, 1, 2 and 5, according to the level of constraint, with level 5 at the highest constraint.

Thematic maps of these indicators are to be analysed in a raster (mesh) form of GIS to be integrated to develop scoring maps based on the above scoring method. A total score for each raster, showing an overall constraint level, is calculated by aggregating the scores of the indicators.

For evaluation of land in this way, the following three evaluation criteria are taken: (1) designated land for protection, (2) land cover, and (3) disaster risk.

Table 2.2.3 Evaluation Criteria for Environmental Zoning

Evaluation Criteria	Description
1. Designated Land for Protection	Environmentally sensitive areas which are designated to be protected or reserved for natural environmental conservation
2. Land Cover	Land use suitability, especially in terms of agricultural production and water supply
3. Disaster Risk	Risks of landslide and flood

Source: The JICA Team

Evaluation maps are generated by the overlaying of scoring maps; three evaluation maps are created which represent the level of constraint in terms of the following environmental information. The following tables describe the evaluation criteria and each scoring method (Table 2.2.4).

Table 2.2.4 Scoring for Environmental Indicators

A. Designated Land Protection

Indicator	Score				Remarks
	0 (low)	1	2	5 (high)	
A1: protected areas	no		<ul style="list-style-type: none"> • Buffer area of sanctuary within 500m • Environmental Protection Zone with periphery within 100m 	<ul style="list-style-type: none"> • Sanctuary¹⁾ with periphery within 100m • National park²⁾ 	1) including conservation forest 2) Botanical garden
A2: Forest	no		<ul style="list-style-type: none"> • Buffer area of reserved forest within 500m 	<ul style="list-style-type: none"> • Reserved forest with periphery within 100m 	

B. Land Use / Cover

Indicator	Score				Remarks
	0 (low)	1	2	5 (high)	
B1 Land cover, plantation	no	<ul style="list-style-type: none"> • Scrub/marsh, Coconut, rubber, • Other cultivation: • (Agricultural Farm, • Banana, • Cashew, • Cinnamon, • Mixed Crops, • Pepper, • Rubber, • Seasonal Crops) • Other forest: • (Forest Plantation) 	<ul style="list-style-type: none"> • Paddy (abandoned), • Tea • Open/Dense Forest 	<ul style="list-style-type: none"> • Paddy (productive) 	
B2 Water body, reservoir	no		<ul style="list-style-type: none"> • Buffer area of water body within 500m both sides or circle 	<ul style="list-style-type: none"> • Water body³⁾ (including 60m width both sides or circle) 	3) River/stream, pond/lake
	no	<ul style="list-style-type: none"> • Proposed service reservoir within 500m circle 	<ul style="list-style-type: none"> • Existing service reservoir within 500m circle 	<ul style="list-style-type: none"> • Water intake with 250m width both sides and 1km upstream 	

D. Disaster Risk

Indicator	Score				Remarks
	0 (low)	1	2	5 (high)	
D1 Land slide risk	Not likely	Modest level	Expected	Most likely,	
D2 Elevation			1,800feet \leq X \leq 2,500feet	Over 2,500 feet	X denotes elevation (ASL)
D3 Slope (degree)	X<20	20 \leq X $<$ 30	30 \leq X $<$ 45	Over 45	X denotes slope degree
D4 Soil condition	Others	Alluvial soil	-	-	

Source: The JICA Team

3) Results: (Environmental Assessment Relevant Database of the Greater Kandy Area)

Output maps are listed in the following tables (Table 2.2.5).

Table 2.2.5 List of Maps for Environmental Zoning Analysis

Thematic Map

Title		Remarks, items
T-1	Designated land protection	Protected areas (A1), Forest (A2)
T-2-1	Land cover	Plantation (B1), Forest, scrub, marsh, home garden
T-2-2	Water body	Water body (B2: river/stream, pond/lake, existing/proposed service reservoir, water intake)
T-3	Landslide risk	Landslide risk (D1)
T-4	Elevation	Elevation (D2)
T-5	Land slope	Land slope (D3)
T-6	Soil Condition	Soil condition (D4)

Scoring Map

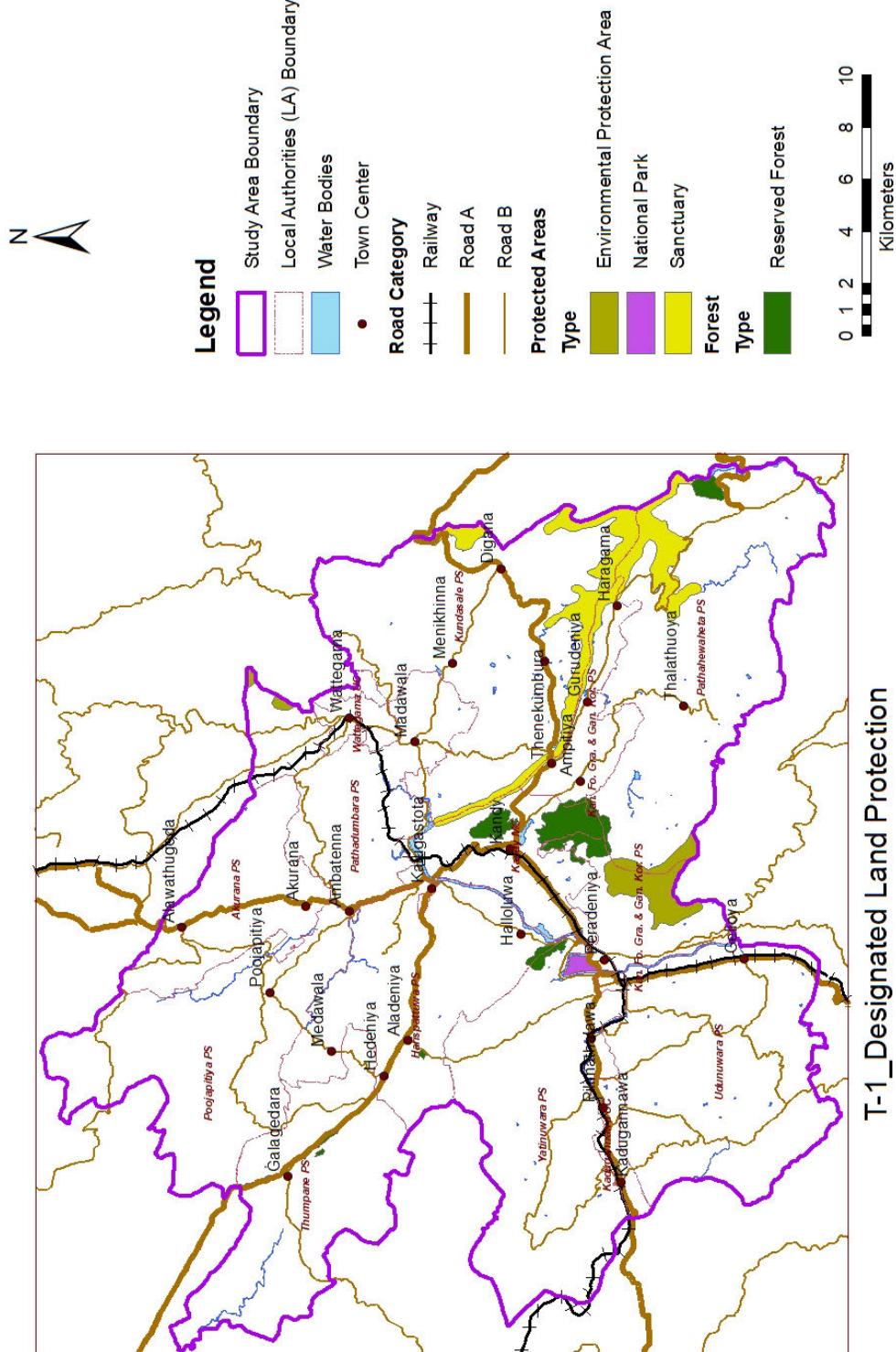
Title		Items	Remark (white / orange / red)		
E-1-1	Protected area	Protected areas (A1)	Low sensitivity	Moderate sensitivity	High sensitivity
E-1-2	Designated forest	Forest (A2)	Low sensitivity	Moderate sensitivity	High sensitivity
E-2-1	Land use	Plantation (B1)	Low sensitivity	Moderate sensitivity	High sensitivity
E-2-2	Water body	Water body (B2)	Low sensitivity	Moderate sensitivity	High sensitivity
E-3-1	Landslide risk	Landslide risk (D1)	Low risk	Moderate risk	High risk
E-3-2	Elevation (feet)	Elevation (D2)		$1,800 \leq X < 2,500$	$2,500$ or more
E-3-3	Land slope (degree)	Land slope (D3)	$20 \leq X < 30$	$30 \leq X < 45$	45 or more
E-3-4	Soil Condition	Soil condition (D4)	Alluvial soils		

Overlay Map (Environmental Assessment Relevant Database of Greater Kandy Area)

Maps	Calculate total score	Level
A. Designated land protection	Score = A1 + A2	0 - 10
B. Land use	Score = B1 + B2 x 2	0 - 15
C. Disaster	Score = D1 + D2 + D3 + D4/2	0 – 13 / 18
T: Consolidated Constraint	Total Score = A x 2 + B + D	0 – 53

Source: The JICA Team

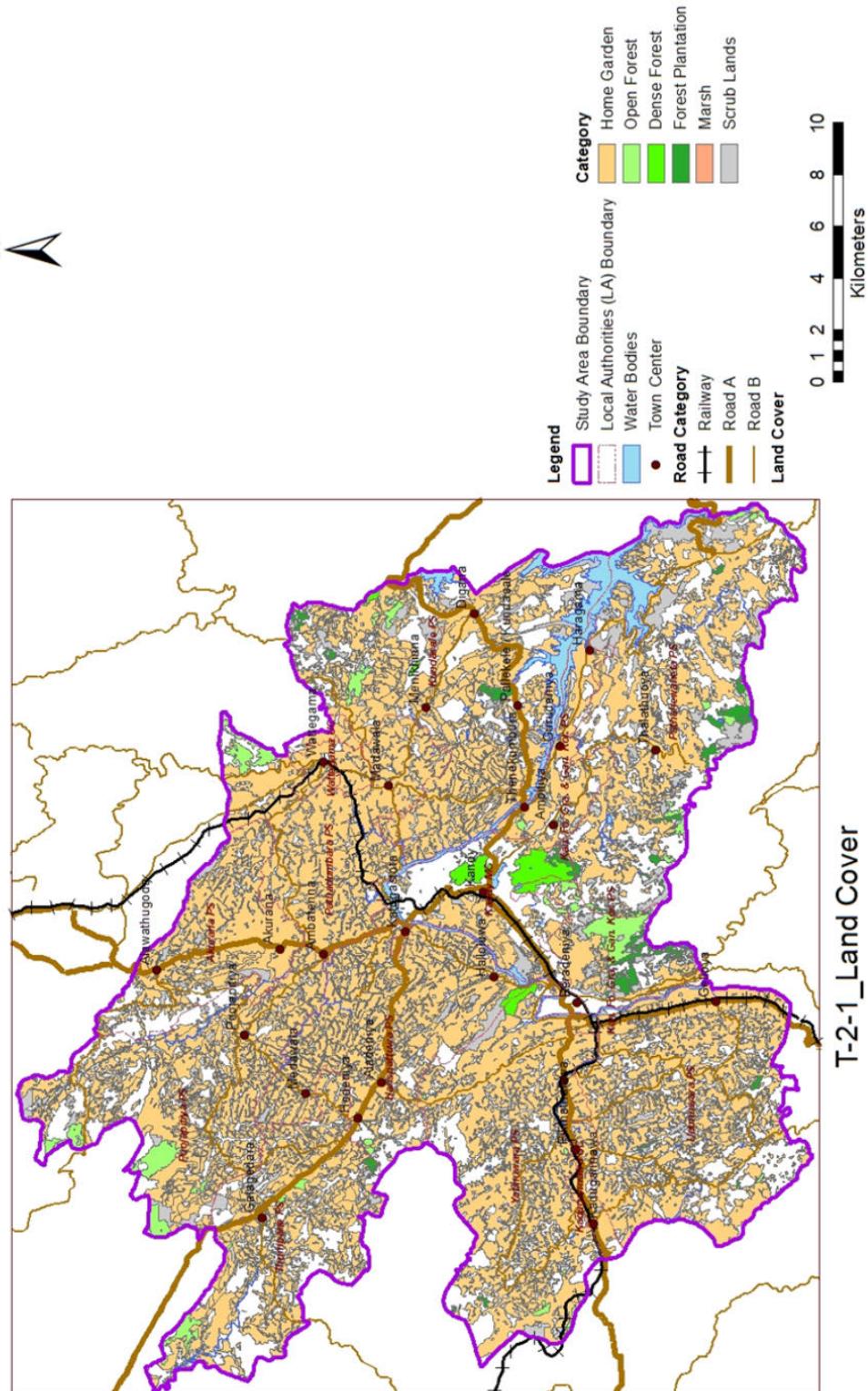
Map of Greater Kandy



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Map of Greater Kandy

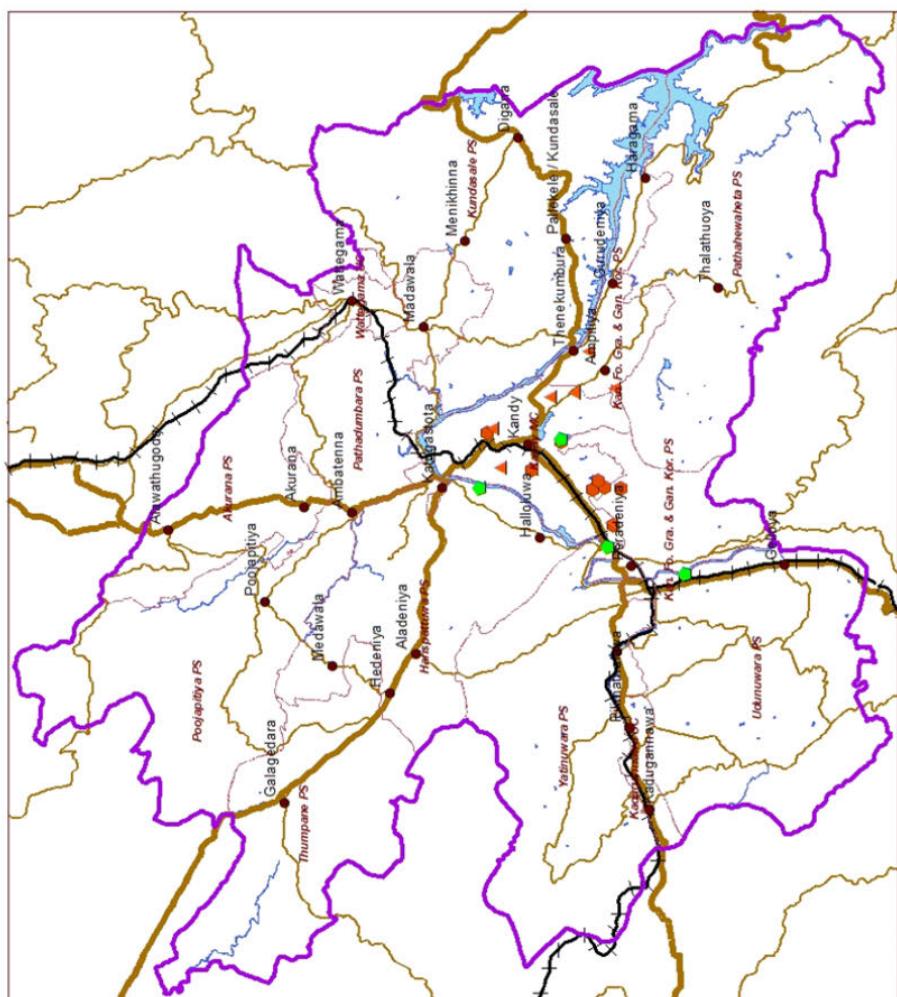
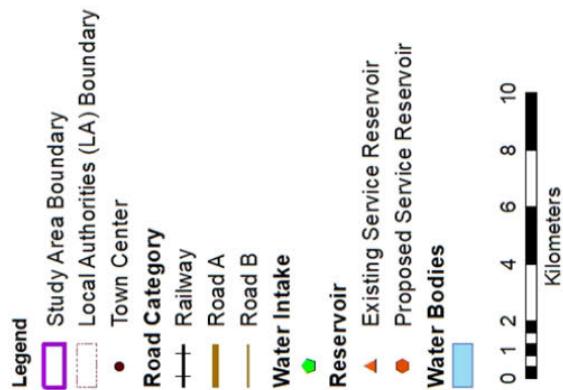
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T-2-1_Land Cover

Map of Greater Kandy

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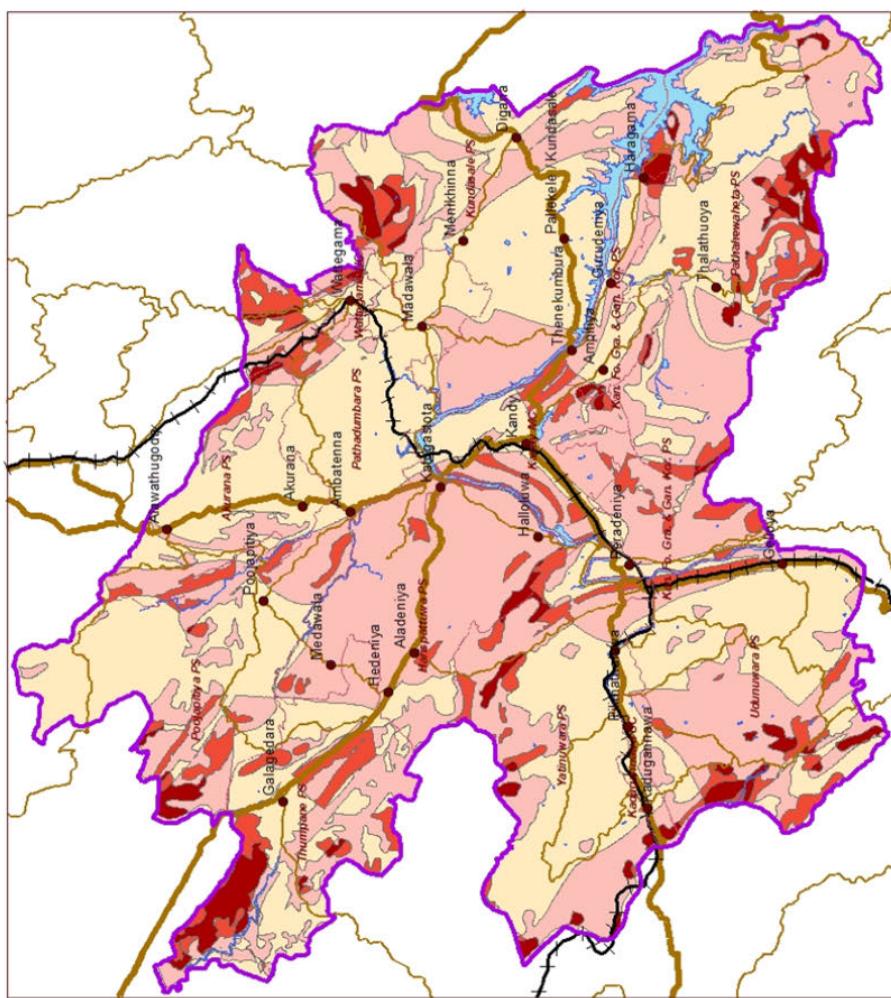
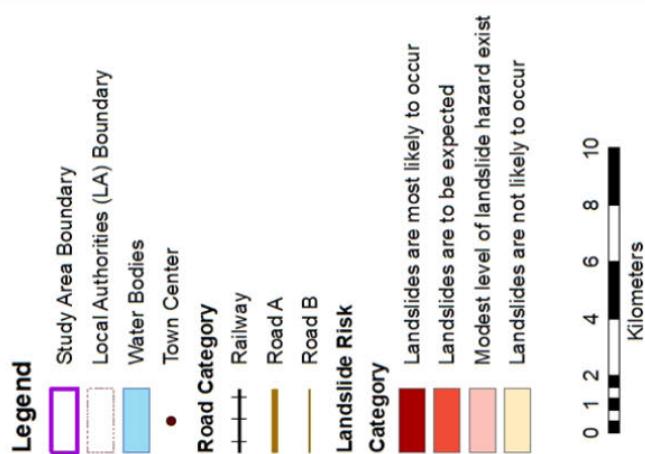


T-2-2_Water Body

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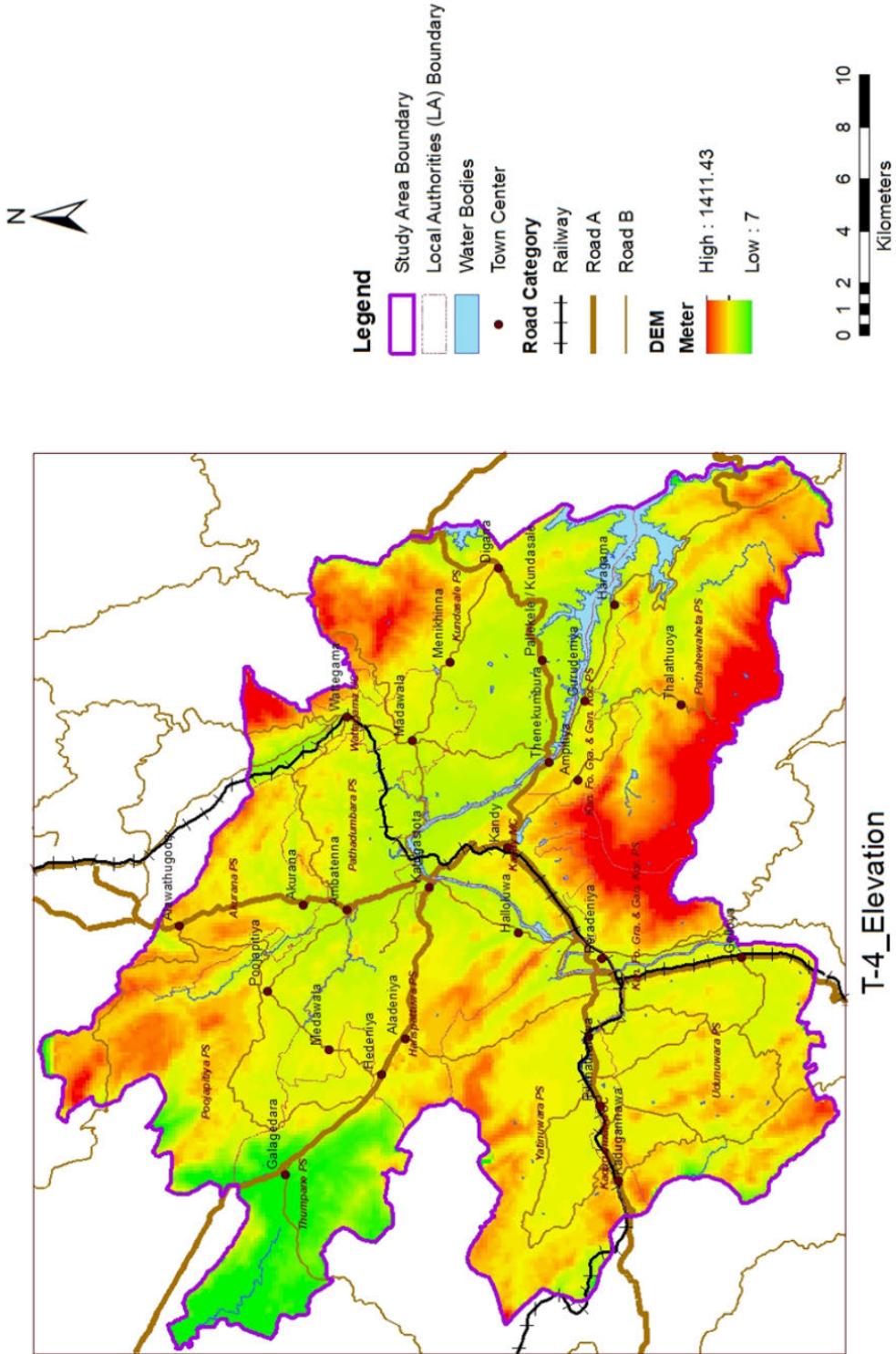
Map of Greater Kandy

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T-3_Landslide Risk

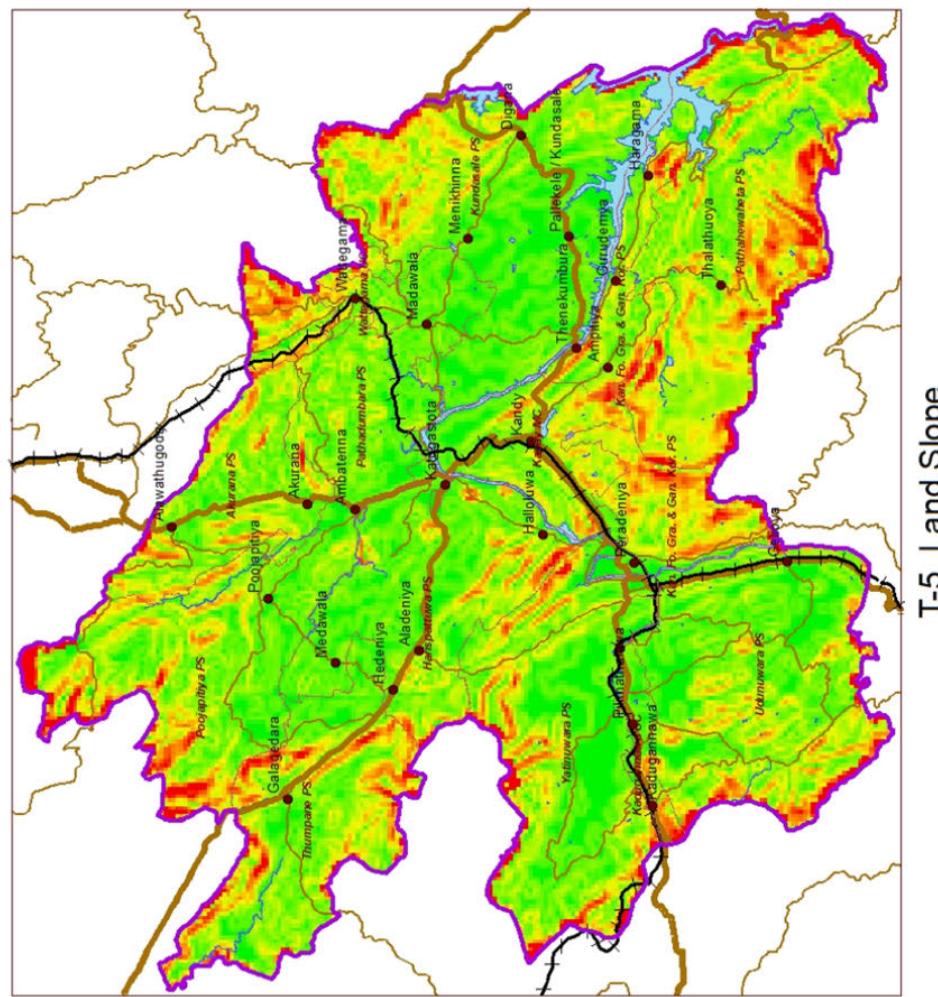
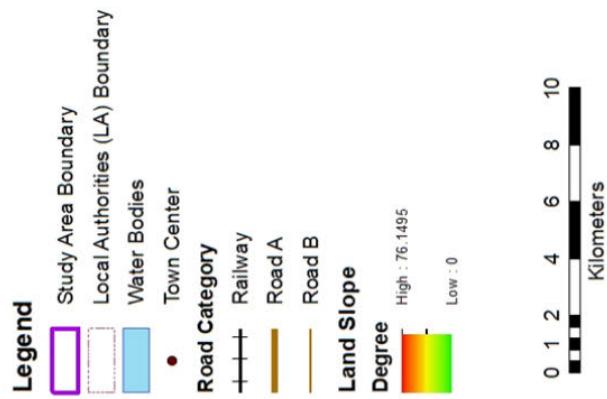
Map of Greater Kandy



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Map of Greater Kandy

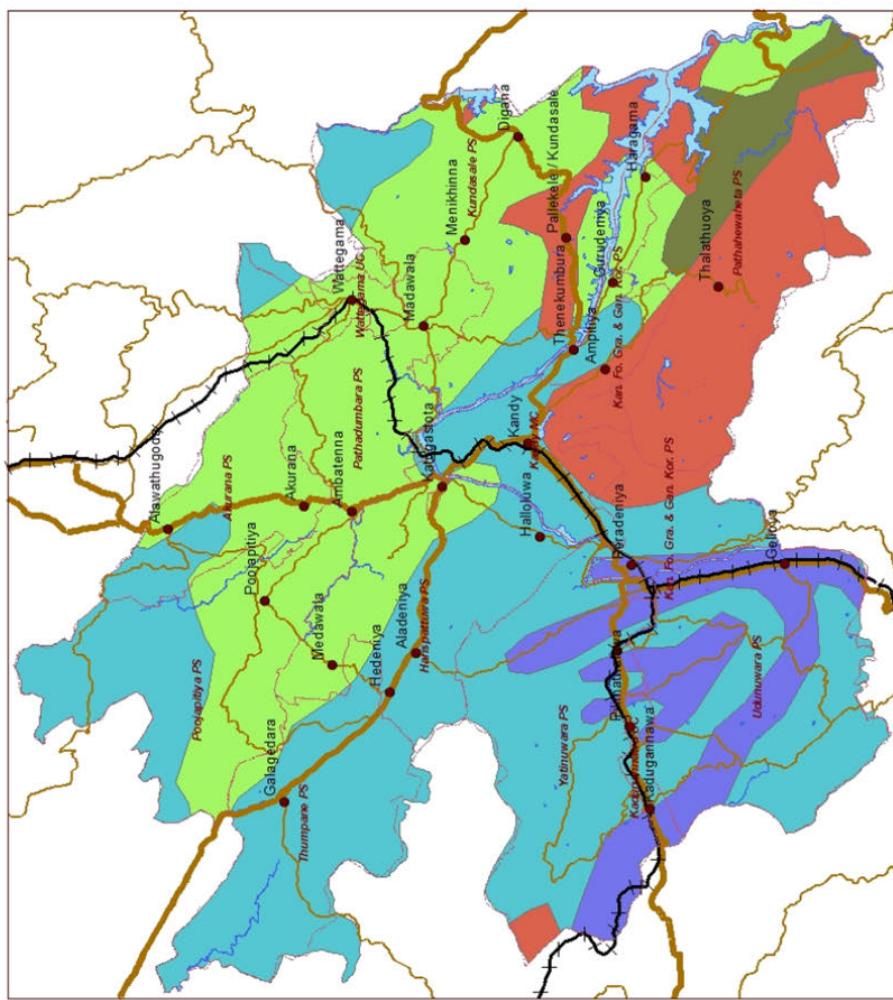
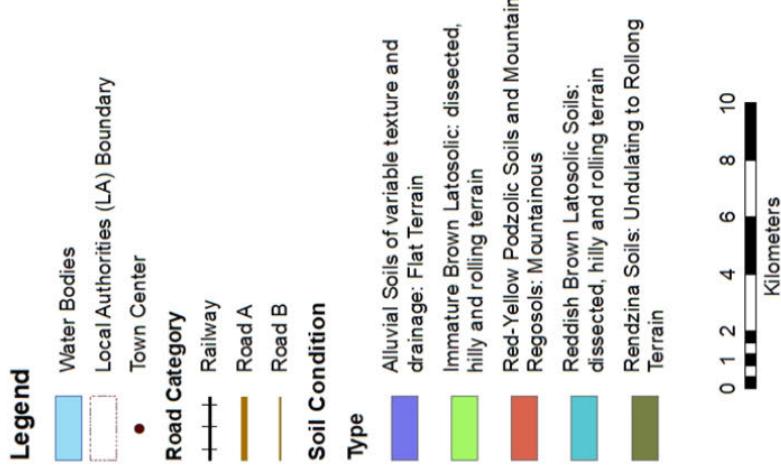
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T-5_Land Slope

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Map of Greater Kandy

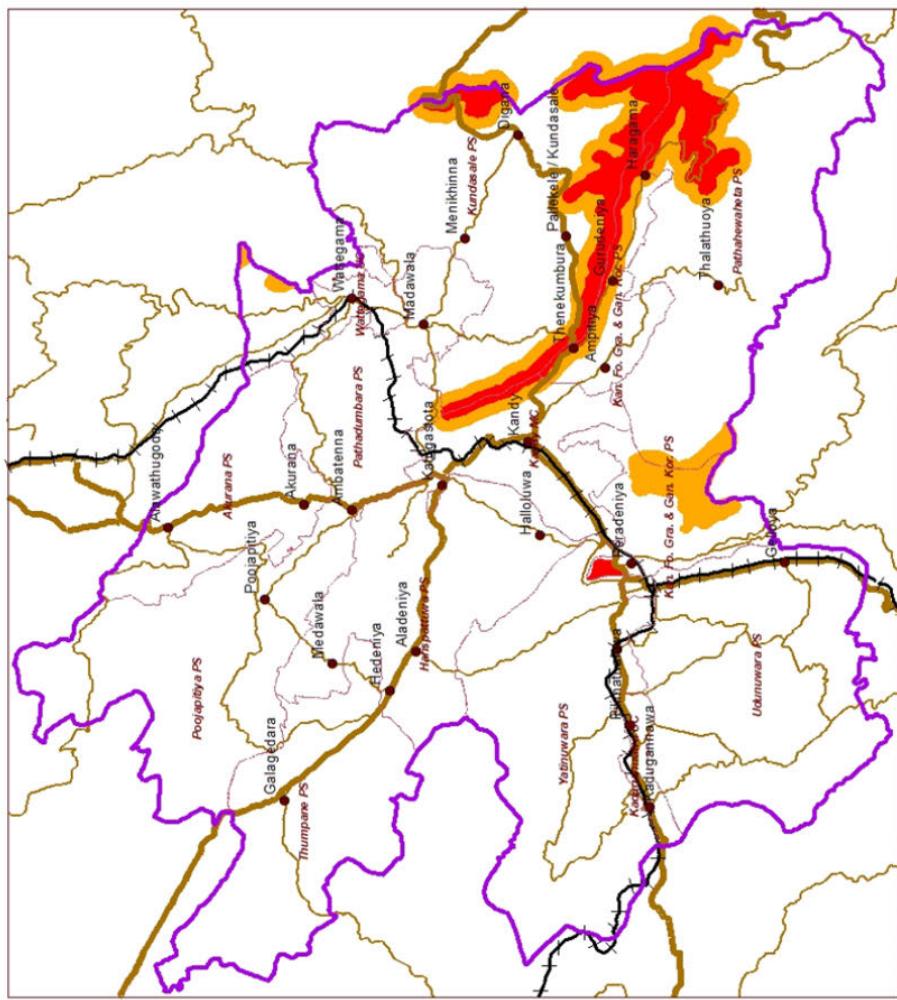
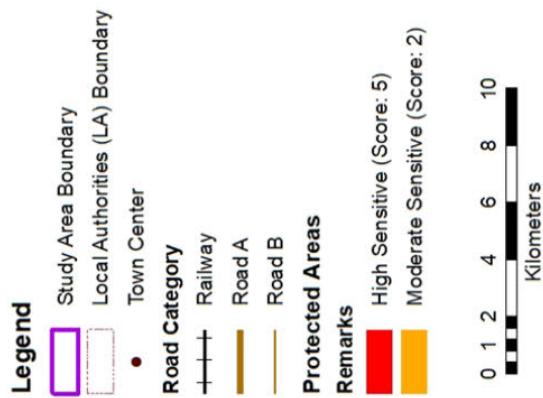


T-6_Soil Condition

The Project for Formulation of Greater Kandy Urban Plan

Map of Greater Kandy

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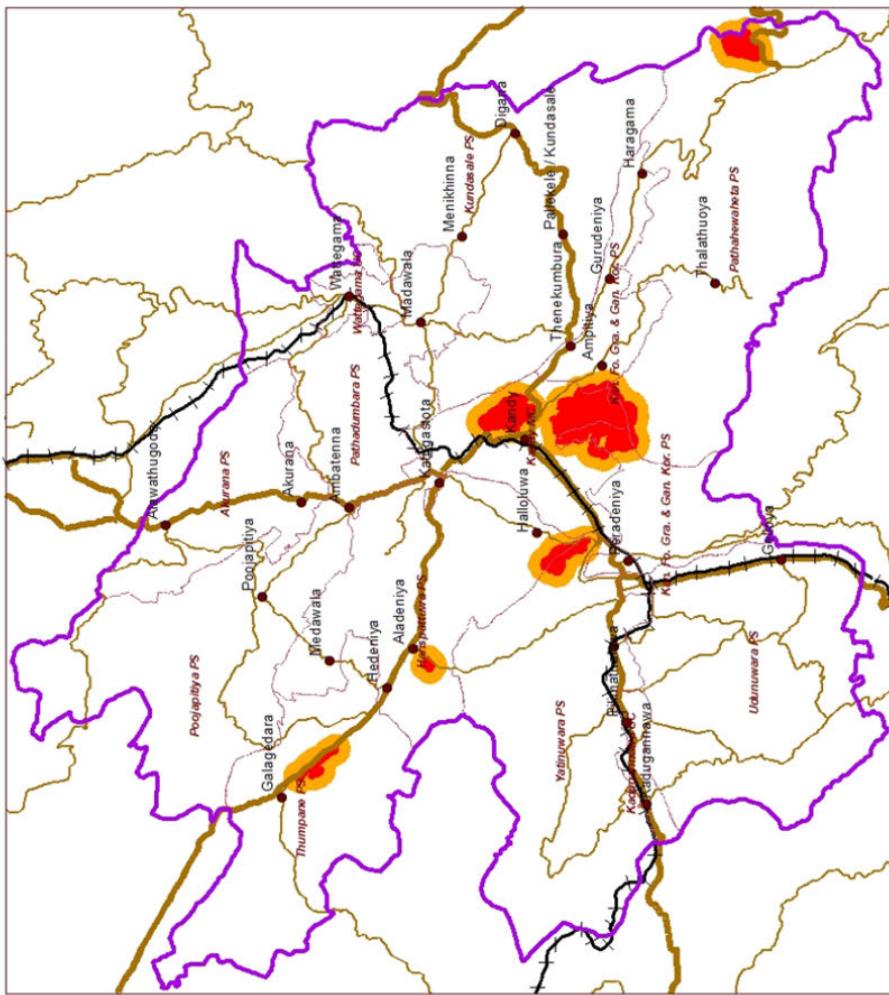
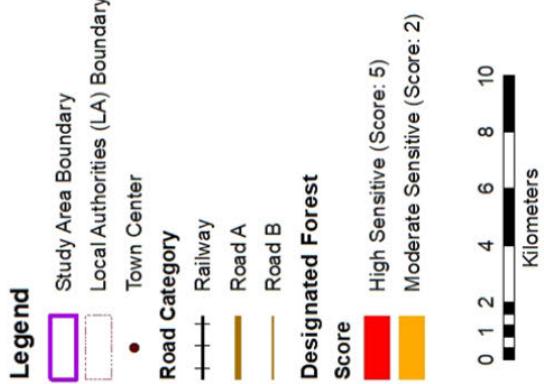


Scoring Map
(E-1-1_Protected Areas)

The Project for Formulation of Greater Kandy Urban Plan

Map of Greater Kandy

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Scoring Map
(E-1-2_Designated Forest)

Map of Greater Kandy



Legend

Study Area Boundary
Local Authorities (LA) Boundary

Town Center

Road Category

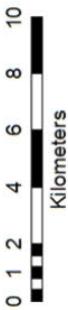
Railway
Road A

Road B

Land Use

Remarks

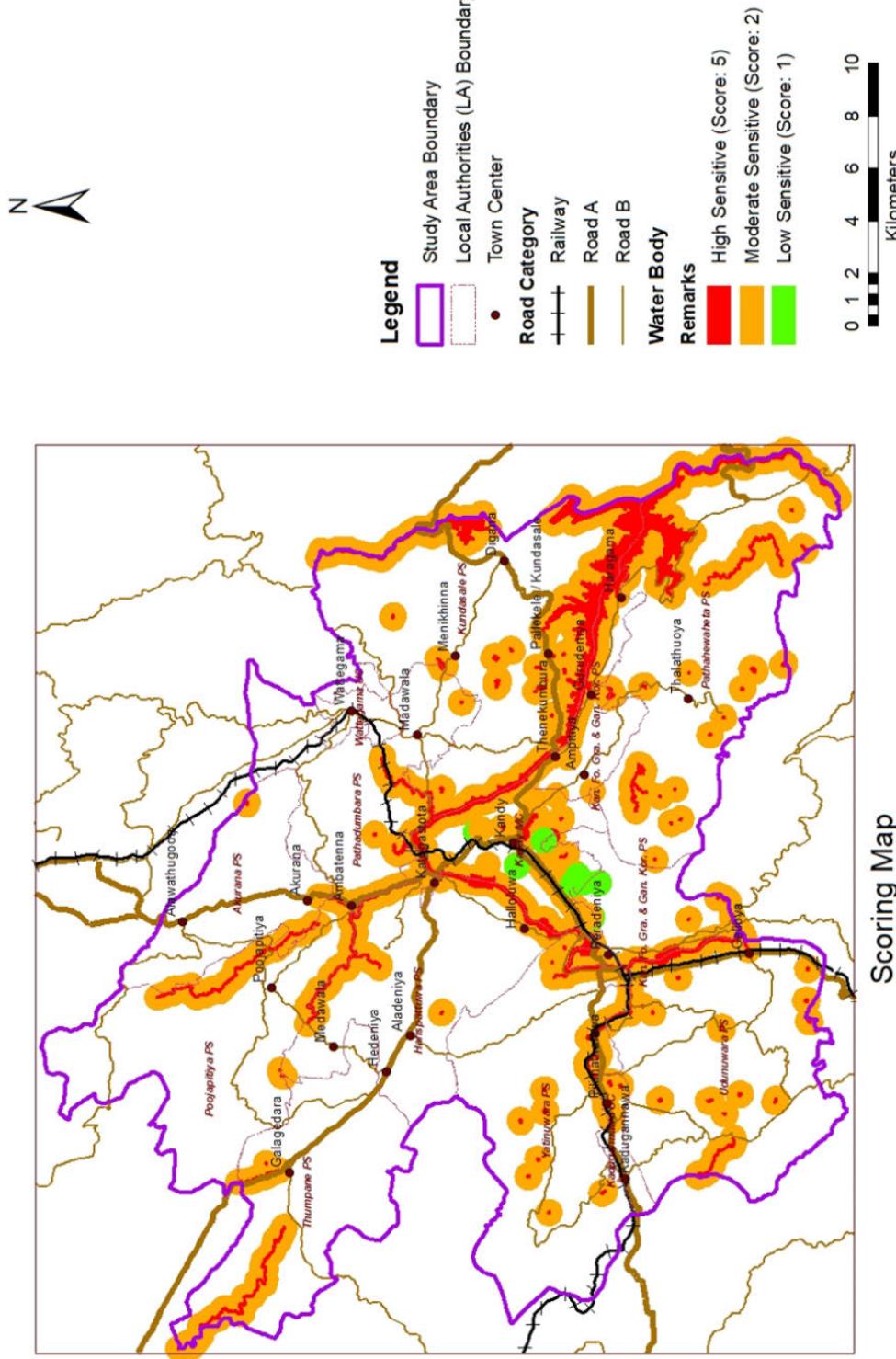
High Sensitive (Score: 5)
Moderate Sensitive (Score: 2)
Low Sensitive (Score: 1)



Scoring Map (E-2-1_Land Use)

The Project for Formulation of Greater Kandy Urban Plan

Map of Greater Kandy

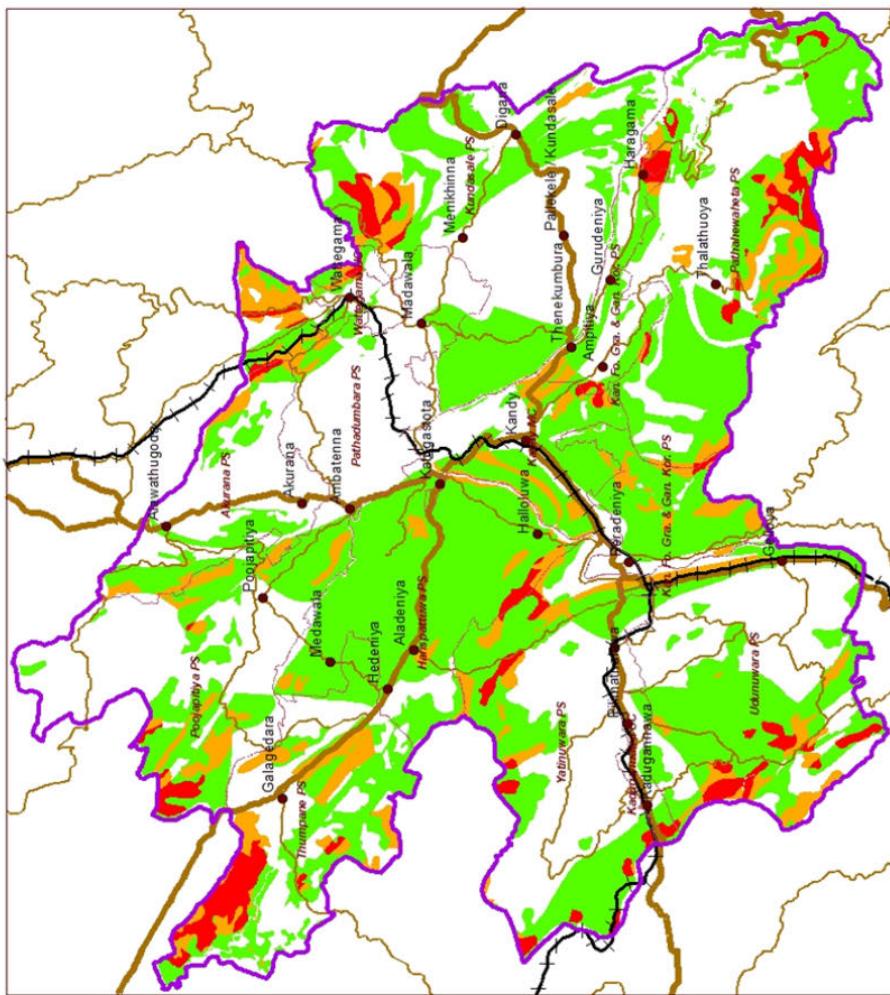
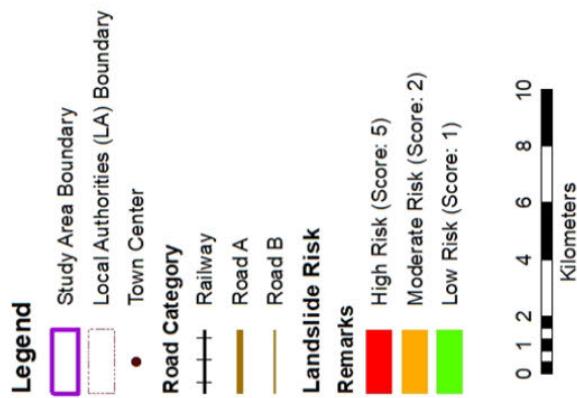


Scoring Map (E-2-2_Water Body)

The Project for Formulation of Greater Kandy Urban Plan

Map of Greater Kandy

N

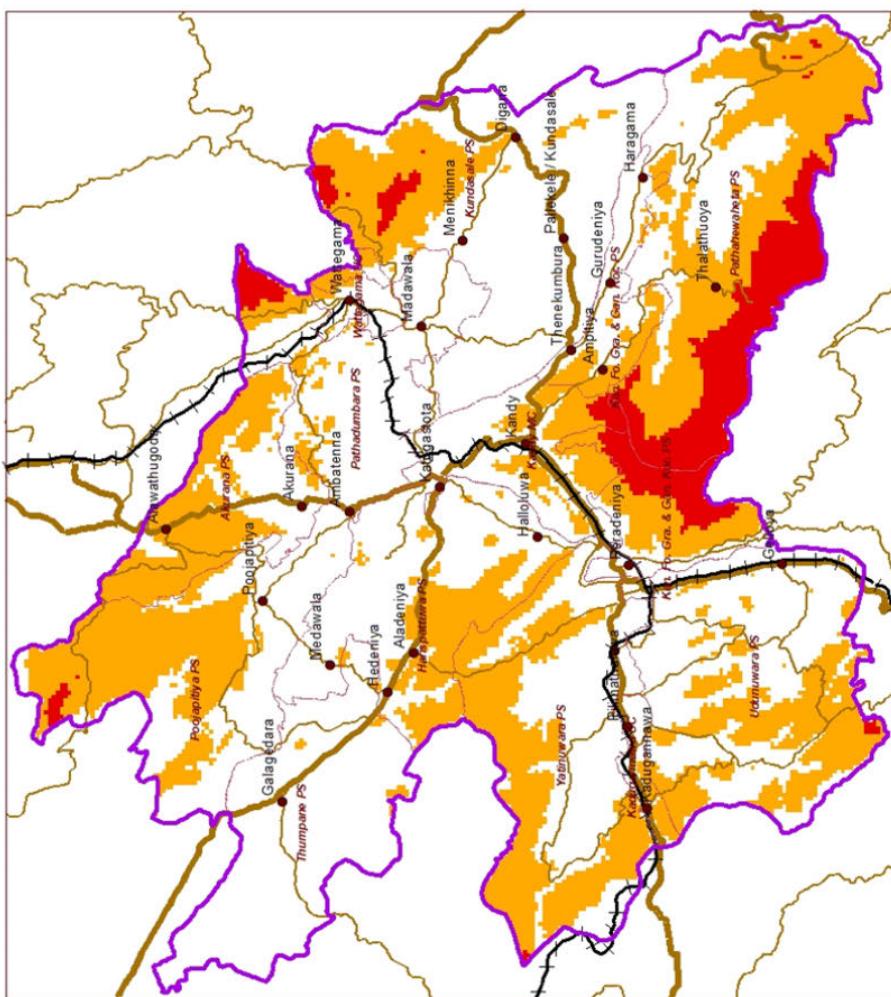
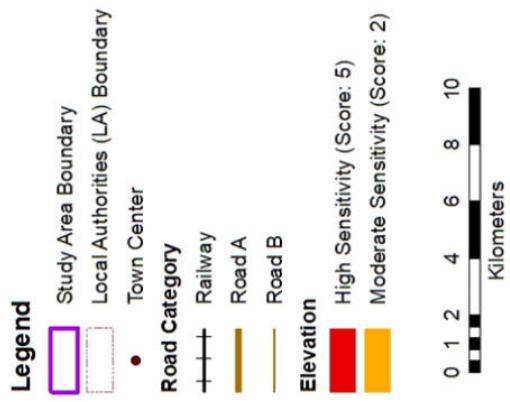


Scoring Map
(E-3-1_Landslide Risk)

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Map of Greater Kandy

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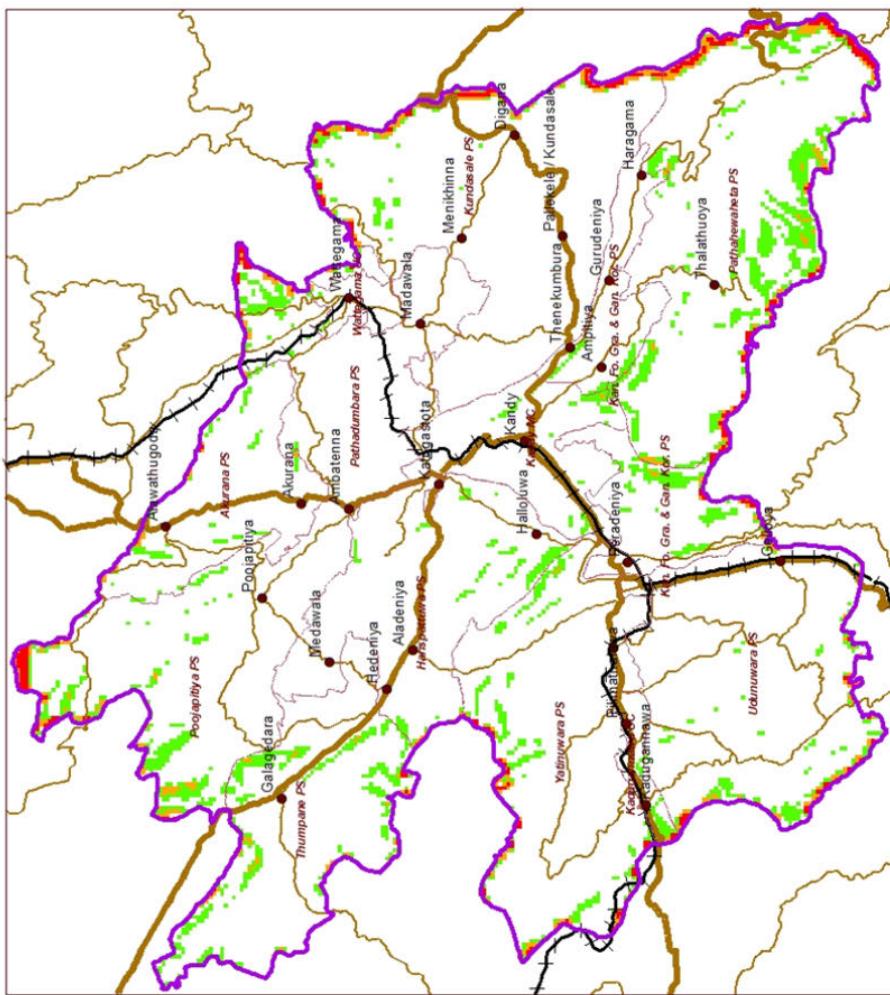
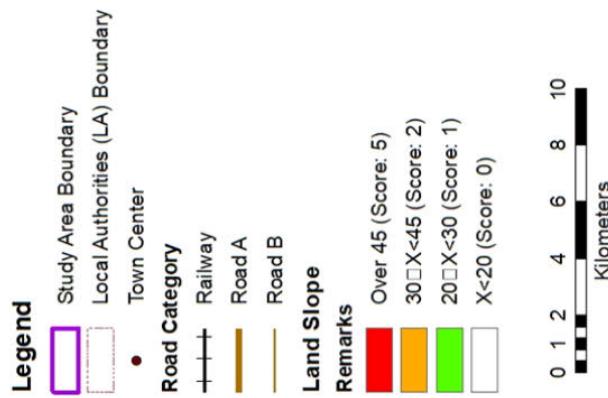


Scoring Map
(E-3-2_Elevation)

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Map of Greater Kandy

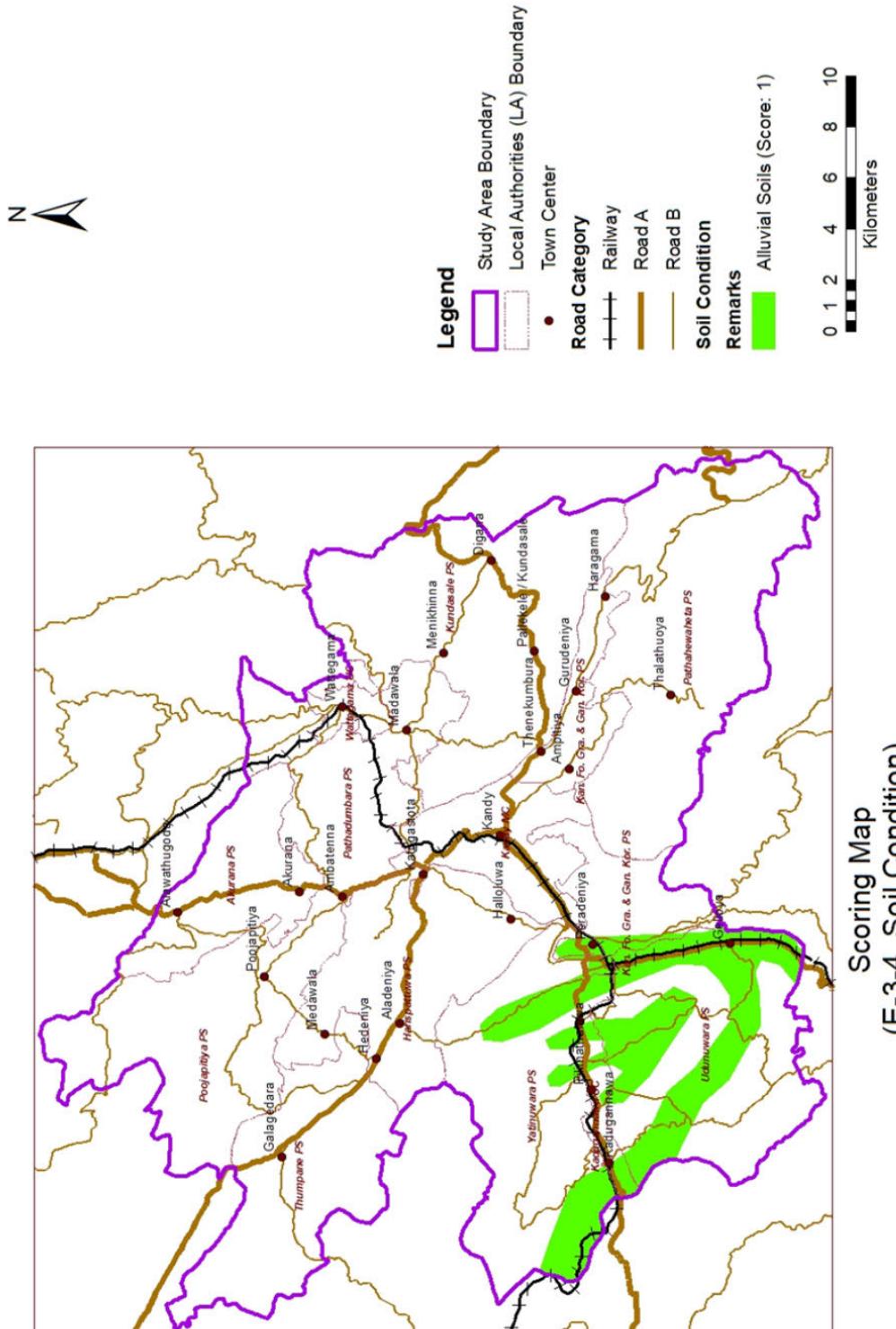
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Scoring Map
(E-3-3_Land Slope)

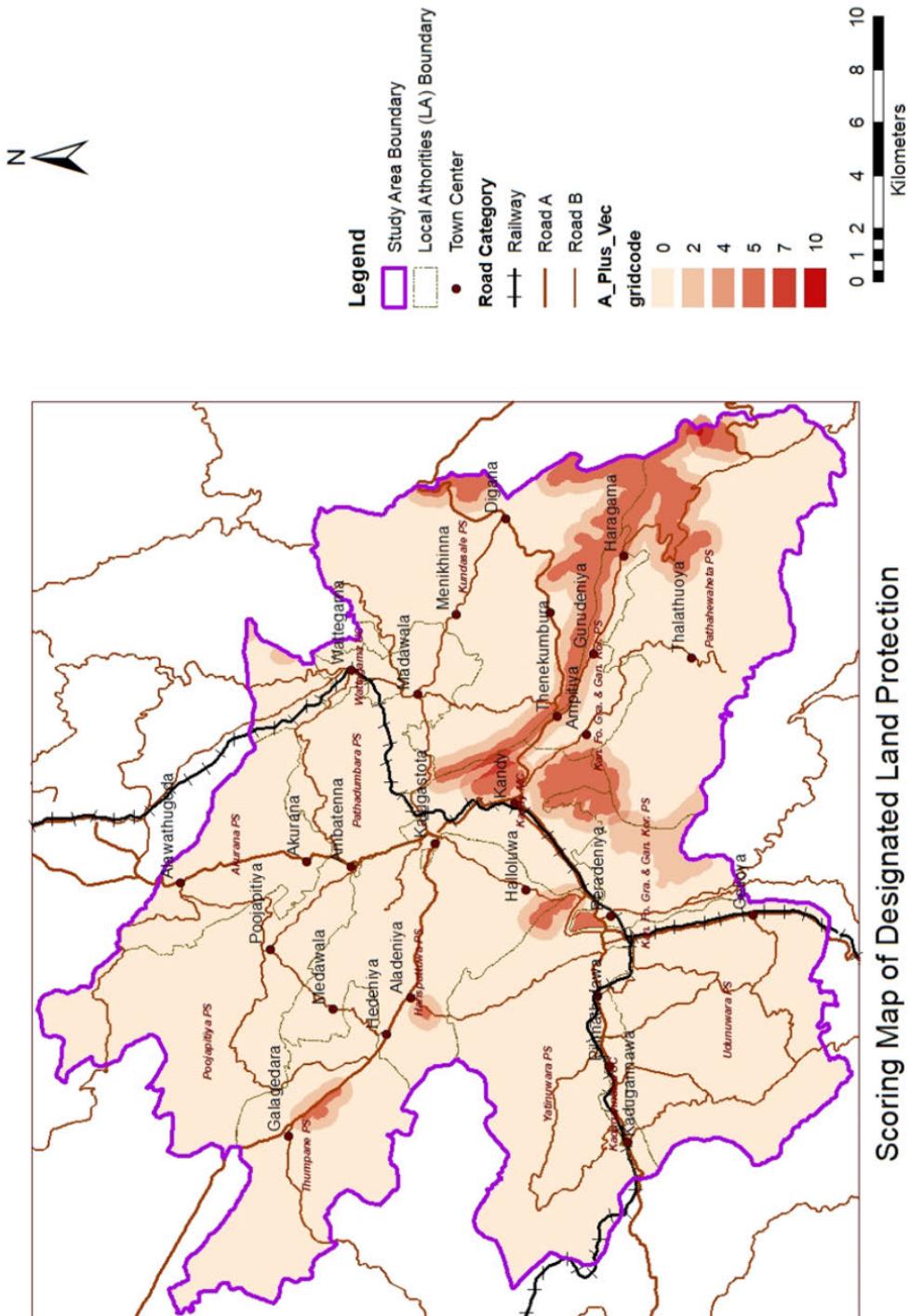
The Project for Formulation of Greater Kandy Urban Plan

Map of Greater Kandy



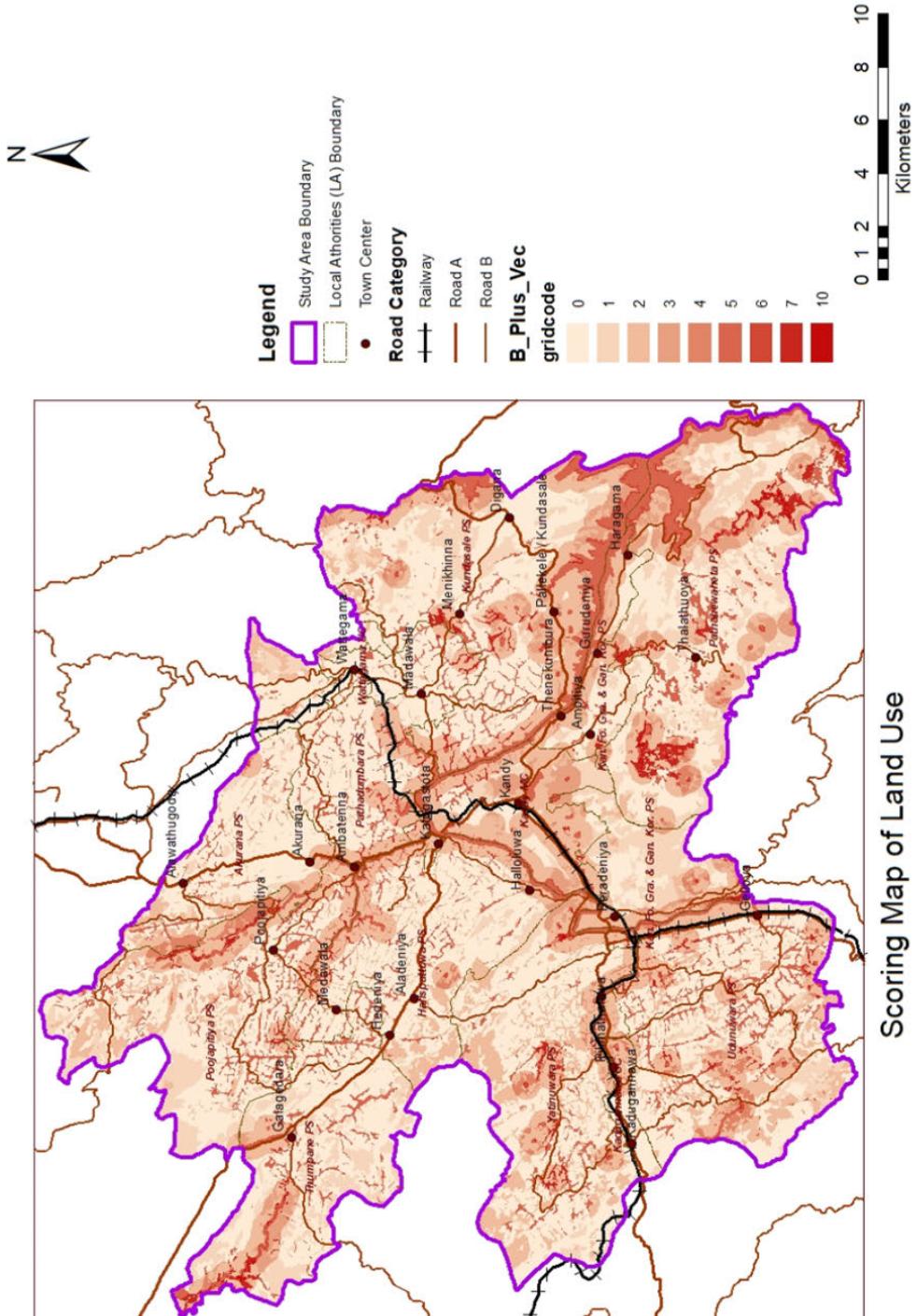
The Project for Formulation of Greater Kandy Urban Plan

Map of Greater Kandy



The Project for Formulation of Greater Kandy Urban Plan

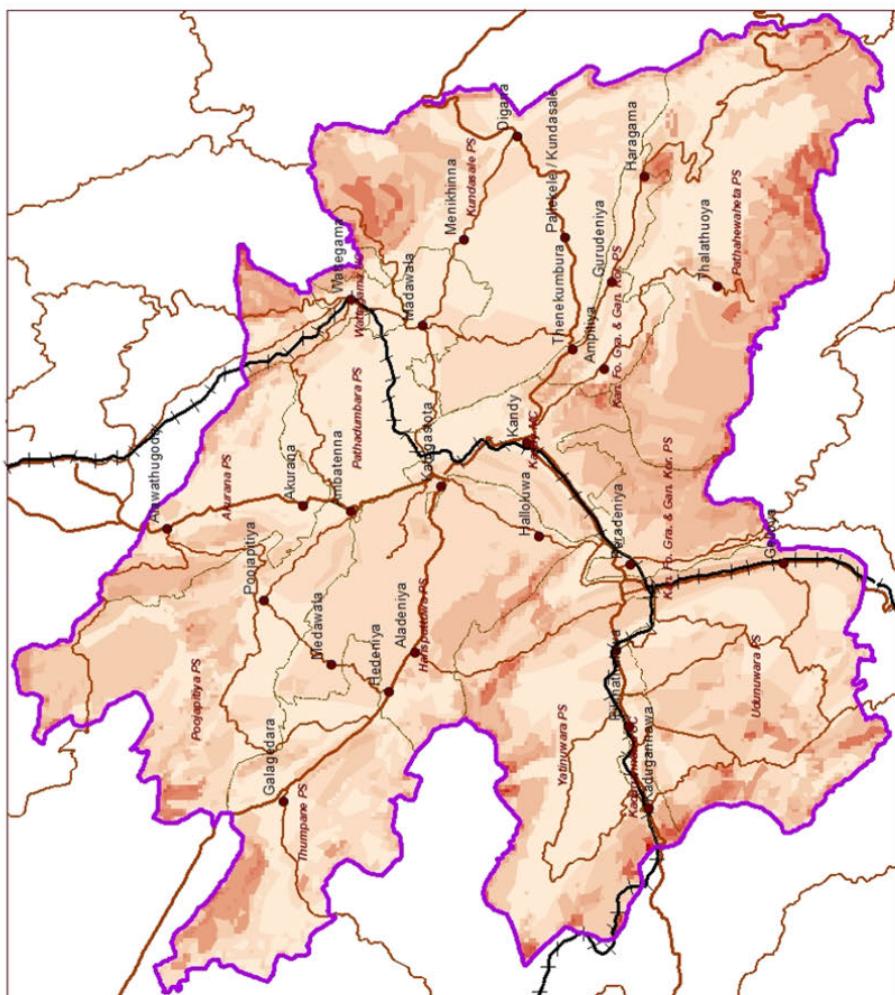
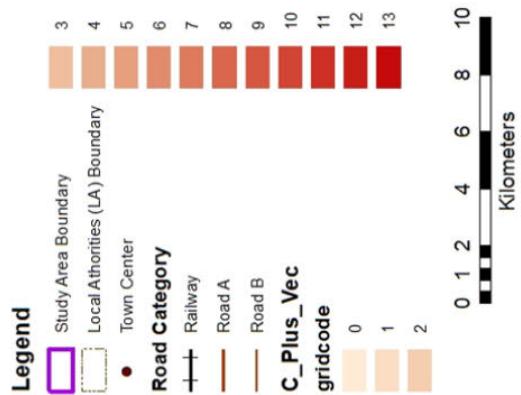
Map of Greater Kandy



The Project for Formulation of Greater Kandy Urban Plan

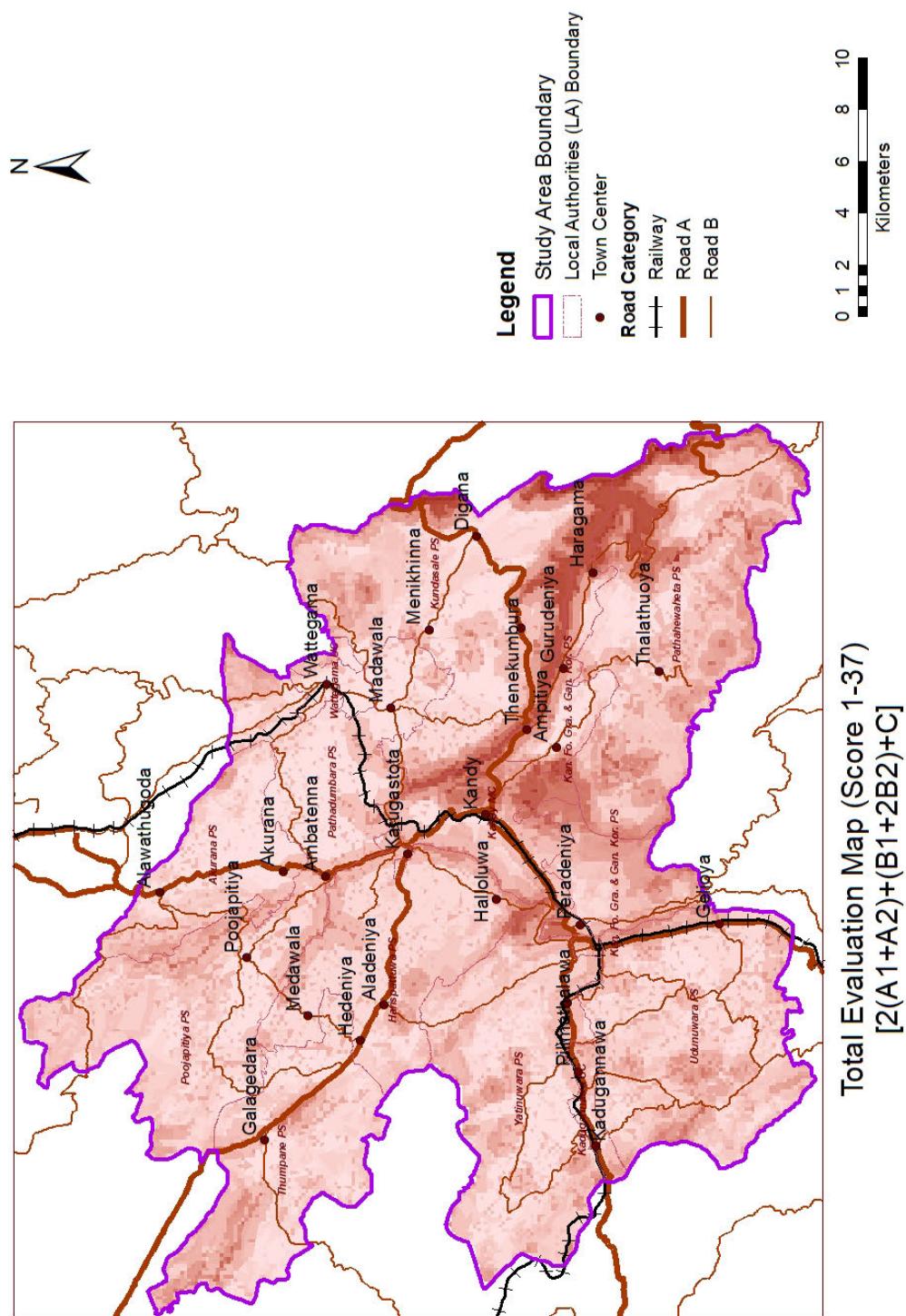
Map of Greater Kandy

N 



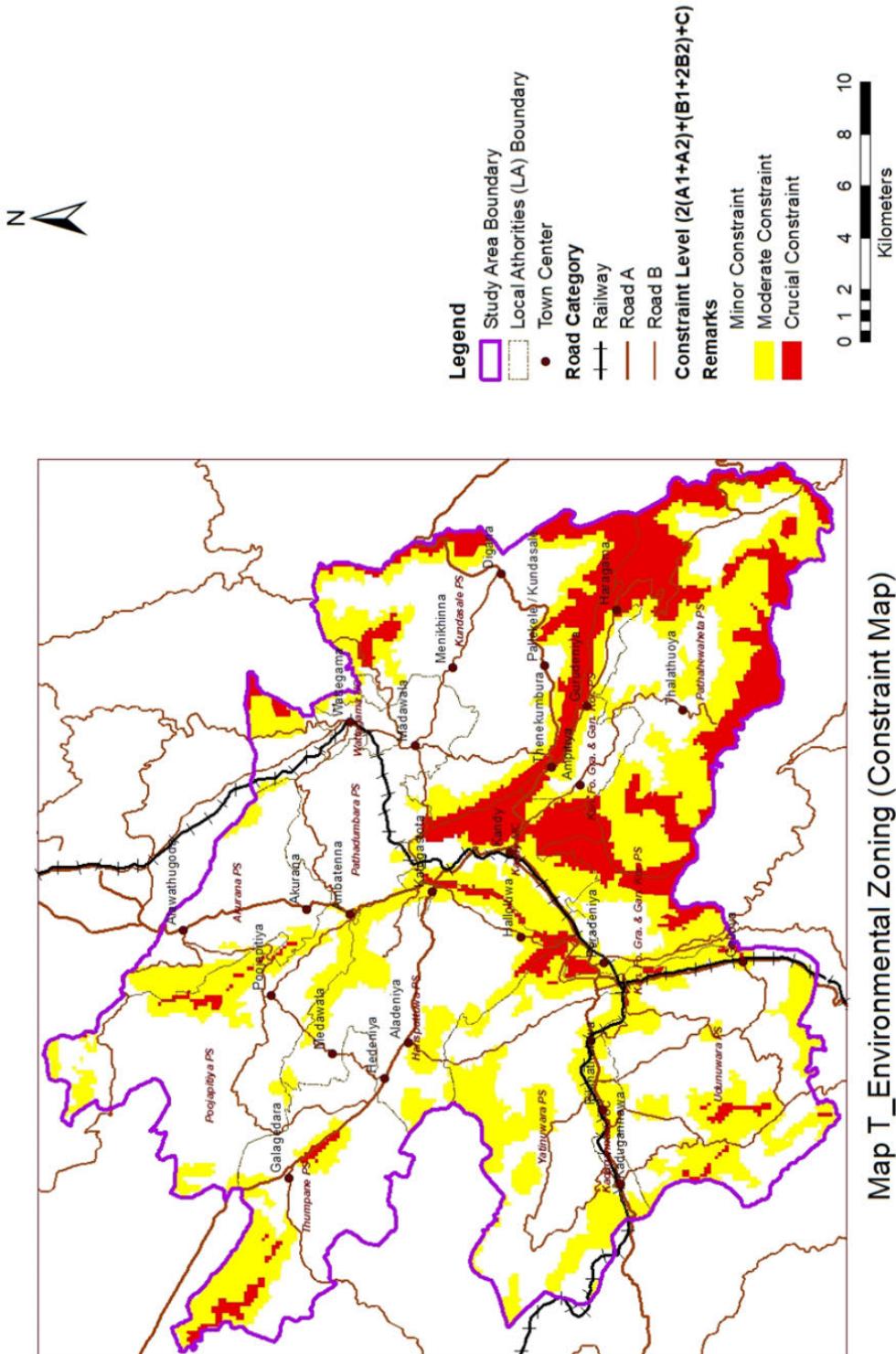
Scoring Map of Disaster Risk
(Map C_Plus)

Map of Greater Kandy



The Project for Formulation of Greater Kandy Urban Plan

Map of Greater Kandy



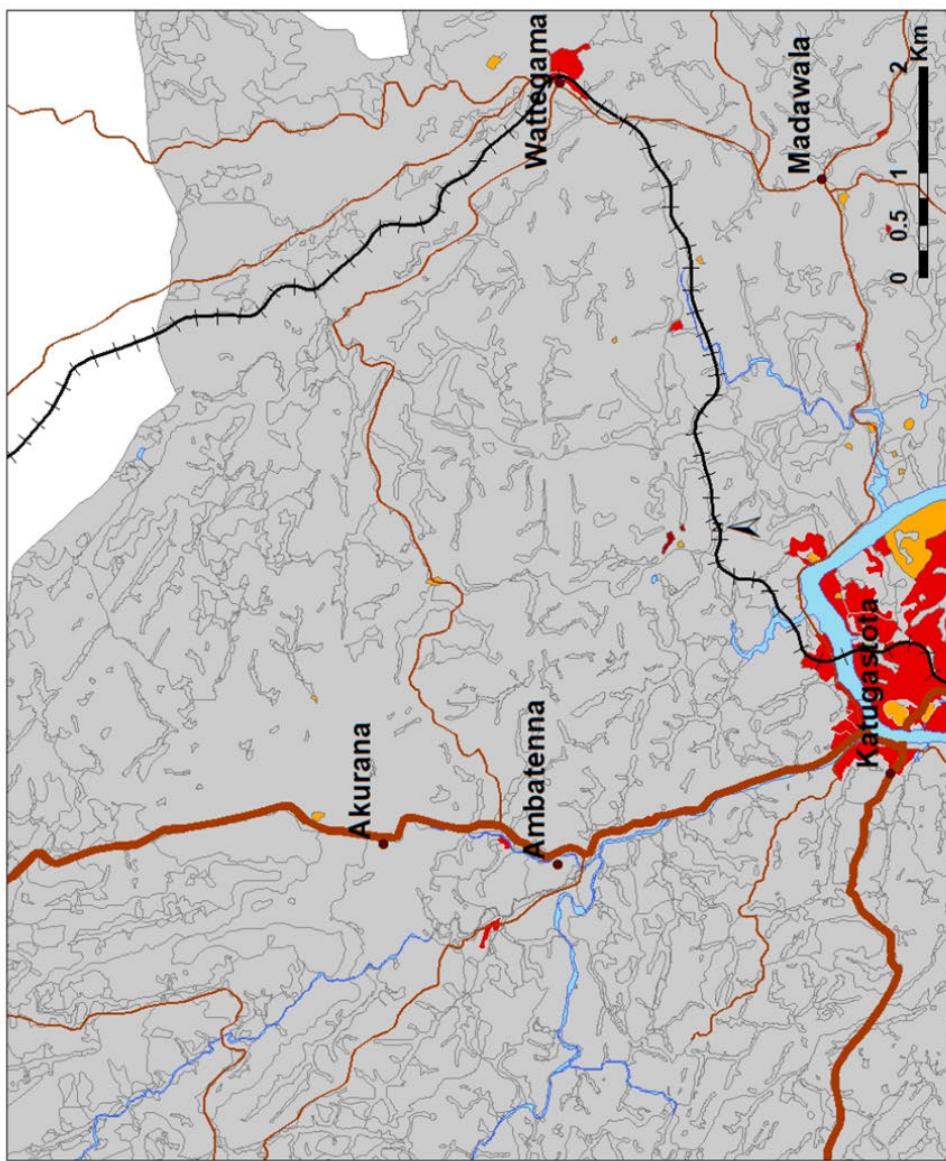
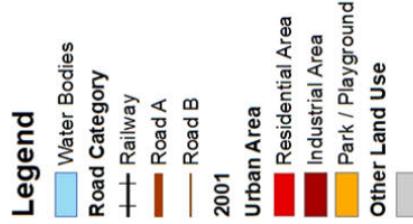
Map T_Environmental Zoning (Constraint Map)

$$2(A_1+A_2)+(B_1+2B_2)+C$$

The Project for Formulation of Greater Kandy Urban Plan

Map of Cluster City

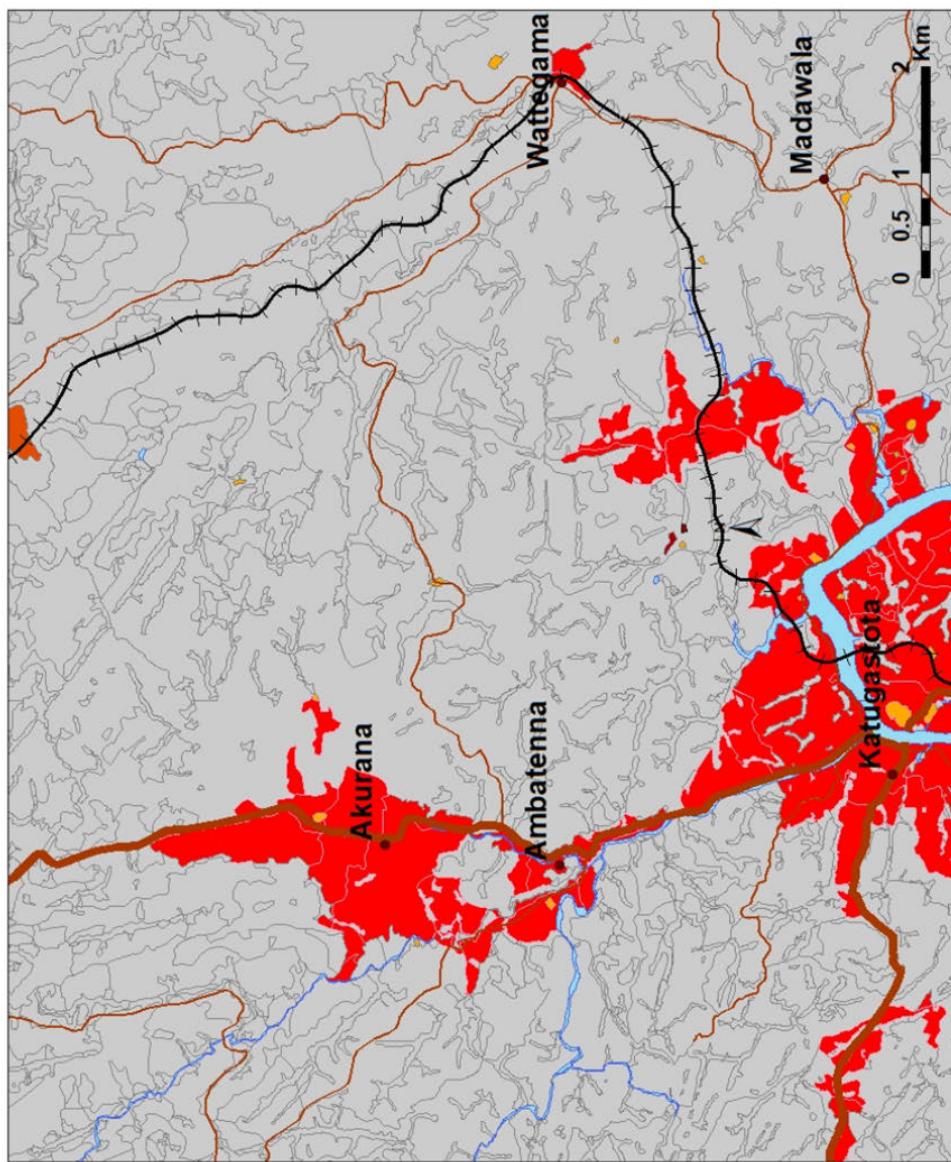
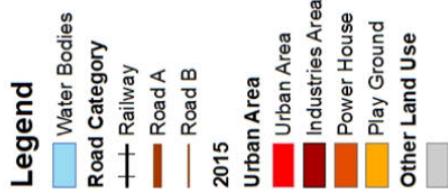
N



Katugastota-Akurana Urban Area Land Use in 2001

Map of Cluster City

N



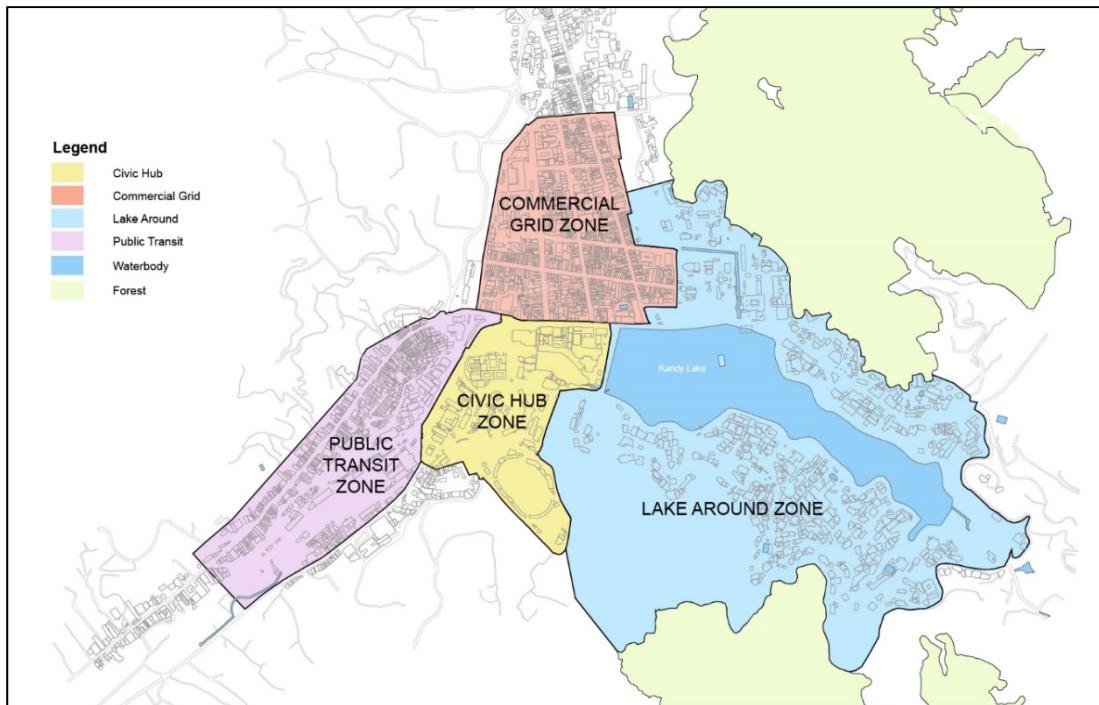
Katugastota-Akurana Urban Area Land Use in 2015

CHAPTER 3 SPATIAL DATA AND THEMATIC MAPS IN THE HERITAGE AREA, KANDY

3.1 Data Description

Database of heritage area, Kandy was established by collecting the primary and secondary data. Site survey was engaged to develop the GIS database and integrated with the database obtained from several authorities.

For site survey, UAV (Drone) photo-survey of Kandy city was conducted to develop a spatial (GIS bases) database for the heritage area, Kandy. The coverage of survey area is shown in Figure 3.1.1. Total area is approximately 2 sq.km.



Source: The JICA Team

Figure 3.1.1 Coverage Area for Taking Aerial Photos in Heritage Area of Kandy

High-resolution aerial photos in the heritage area were taken using by drone, which shall be overlapped with 60 to 70% with high accuracy level. Orthophotos with a scale of 1:2,000 were created, which shall be overlapped with 60 to 70% with a scale of 1:2,000. GIS formatted base maps were created with a scale of 1:2,000 based on the above orthophotos. Attribute data are included buildings, roads, water bodies, parks and open spaces, transport facilities, green coverage areas, and spot elevation data.

The overall development process of the GIS database is categorized in to 3 main components,

1. UAV (Drone) Photography and image processing

2. Development of the database structure and populating the database
3. Integrate information gathered from other surveys with the GIS database

3.1.1 Definition of Geodetic Reference System

28 Ground Control Points were established / identified covering the whole project area and their coordinates were gathered using a Differential GNSS survey. The GNSS receivers were dual frequency receivers with post-processing capabilities. The average horizontal accuracy was 5cm and vertical accuracy was 10cm. The coordinate system used was SLD99 Sri Lanka Grid 1999 (EPSG: 5235).

3.2 Category of Spatial Data Accumulated in Spatial Database

3.2.1 Fundamental Spatial Data and Thematic Maps

Development of the GIS database was mainly done by manual digitizing based on UAV Orthomosaic. Digitized layers are Buildings, Open spaces, Roads (centerline and outer lines as separate files) and Water bodies. Based on the DSM and the Road centerline, the street elevation was acquired along the road in 10m intervals. Besides, the database regarding the Household sample survey was done by conducting the interview survey to the houses facing main street. The result was integrated in the GIS database as well. The thematic maps were developed by combining the datasets collected by the method above.

a) Structure of GIS Database for Heritage Area, Kandy (Site Survey: Drone Survey and building survey)

The GIS Database is generated in the form of ESRI File Geodatabase. The structure of the Database is depicted as Table below:

Table 3.2.1 Structure of the GIS Database (Site Survey)

Feature Class & Description	Attribute	Description of the Attribute	Applicable Values
<i>Building Feature Dataset</i>			
Building (3977 features) Footprint of Buildings within the Project Area. These are identified by the UAV Orthomosaic and manually digitized.	BuildingID	An unique ID composed with the BlockID, facing street and a number	
	Street_Name	Name of the street, if the building is facing a main street	
	Building_Name	Name of the Building	
	Year	Year of development	
	No_of_Stories	Number of floors	Number of floors -1 : if unknown
	No_of_facades_Ground_Floor	Number of facades in the ground floor	
	Roof_Type	Type of the roof	Flat Sloped Not Visible Other
	Roof_Material	The materials used for the roof	Asbestos Metal roof tile Slab Metal sheet Tiles (Clay or Concrete)

Feature Class & Description	Attribute	Description of the Attribute	Applicable Values
<i>Building Feature Dataset</i>			
			Other Unknown (not visible)
	Cat_Primary	Primary usage category	Private Public Other
	Cat_Secondary	Secondary usage category	Administration Bank/Financial Commercial Religious Under Construction Information Center Education Hospital Health Hotel Restaurant/Cafe Professional Office Residential Socio-Cultural Defence & Security Recreational/Entertainment Mixed – Commercial & Residential Mixed – Commercial & Restaurant Mixed - Other Under Construction
	Cat_Ternary	Ternary usage category	Buddhist Catholic/Christian Hindu Islamic Primary Education Secondary Education Higher Education Vocational Education Sri Lanka Police Sri Lanka Army
	Surveyed	Whether the building was included in field Building Survey	Yes No
Façade_Info <i>(2386 features)</i> The table is generated based on the information collected by field survey under the project “Building Survey”	BuildingID	Corresponding Building from Building Dataset	
	FacadeID	An unique ID for each façade derived by BuildingID and a number	
	Assessment No	Number in the address	
	Floor	Floor number the façade is in	
	Width(m)	Width of the façade in meters	
	Height(m)	Height of the façade in meters	
	Current_Use	Purpose of usage	Bank/Finance Commercial Education Health

Feature Class & Description	Attribute	Description of the Attribute	Applicable Values
<i>Building Feature Dataset</i>			
			Hotel Restaurant/Cafe Information Center Office (Public/Private) Professional Office Public Public Service Religious Residential Socio-Cultural Under Construction Vacant Other Unknown
	Façade_Sign_Board	Characters in the sign board (In English Letters)	
	Plaque	Whether there is a plaque on the front wall	Yes No
Household Survey <i>(2000 features)</i> Information gathered by separate interview field survey			

b) Fundamental Spatial Data with Thematic Map

Thematic map developed by the site survey data and collected secondary data from related authorities as Table 3.2.2:

Table 3.2.2 Fundamental Spatial Data and Thematic Maps for Heritage Area, Kandy

Heritage Area			
Category of Inventory Data		Type of Data	Source
Natural Setting	Contour Map	Line	Site Survey, 2017
	Slop map		Site Survey, 2017
	Open Space		Site Survey, 2017
Building Attribute	Roof Type	Polygon	Site Survey, 2017
	Roof Material	Polygon	Site Survey, 2017
	Height	Polygon	Site Survey, 2017
	Number of Stories	Polygon	Site Survey, 2017
	Number of Façade	Polygon	Site Survey, 2017
	Building Uses at Ground Floor		Site Survey, 2017
	Building Uses at First Floor		Site Survey, 2017
	Building Uses at Second Floor		Site Survey, 2017
	Heritage Building	Polygon	UDA, 2013
	Building with Heritage Plaque	Polygon	Site Survey, 2017
Facilities	Special Heritage Building	Polygon	DoA
	Public Facilities (Commercial Grid Zone)	Polygon	Site Survey, 2017
	Public Facilities (Public Transit and Civic Hub Zone)	Polygon	Site Survey, 2017
Streetscape	Public Facilities (Lake Around Zone)	Polygon	Site Survey, 2017
	6 Streets:		Site Survey, 2017

Heritage Area			
Category of Inventory Data		Type of Data	Source
Photos	<ul style="list-style-type: none">● Colombo Street (North & South)● King's Street (North & South)● Cross Street (North & South)● Hill Street (North & South)● D.S.Senanayake Veediya (East & West)● Kotogodalla Street (East & West)		

DoA: Department of Archaeology

DoS: Department of Survey

NBRO: National Building Research Organization

UDA: Urban Development Authority

