SUPPORTING REPORT (2)

ANNEX 4 : LAND USE

THE STUDY ON STORM WATER DRAINAGE PLAN
FOR THE COLOMBO METROPOLITAN REGION
IN
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

FINAL REPORT

VOLUME IV : SUPPORTING REPORT (2)

ANNEX 4 : LAND USE

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CHAPTER 1 OBJECTIVES OF THE STUDY

1.1 Background of the Study

During and following the UN International Decade of Natural Disaster Reduction, significant focus was placed on urban disaster management in the developing countries. There are now about 450 cities worldwide with a population of more than 1 million inhabitants. Of these, 50 cities have a population greater than 3.5 million and 25 cities have populations greater than 8 million. The concern over the risk to these mega cities, particularly in the developing world, is their growing vulnerability caused by their hyper-concentrations of population and dependence on disaster-prone settlement.

Among several disasters, such as earthquakes, typhoon and cyclones, landslides, and tsunami, flooding is one of the most common and frequent disasters in metropolitan areas located in the inter-tropical convergence zone where severe heavy rainfall occurs. In the case of Metropolitan Colombo, flooding is a frequent phenomenon, because the city extends over the coastal floodplain.

One of the triggers of this flooding is the conversion of areas to urbanized use, and the consequent increased runoff rate. It is reported that the urban fringe is expanding rapidly especially in the form of land-filling in lowland areas. These encroachments are mainly occupied by the poor people, who are frequently affected by the flood and suffering from poor drainage of storm water. There is a convergence point between urban disaster management and urban poverty problem. An integrated approach with urban disaster management and poverty reduction strategy must be adopted.

Although there are several dimensions[1] in urban poverty context, such as income, health, security, education and empowerment, flood problem could be regarded as threatening the land security of the urban poor. It means that the urban poor are obliged to live in areas prone to disaster due to the lack of adequate mitigation measures and land use policy. Adequate countermeasures should be adopted to save the urban poor from this disaster. In addition, appropriate development and regulations of land should be established based on the scientific evaluation of the project area.

Land use planning with GIS could be an integral part of urban disaster management, which comprises of five sub-components: assessment of hazards and risks, preparedness, response and relief, mitigation, and information dissemination. Land

[1] PRSP Sourcebook, Worldbank, 2001.

use planning with GIS also helps to harmonize the development of metropolitan areas with sustainable growth management, especially for land security of the urban poor, by using techniques such as urban poverty mapping. This could be much more effective, with a control of land supply, planning regulation, and zoning of human habitation, thereby contributing to prevent the encroachment to the lowland as well as the damage from the flood-related disaster. Much more focus should be placed on the growth management of metropolitan area from the viewpoint of disaster prevention and environmental protection.

1.2 Objectives of the Study

The goal for this study is to formulate the storm water/flood-related disaster management plan, or disaster prevention plan, focusing on the environmental and social aspects.

The objective of this study is to propose the appropriate use of land to prevent the flood damage in the lowland in the metropolitan Colombo, with a special focus on the Weras Ganga sub-catchment. The current land use was identified in the course of the study. Special care was paid to the information of the physical and social conditions, as well as scientific evaluation of the land.

In order to attain this, the targets of the study were set up as follows;

1) To provide a watershed-wide map of present land use for hydrological analysis
2) To prepare a watershed-wide map of future land use pattern

1.3 Output of the Study

It was identified at the first field work in Sri Lanka that no precise land use plan exists, except for the Colombo Metropolitan Structural Plan, which mainly focuses on the Provincial-wide aspect, not for our feasibility study area.

Therefore, urgent needs arise to prepare the present and future land use map, which was intended to be used as input for further investigation on the flood-related analysis, such as the hydrological analysis or flood damage survey. The characteristics of the map of future land use pattern prepared during the study are one of the assumptions for formulating the storm water drainage plan.

The following outputs were prepared during the F/S.

1) Current Land Use Map with an accuracy of scale of 1:10,000
2) Future Land Use Map with an accuracy of scale of 1: 10,000

CHAPTER 2 METHODOLOGY

2.1 Sequence of the Analysis

In preparing the land use map in the current situation, the following work steps were carried out: (a) collecting of materials and information, (b) set up of classification scheme, (b) set up of interpretation key and field validation, (c) interpretation, (d) preparation of land use map by on-screen digitizing.

2.2 Data Collection

New data sources for determining the current condition of land use were determined during the second field work in Sri Lanka. These data are (a) aerial photo with a ground resolution of 1:8,000 and (b) digitized map with a scale of 1: 2,000. Both of these data were prepared by Survey Department.

2.2.1 Aerial Photo

Aerial photos in the study area were taken in 1960's but are too outdated for determining the current pattern of land use. However, within the feasibility study area, 138 additional photos, taken in 2000 and 2001, have been made available and have a ground resolution of 1:8,000. Figure 2.2.1 shows the point of shot in the study area. Despite the huge amount of data, it is a good source of information as it represents the recent situation on land use.

2.2.2 Digital Map

In addition to the aerial photos, Survey Department, in March 2002, completed a more detailed map with a scale of 1:2,000 in a digital form, with technical and financial assistance from the Norway Government. The data contains 66 layers, each of which represents basic skeletons of the city, such as contours and elevation, drainage network, coastal lines, buildings, road, waterbody, and major land use. The detailed technical specifications are described in Table 2.2.1.

These data are expected to contribute as a spatial data infrastructure, to formulate an efficient planning for physical infrastructures, such as urban drainage network plan or road construction. From the viewpoint of preparing land use map, it is beneficial, because the information on locations of building can be obtained from this map. The information is crucial for calculating building density of the study area, a key indicator for land use planning in urban sprawl context.

2.3 Categories of Land Use

The first step to prepare the land use map is to define the categories of land use. It is essential that the classification scheme should depend on the objectives of the analysis that the land use map will be used for. In the case of this feasibility study, the objectives of the analysis are two-fold:

1) To prepare a land use map that can be used as an information source for hydrological analysis
2) To provide information for damage estimation of flood inundation.

Theoretically, when focusing on the first objective, more attention should be paid to the natural aspect of land use, especially in terms of surface conditions of land, such as a criterion of pervious or impervious, dry or wet. On the other hand, if we focus more on the latter objective, the human use or occupancy of land, such as residential use, commercial use or industrial use, should be clarified. Practically, however, this can be difficult by relying on the collected data only. For example, the numbers and the form of buildings can be identified with the aerial photo, but building use (type of occupancy or perviousness of the land), cannot be identified. This information could be obtained from other sources, but is not objectively verifiable through the data and information collected.

Therefore, this study focuses on the objectively verifiable evidence that derives from the data collected. For these purposes, three proxy indicators are selected for the conduct of the study: (a) elevation, (b) building density and (c) the existence of tree cover. The elevation is used as an indicator for distinguishing high-land from lowland, which means the dryness or wetness of land. Building density, on the other hand, is regarded as a proxy indicator of a degree of urbanization. The existence of tree cover can be regarded as a proxy indicator for perviousness of land.

These indicators can be verifiable from the aerial photo, digital map, and other sources of information. Based on these criteria, thirteen categories were established: (a) shanty, (b) high density area, (c) homestead, (d) garden, (e) grassland, (f) airport, (g) factory, (h) vacant, (i) dumping site, (j) paddy, (k) marsh, (l) vegetation, and (m) water. The definition of each category is summarized in Table 2.3.1.

2.4 Interpretation Key

Setting up an interpretation key is a normal procedure at the commencement of photo interpretation. The interpretation key is a description of a photo in a typical area.

The keys are set in a following manner: firstly, candidate points of key setting are explored, by over-viewing the whole sheet of an aerial photo, and selecting the typical area for the categories. In the next step, field validation is carried out for each category of land, after confirming the existing land use by field visit. Photo interpretation is carried out referencing the interpretation key.

The results of interpretation are transferred to the topo-map. In the study, the topo-map has already been acquired in a digital form, so that GIS were used as an instrument.

CHAPTER 3 PRESENT SITUATION ON WATERSHED WITH RESPECT TO LAND–RELATED ASPECT

3.1 Overview of the Current Situation on Land Use Pattern

Figure 3.1.1 shows the current pattern of land use in the feasibility study area. The amounts of land and its share for respective categories are shown in Table 3.1.

Spatial pattern of land use in this area is characterized by its landform or elevation. For example, in the lowland under the elevation of 5 m, paddy, grassland, and marsh are dominant categories. Lands categorized as grassland are observed on the micro-relief, although this could be regarded as an abandoned paddy. In some upland areas, which are relatively free from flood inundation, residential areas are observed, some of which is now being developed with clearance of the coconut forest.

Another factor that determines the spatial pattern of land use is the east-west bank contrast of Weras Ganga. On the eastern side of Weras Ganga basin, important infrastructure/facilities for national economy are concentrated, such as industrial facilities and the airport, while on the eastern side only a few factories could be observed.

Localized characteristics of land use with respect to land-filling can be summarized as follows:

1) Urban sprawling and encroachment to marsh are observed in the Thumbowila area, a south-western part of the feasibility study area. Comparing the aerial photo taken in 1981, the situation in Thumbowila is quite similar to the situation around the area of Moratuwa University.
2) Several land-filling areas for waste dumping are observed in the lowland such as the Muthurajawela Marsh and Thumbowila.
3) Major factories are located in the western part of the basin, especially in the jurisdiction of the Dehiwala - Mount Lavinia Municipal Council. These factories are located at the midst of the lowland where the Horana roads cross the Maha Ela.
4) Artificial transformation of landform was also observed in the western part of the Attidiya Marsh area, which is also used as a residential area, under the favor of the improvement of drainage system.

3.2 Building Density

As mentioned in the section 2.3, building density is a crucial indicator for land use planning. Figure 3.2.1 shows the thematic map of the building density of the

feasibility study area. The number of buildings was counted for each lattice with a spacing of 200 m that is depicted on the map of 1:2,000.

High density cluster with a category of over 20 buildings/ha can be observed in the following area: Attidiya area, Nedimala area, Boralesgamuwa area, Gangodawila area, Rawatawatta area and Katsubedda area. The criteria for this category correspond to 2,000 buildings/km^2. Considering the average household size of six persons per household, the population density in this category can be estimated at 6,000 persons/km^2. This figure almost corresponds to the criterion of built up area (Densely Inhabited District, DID) in Japan, which is defined as over 4,000 persons/km^2 and an agglomeration of 5,000 person.

On the other hand, low density area, defined as fewer than five buildings/ha (i.e. 50 buildings/km^2), spreads over the area near the lowland, such as (g) southern part of Werahera, (h) Thumbowila, (j) Siddamulla area. These areas still have room for future urban sprawl.

3.3 Tree Cover

Tree cover is regarded as a proxy indicator for surface condition. In a more complex hydrological model, such as SHE (System Hydrologique European), leaf area index derived from the satellite image analysis, is used as a proxy indicator of canopy interception. In this study, however, tree cover is used as a criterion for distinguishing between land use categories of home garden and grassland in a low-density area with 7.5 buildings/ha.

Area covered with tree crown cover was detected by visually inspecting aerial photos, while referencing the interpretation key. Area covered with tree crown cover is categorized as a home garden and area without tree cover fell into the category of grassland.

CHAPTER 4 FORECASTING FUTURE LAND USE PATTERN

4.1 Methodology

Research activities on land use modeling to forecast the spatial pattern of the urban sprawl have been extensively carried out in the research community of LUC (Land Use Change) Study. The methods have been developed and applied in the metropolitan regions throughout the world, and their effectiveness has been validated. These methods can be broadly classified into two mainstreams: (a) stochastic-based modeling approach and (b) rule-based approach.

Stochastic-based approach is based on the use of some stochastic models, which incorporates the concept of probability into a change of land use. Several models have been proposed, such as Logit model, Markov chain model, and Cellular Automata (CA) model. Cellular Automata is a trend for application in recent work, because it fully takes into account the spatial aspect of land use change. Cellular Automata is a kind of spatial-explicit model that expresses diffusion phenomenon. The concept of the model relies on the fact that the urban sprawl is likely to occur near the area adjacent to the already-urbanized cell. The likeliness of this transformation is expressed by a probability concept, and mathematically expressed in a stochastic differential equation. The model is normally converted into computer code, and Monte-Carlo simulation is carried out by random number generation. The CA model contributes greatly to simulate and evaluate alternative scenarios, such as the effect on policy introduction of land use regulation. In the case of Colombo Metropolitan Region, Watanabe (1998) has made an effort to apply a CA model to the area. However, it requires a huge amount of data and computing resources as well as time to develop the computer code for the analysis. Therefore, it is not a good strategy to adopt this method under limited schedule of the study.

Rule-based approach, on the other hand, focuses more on the driving forces of the use change of land. The spatial trends derived from observing the phenomenon is expressed in a rule of conversion that can consider fully the spatial dimensions, and apply them to forecast the future pattern.

This study adopted a kind of rule-based approach. It requires some spatially-explicit rule for estimating future pattern that take into account the factor of change, and validates these factors in a local settings. The following four steps were adopted to formulate some rules and to draw out the future pattern of land use in the feasibility study area.

1) Identify the area or spatial trends of urbanization by comparison of previous aerial photo and current situation;
2) Collect information that relates to the future proposal or development plan in the study area, and identify its location and implementing schedule;
3) Consider the development factors and limiting factors in the study area; and
4) Summarize the results and draw up future pattern by GIS operation.

4.2 Spatial Trends in the Feasibility Study Area

In order to characterize the change of land use and its spatial trends, changes of land use patterns in the study area are examined, including examining historical materials and with a visual comparison of aerial photos between 1981 and 2000.

Following major changes are observed:

1) Paddy compartment disappears in the lowland, because cultivation has been abandoned. Paddy was converted into marsh or grassland.
2) Artificial transformation of land (i.e. large-scale land filling) was also observed at the western part of the Attidiya Marsh. These transformations were carried out by the NHDA/SLLRDC housing scheme or private companies such as CEILINCO in order to develop the residential area.
3) Encroachment to lowland is also observed at Thumbowila in the east bank of the Weras Ganga. Several low-quality settlements characterized by the high building density can be identified at several points of the riverine area of Weras Ganga, which was formed because of the land filling of lowland.
4) Trends in urbanization along the road can be observed, especially at the upper area of Weras Ganga, such as Nugegoda and Maharagama. Some are established as commercial centers.
5) Conversion of vegetative area into residential area can be identified in the area of Sadamulla area, a southern part of the study area.

4.3 Proposal/Development Plan for the Feasibility Study Area

There are two plans prepared by UDA in the area, each of which is mutually contradictory. No comprehensive land use plans could be found that the study can rely on. Therefore, several proposal or development plan was collected and mapped out in the same map.

4.3.1 Zoning Plan by UDA

General zoning plan along the Weras Ganga was drafted by UDA in 1991. The proposal is comprised of following zones, such as:

1) Core Area of the marsh to preserve
2) Proposed Green belt/open spaces in the area outside of the core area,
3) Industrial Estate along the eastern side of the Horana road
4) Lake extension to the eastward direction
5) Potential area for tourism in the center of the area as a strip along the west bank of Weras Ganga.
6) Middle-class housing scheme at the north-eastern part of the Core Area of the Welawatta-Attidiya Marsh.
7) Middle-class housing scheme at the west bank of Weras Ganga, and
8) Housing scheme at the northern part of the Depawa Ela near Werahera

4.3.2 Master Plan for Lowland by UDA

In 1996, Environmental and Landscape Planning Division of UDA proposed a master plan for lowland. Although this plan mainly focuses on the lowland in the Core Area in the CMR Structural plan, especially around the Parliament Lake in Sri Jayawardenapura Kotte Municipal Council, the north-eastern part of catchment area of Weras Ganga is also included in the map extent. The lowlands are divided into three categories; (a) nature park, (b) parks and play ground, (c) nature park/special recreational project (golf)/agricultural/tree crop, etc. Figure 4.3.1 shows the plan.

There are some discrepancies between the zoning plan in Weras Ganga in 1991 and the master plan for lowland in 1996, with respect to land use in some areas. For example, some housing scheme were included in the 1991 plan, at the point (f), (g) and (h) in Figure 4.3.2, while the same area was proposed as a nature parks or parks & playground in Figure 4.3.1. Interview with UDA directors was carried out on July 19, 2002 to confirm these facts and legacy of the plan. According to the interview with the Environmental and Landscape Planning Division of UDA, the plan was the latest and officially gazetted in 1999 as a part of CMR Structural plan. However, the status of this plan is not clear in relation to the zoning plan mentioned in section 4.3.1, and its legal status is uncertain.

In addition, the master plan does not mention the lowland along the west bank of Weras Ganga and in the southern part of Depawa Ela.

4.3.3 Bellanwila-Attidiya Wildlife Sanctuary

Conservation on the Bellanwila-Attidiya Wildlife Sanctuary has been debated for a decade. Historically, this marsh was declared as a sanctuary under the Flora and Fauna Protection Ordinance by gazette notification in July 25, 1990. CEA Wetland conservation report in 1994 summarizes its history, characteristics of ecosystem, and threat to the marsh, and recommends a conservation plan in the area. Although the

area still has a legal status on the sanctuary, the quality of the marsh as a habitat has already been degraded, compared to the last 10 years when the report was prepared. For example, western part of the marsh has already been lost due to several land-

filling activities, and encroachment onto marsh is continuing. In addition, southern part of the core area has been used as a waste garbage dumping site, although a court order for removal was issued in March, 2002.

Department of Wildlife Conservation (DWLC), a responsible entity for declaring the sanctuary, does not pay much attention to the ecological importance to this marsh, because of the degraded quality of habitat. However, an interview with Environmental & Landscape Planning Division of UDA reveals that UDA has a plan to extend this sanctuary area to the eastward direction, although the plan is not documented. There is still uncertainty whether this marsh will be preserved or encroached by the human activities.

4.4 Development Projects

The following projects are anticipated to trigger large-scale change of land use.

4.4.1 Ratmalana Airport Expansion Project

Runway expansion project at Ratmalana Airport, which was initiated by the Ratmalana Airport Authorities, was emerging at the beginning of 1990's. The purpose of the project is to expand the runway, which enables large-scale aircraft or small jet to land or take off. The proposal comprises a 2,000 feet (610 m) expansion of runway to the direction of marsh and 28 ha of land-filling. For security reasons, a buffer zone around the runway edge is also planned. In order to keep the retention area, some private land is to be acquired by the Airport Authority for the purpose of establishing a retention area in the area of south-eastern part of Boralesgamuwa. Figure 4.4.1 shows the layout plan of the project. The plan contains a shift of the existing channel to the eastern side and directly connecting to the lake at downstream, thus there might be some impact to the drainage of Weras Ganga.

4.4.2 Police Academy Project

Police Academy Project is a project that aims to construct a training center for police officers as well as housing at the Badowita tract, located at the west part of the Bellanwila-Attidiya marsh (Figure 4.4.2). The project is initiated by the Police Department and filling-up the land is conducted by SLLRDC. In addition to the academy for police officers, the proposal includes some residential use for people working in the area. Part of the proposed site has already been reclaimed by

SLLRDC. Some ten acres of the backyard of the proposed site is planned to be reserved as a retention area.

4.4.3 Bolaresgamuwa Theme Park Project

Bolaresgamuwa Theme Park Project is a project initiated by Sri Lanka Ceramic Corporation, a private company with technical assistance from UDA. The project site is located in the area marked (b) in the Figure 4.4.3, where there is an abandoned kaolin refinery site owned by a private company along the swamp of Weras Ganga. Layout plan for several facilities is designed to maximize the use of existing conditions of the riverine environment, and several facilities are designed to be submerged when high water level arises. It appears that this project will not affect the flow regime of the Weras Ganga, although a precise study will be carried out at the drainage plan section of this report. The project will be operated by the company and construction is expected to start in 2003.

4.4.4 Baseline Road Extension Project

There is also a plan, by RDA, to extend the Baseline Road to the Ratmalana Airport. The land for the development road has already been acquired by RDA, which was reclaimed by SLLRDC (Figure 4.4.4).

4.5 Driving Forces of the Land Use Change in the Feasibility Study Area

The major phenomena that can be identified in this area are the processes of urban sprawl in the high land and land-filling in lowland. As mentioned in the Master Plan study, urban sprawl, which means the expansion of built-up area, could be conditioned by four factors, such as population density factors, transportation factors, planning factors and limiting factors. Table 4.5.1 summarizes the factors and their criteria, and its rule of change.

4.5.1 Density Factor

As confirmed in section 3.2, there was observed some low-density area in the watershed, especially in the south-western part of the area. Density of this category corresponds to about 5-10 buildings/ha. Considering the situation of current land use, this area is expected to change into a higher density of 10-20 buildings/ha. Therefore, rule of transformation that represent the population density factor could be expressed as follows:

Rule #1: Areas with a building density of 5 buildings/ha are to be upgraded to 10-20 buildings/ha. Due to this change, the area that falls into the categories in garden will be turned into the categories of homestead.

Rule #2: Area comprises few buildings in a large lot, such as universities, institute, large-scale private companies, will not be affected by rule #1.

4.5.2 Transportation Factor

Considering the transportation factors, road networks in the study area should be taken into account. These include three major roads: Galle Road, Colombo-Horana Road, and High Level Road. The road network indicates that the north-south linkage is well developed, while the east-west linkage is weak.

There is a possibility that the urban sprawl will progress along these roads. It is anticipated that population density will be increased in a buffer zone of about 500 m on both sides along the road.

Current situation of the roadside area along Galle Road, and High Level Road, built-up area has already been established, while along Colombo-Horana Road, the degree of urbanization is relatively small. Therefore, Colombo-Horana Road is a direction of urban sprawl in this area. In addition, an extension of Baseline Road might improve greatly to the access of the area of Attidiya Area, which indicates the change of conditions.

Another change of condition in terms of transport is the construction of Bolpana bridge that crosses over the Weras Ganga at Werahera. Although this is small change locally, this bridge improves, to some extent, the access to the southern part of Werahera area from the Moratuwa side, which might have a possibility to trigger the conversion of more land into residential area.

The major means of public transportation is bus. There are bus terminals at Maharagama and Piliyandara, which are third-order and fourth-order town centers, respectively. Within 2 km from these centers there is good access on foot to the bus centers.

A third change of factor in this area would be the construction of a light rail system along the boundary of Core Area of CMR Structure Plan. Although the plan mentioned some information on the project[2], such as the route, its cost of construction, and a responsible entity, it does not describe concrete information concerning the schedule of implementation. Therefore, there is still an uncertainty whether this rail system will be constructed or not.

To summarize the points mentioned above, the rules for transformation are established as follows:

[2] Project cost is estimated 15 billion, and responsible agency is Sri Lanka Railway (Volume II, CMRSP).

Rule #3: Major road buffer with 500 m are changed.

Rule #4: 2 km from the town centers, such as Maharagama and Piliyandara is to be urbanized to the categories of homestead, and one km from the town centers are converted into the categories of high-density.

4.5.3 Planning Factors

As described in section 4.3, two plans co-exist with respect to Weras Ganga area. Some projects have a high possibility of implementation, while others do not, so that there still remains uncertainty in terms of implementation of the projects. Therefore, it may be prudent to assume several scenarios as input for the hydrological analysis and drainage network plan formulation. In preparing the future pattern of land use, two projects, the Police Academy Project and the Ratmalana Airport Expansion project are confirmed to be implemented.

4.5.4 Limiting Factor

Three limiting factors could be considered: (a) Sanctuary, (b) Marsh area, (c) Abandoned paddy. The legal status of the Bellanwila-Attidiya Sanctuary area still exists. Therefore, it is anticipated that this area will not convert to other use. In terms of marsh area, there is a description[3] in CMRSP that "In exceptional cases, marshes may be utilized in developing infrastructure such as roads, rail tracks, and other public amenities". This description represents a UDA policy on marsh. Abandoned paddy, represented as a category of grassland, in the land use pattern map, is to be converted into homestead use, while paddy land that is still cultivated remains.

4.6 Future Patterns of Land Use in the Feasibility Study Area

Figure 4.6.1 shows the future pattern of land use in the study area, and the Table 4.6.1 shows the transition matrix between categories. Transition matrix is a matrix that can explicitly represent the causal change between categories. For each category of land use, the amounts to be converted and its use could be identified Diagonal elements represent the amount of land that cannot affect the change. The matrix indicates that 851 ha of garden land is likely to be converted to homestead category.

The results of change between present situation and future (forecast) situation can be summarized as Table 4.6.2. It reveals that, although the share of urbanized use does not change significantly, compositional change between categories occurs, especially between garden categories and homestead categories. The share of homestead area grows rapidly, increasing to 50.3%. In terms of natural use, the share of paddy

[3] Volume II, CMRSP

lands remains even, while marsh and vegetation categories are on the decline, triggered by the expansion of airport runway. This result does not include the implementation of the housing scheme. However, if these schemes are to be implemented, an additional 3.6 ha will be converted from marsh category to high-density categories.

Tables

Table 2.2.1 Detailed Specification of Digital Map

CODE	Features	Registration mode
10	Road center line	LINE
11	Road edge	LINE
12	Path	LINE
13	Railway	LINE
14	Air strip, runway	LINE
15	Building line	LINE
16	Building line under construction	LINE
17	Building ruin	LINE
19	Culvert line	LINE
24	Bridge	LINE
25	Pedestrian overhead crossing	LINE
26	Structure	LINE
28	Wall	LINE
29	Retaining wall	LINE
30	Fence	LINE
31	Dam	LINE
32	Coast	LINE
33	Lake	LINE
34	Pond	LINE
36	River	LINE
37	Pool	LINE
38	Reef	LINE
55	Contour	LINE
57	Pipeline	LINE

Table 2.3.1 Definition of Each Category of Land Use

Category	Criteria
Very High Density Area	(a) Extremely high building density are observed (b) No tree cover can be observed
High Density Area	(c) Over 12.5 buildings per hectare (d) No tree cover can be observed
Homestead	(a) Over 7.5buildings and less than 12.5 buildings per hectare are identified (b) Tree cover can be observed
Garden	(a) Under 7.5 buildings per four hectare (b) Dominant canopy cover can be identified
Grassland	(a) Under 7.5 buildings per four hectare (b) No canopy cover dominant
Airport	(a) Information from the field survey
Factory	(a) Lange scale lot & building can be identified (b) Other source of information and field survey
Vacant	(a) Bare soil on the land cover can be observed
Dumping Site	(a) Bare land cover can be observed (a) Other source of information and field survey
Paddy	(a) Elevation less than 5 meters (b) Compartment can be observed
Marsh	(a) Elevation less than 5 meters (b) Compartment cannot be observed
Vegetation	(a) Closed canopy cover observed (b) No buildings can be observed
Water	(a) Blackish texture can be identified (b) Information from the digital map

Table 3.1.1 Current Land Use in the Feasibility Study Area

Categories	Area Extent (ha)	Percentage
Urbanized Use	4,185	80.6
Very High Density Area	22	0.4
High Density Area	819	15.8
Homestead	1,447	27.9
Garden	1,310	25.3
Grassland	229	4.4
Airport	139	2.7
Factory	136	2.6
Vacant	75	1.4
Dumping Site	8	0.2
Natural/Rural Use	1,002	19.3
Paddy	359	6.9
Marsh	302	5.8
Vegetation	219	4.2
Water	122	2.3
Total	5,187	100.0

Table 4.5.1 Factors and Rule of Changes

Factors	Rule of Change
Density Factor	Rule #1: Areas with a building density of 5 buildings per hectares building per hectare is to be upgraded to 10-20 buildings per hectares. Due to this change, the area that falls into the categories in garden will be turned into the categories of homestead. Rule #2 : Area that have an area with few buildings in large lot, such as universities, institute, large-scale private companies, will not affected to rule #1
Transportation Factor	Rule #3 Major road buffer with a 500 meters are changed Rule #4 Two kilometers from the town centers, such as Maharagama and Piliyandara is to be urbanized to the categories of homestead, and one kilometers form the town centers are converted into the categories of high-density.
Planning Factor	Rule #5 Police Academy Project and the Ratmalana Airport Expansion project is to be implemented
Limiting Factor	Rule #6 Paddy, represented as a category of grassland, is to be converted into homestead use. Rule #7 Paddy land still cultivated still remains as a paddy land.

Table 4.6.1 Transition Matrix

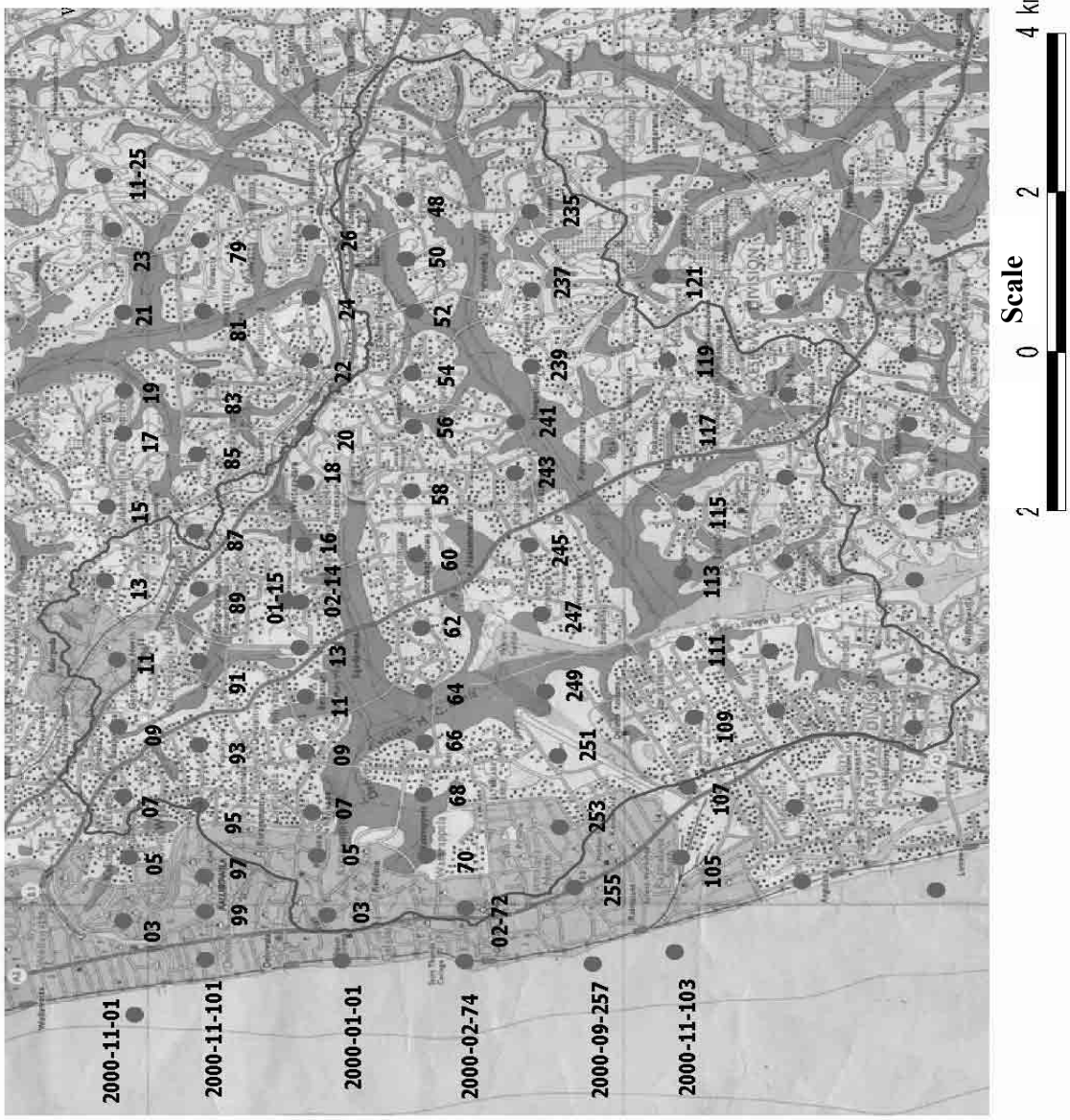
(Unit: ha)

Present Land Use	Future Land Use										
	(a)	(b)	(c)	(d)	(e)	(h)	(I)	(k)	(l)	(m)	Total (ha)
(a) Very High Density	22	0	0	0	0	0	0	0	0	0	22
(b) High-density	0	819	0	0	0	0	0	0	0	0	819
(c) Homestead	0	55	1,392	0	0	0	0	0	0	0	1,447
(d) Garden	0	0	851	458	0	0	0	0	0	0	1,310
(e) Paddy	0	0	0	0	359	0	0	0	0	0	359
(f) Grassland	0	0	229	0	0	0	0	0	0	0	229
(g) Vacant	0	0	75	0	0	0	0	0	0	0	75
(h) Airport	0	0	0	0	0	139	0	0	0	0	139
(I) Factory	0	0	0	0	0	0	136	0	0	0	136
(j) Dumping Site	8	0	0	0	0	0	0	0	0	0	8
(k) Vegetation	0	0	65	0	0	28	0	126	0	0	219
(l) Marsh	0	9	0	0	0	0	0	0	292	0	302
(m) Water	0	0	0	0	0	0	0	0	0	121	121
Total	30	883	2,612	458	359	166	136	126	292	121	5,185

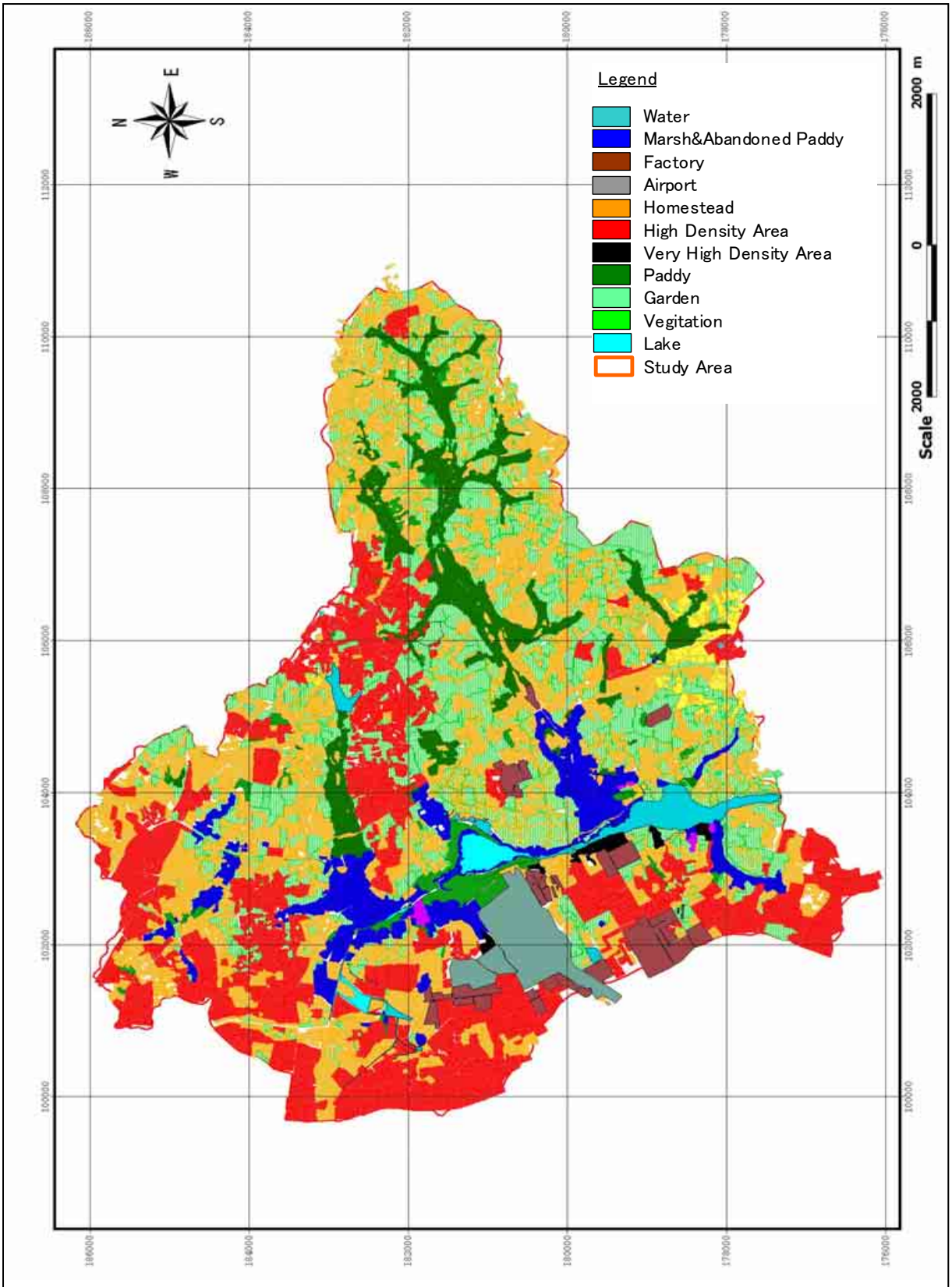
Table 4.6.2 Future Land Use in the Feasibility Study Area

Categories	Present		Future	
	Area Extent (ha)	Percentage	Area Extent (ha)	Percentage
Urbanized Use	4,183	80.6	4,285	82.6
Very High Density Area	22	0.4	30	0.5
High Density Area	818	15.8	883	17.0
Homestead	1,447	27.9	2,612	50.3
Garden	1,310	25.3	458	8.8
Grassland	229	4.4	0	0
Airport	139	2.7	166	3.2
Factory	136	2.6	136	0.2
Vacant	75	1.4	0	0
Dumping Site	8	0.2	0	0
Natural/Rural Use	1,001	19.3	899	17.3
Paddy	359	6.9	359	6.9
Marsh	302	5.8	293	5.6
Vegetation	219	4.2	126	2.4
Water	121	2.3	121	2.3
Total	5,184	100.0	5,184	100.0

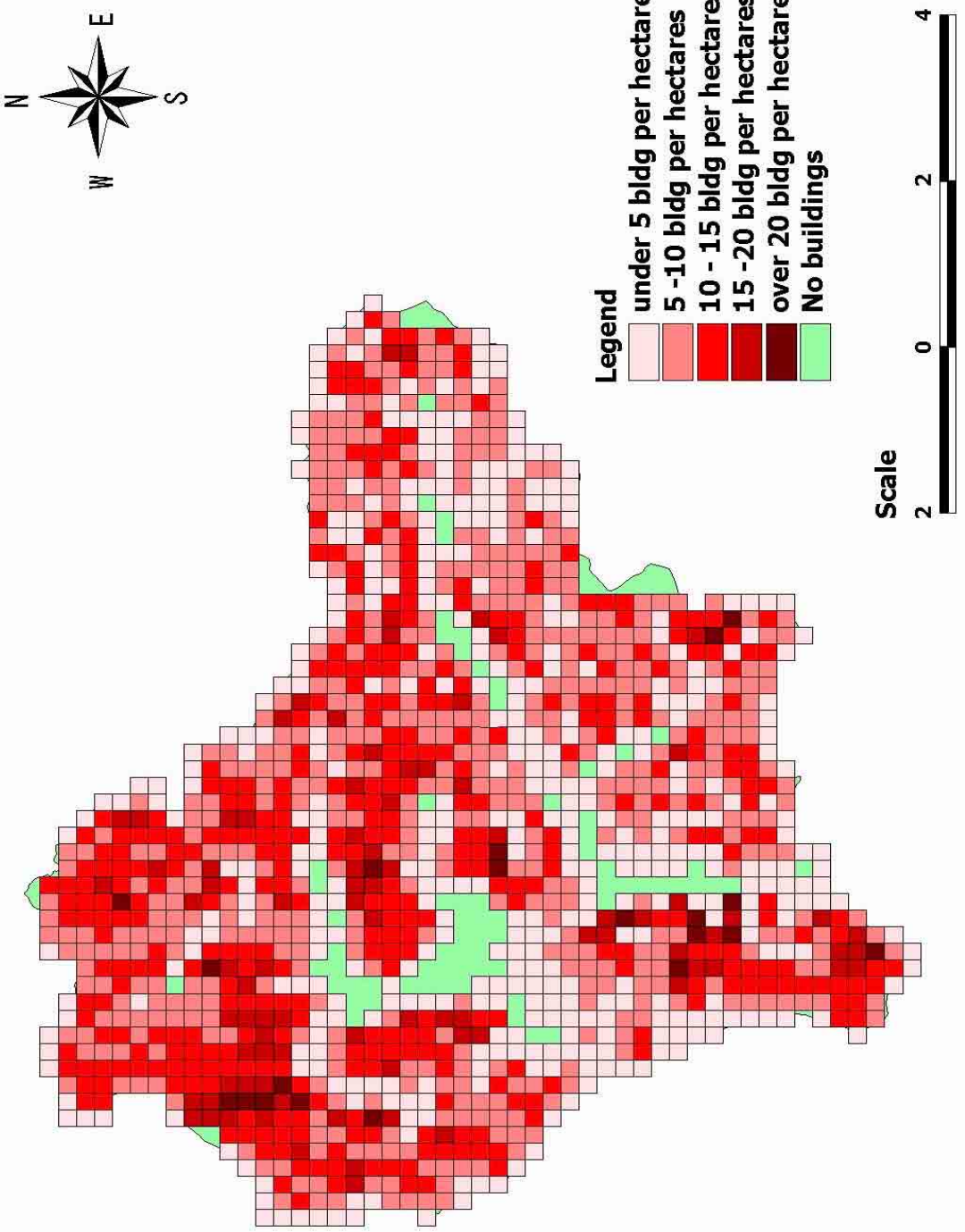
Figures



The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 2.2.1 Location of Aerial Photos
JAPAN INTERNATIONAL COOPERATION AGENCY	



The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 3.1.1 Present Land Use Pattern in Weras Ganga Basin
JAPAN INTERNATIONAL COOPERATION AGENCY	



The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka	Figure 3.2.1 Building Density in the Feasibility Study Area
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