CHAPTER 3
LAND DEGRADATION AND DEPLETION OF URBAN GREENS

INTRODUCTION

Kuala Lumpur or the Federal Territory has an area of 243 sq. km and is located in the centre of the Klang Basin. Kuala Lumpur is an urban conglomerate that is rapidly developing and today more than 70% of its area is developed. Kuala Lumpur development planning has given emphasis to housing, the city centre, satellite towns and areas for government administration, industry, institutes of learning, mining, parks and open spaces. There are plans to connect all these growth areas through an extensive and integrated transportation system.

Changes in the landuse in the last ten years have been dramatic. Forest, agricultural and mining areas have been converted to new residential areas, satellite towns, industrial zones and transportation corridors. These changes have led to rapid land degradation and depletion of green areas. Development in unsuitable and environmentally sensitive areas has been inevitable and the urban sprawl has spread to the highlands, areas with foundations containing limestone cavities and ex-mining land. All this has led to further land degradation.

The increase of geohazard events in the last five years is a clear sign of the negative impacts of increased land degradation. Between 1990 and 1996 there were 102 river flooding and flash floods, 21 landslips, 21 riverbank erosion and 8 subsidence events in Kuala Lumpur, a most worrying trend indeed. The majority of these incidents have entailed large property, loss of lives, disruption to the comfort of the populace and productive hours.

In its broadest sense, land degradation can be described as the end result of any factor or combination of factors which damage the land, water or vegetation resources and restrict their use or productive capacity (Chartres 1987; Burch *et al*. 1987). This report will focus on physical and biological aspects of land degradation in the Kuala Lumpur area.

URBAN PLANNING

Kuala Lumpur has undergone several stages of planning since the first plan was conceived, i.e. the Zoning Plan of 1931. This was superseded by the first Town Plan of 1939 which was in turn followed by the Town Plan of 1950. In 1967 a new master plan was introduced which consisted of a set of three plans, namely the Central Area Development Plan L886, the Residential Density

Zoning Plan L887 and the Land-use Zoning Plan L888. In 1970 these three plans were modified and renumbered to become the Comprehensive Development Plan No. 1039, 1040 and 1041. These plans covered the then Federal Capital area of 93 square kilometers (36 square miles). In 1973 the Federal Capital was enlarged to 243 square kilometers (94 square miles) by decree and was henceforth known as the Federal Territory.

Today urban planning for the city of Kuala Lumpur or the Federal Territory is based on the first Kuala Lumpur Structure Plan (1984) prepared for Dewan Bandaraya Kuala Lumpur. The plan is a written statement which contains the broad goals and objectives, policies and proposals pertaining to the development, landuse, the improvement of social, economic and physical environment and management of traffic within the Federal Territory. The current structure plan has a perspective period of 20 years up to the year 2000.

The planning of Kuala Lumpur is based on the premise of continuing population and economic growth adapted to the changes in the structure of economic activities of the Klang Valley. The principal concepts embodied in the plan are as follows:

- Hierarchy of urban centres: a definite concentration of physical and economic activities in the centre with ribbon developments along the major arteries leading into the city. The hierarchy are City Centre, Major Sub-centre, Intermediate Sub-centre and Local Centre.

- Variety of residental densities: In areas of high employment a higher density of residential population be located, and conversely, in areas where the environment has been well preserved a lower density of residential population be located.

- Restructuring of industries and industrial activity areas: Big and polluting industries be located away from Kuala Lumpur. Only non-basic industries such as workshops, repair services and food manufacturing serving the city residents are encouraged to be set up in Kuala Lumpur.

- Variety of open space: The provision of a comprehensive open space system be an integral part in the development plan of Kuala Lumpur. A system comprises a range from incidental, local to metropolitan open spaces.

- Efficient system of transportation: To reduce the current congestion during peak hours by ensuring a satisfactory flow of people and goods. A comprehensive transport system should be planned to ensure efficient and maximum mobility for people and goods.

- Comprehensive network and system of pedestrian movement: It is desirable that Kuala Lumpur plan for a comprehensive pedestrian movement system. Preferably the system should be designed to link public transportation terminals, major activities centres and open spaces.

This master plan forms for the basis for land-use in Kuala Lumpur in terms of zonations and other matters related to it. Figure 3.1 shows the planning concept of the hierarchy of urban centres in the Klang Valley region while Figure 3.2 shows the arterial system and the location of new growth areas in the Federal Territory.

LAND-USE CHANGES

Kuala Lumpur began in 1859 as a small hut built for commercial activities by Hiu Siew and Ah Sze. Mining activities were the main agent of growth of Kuala Lumpur then. Tin mining was initiated in small ways but the introduction of new technology (the steam engine and the dredge) broadened mining activities and mining production increased many fold. By 1887 Kuala Lumpur had 45 tin mines while 57 more were scattered in the proximity (Gullick 1988).

In the 1960's land-use in Kuala Lumpur began to be better planned and controlled. Squatter areas were redeveloped as business and commercial centres or organised residential areas. Several new industrial and business areas were developed in peripheral areas such as Petaling Jaya, Jalan Sungai Besi, Jalan Klang Lama, Jalan Cheras, Jalan Pahang and Jalan Ipoh. Zones for administration, education and similar services were set up along Jalan Duta, Jalan Tun Razak, Jalan Cheras and also in the Damansara area. Parks and open areas were planned and located in a more orderly fashion.

Kuala Lumpur's rapid development made it necessary for forested, agricultural and ex-mining areas to be converted into residential, commercial and recreation zones. The land-use changes of Kuala Lumpur from the 1960's to the 1980's are shown in Table 3.1. The table clearly indicates that agricultural and forest areas have shrunk from 52.9% in 1966 to 34.3% in 1985. Urban development on the other hand expanded from 33.4% to 58.7% in the same period. The 1996 figure, in fact suggest that this may now have reached more than 70% (Ibrahim 1996).

Table 3.1: Kuala Lumpur Land-use Changes 1966-1985

Type	**1966 ha(%)**	**1974 ha(%)**	**1985 ha(%)**

Urban Development	7985(33.4)	10374(43.4)	14273(58.7)
Agriculture	11878(49.7)	10271(42.9)	8265(34.0)
Mining	2692(11.3)	1865(7.8)	1940(6.8)
Forest and Swamp	770 (3.2)	955(4.0)	62(0.3)
Others	589(2.4)	449(1.9)	60(0.2)
Total	23914(100)	23914(100)	24300(100)

Source: Katiman (1995)

Urban development can be categorized into various types and is summarized in Table 3.2 which also indicates the percentage of each type of urban development land-use acreage. In a short pace of time Kuala Lumpur underwent dramatic change.

Table 3.2.: Land-use Acreage in Kuala Lumpur

Type of Land-use	**Acreage (ha)**	**Percentage**
Residential	7145	45
Institutional	3165	20
Parks and Open Areas	1630	10
Commercial	893	6
Industrial	686	4
Others	2401	15
Total	15920	100

Source: Kuala Lumpur Structure Plan 1984

The construction of high-rise buildings along Jalan Melaka, Lebuh Ampang, Jalan Gereja, Jalan Silang, Jalan Pudu, Jalan Sultan Muhammad, Jalan Cheng Lock and Jalan Tun Perak transformed Kuala Lumpur into an international business centre. International standard hotels began mushrooming along Jalan Imbi, Jalan Raja Laut and Jalan Bukit Bintang, while shopping centres were positioned in the city centre, all along Jalan Tuanku Abdul Rahman, Jalan Imbi, Jalan Ampang, Jalan Sultan Muhammad and Jalan Raja Laut. The transportation system was improved through widening, improving and adding new highways in order to provide a more orderly and effective communications infrastructure. Service centres and suburbs are located at the periphery of the Federal Territory: Apart from Petaling Jaya, new urban areas are located at Bandar Tun Razak, Cheras, Bandar Baru Selayang, Wangsa Maju, Bandar Damansara, Bangsar Baru, Segambut, Bukit Jalil and Bukit Indah. Despite the rapid commercial development taking place, the largest land-use in Kuala Lumpur is for residential development: Multitudes of residential areas and condominiums have been built or are in the planning.

HIGH RISK DEVELOPMENT

The rapid expansion of the city which is topographically and politically constrained has meant that development has had to extend into sensitive and problematic areas. This has resulted in a severe degradation of the land and high risk to geohazard.

In Kuala Lumpur there are several problematic or unsuitable terrain for major constructions because of inherent geological or geomorphological properties. The construction of highrise building, heavy infrastructure or large housing estate on such terrain exposes them to high risk of foundation failure, land subsidence and slope instability. Even though mitigating engineering measures can be adopted in such a terrain, risk of failure cannot be eliminated and construction costs can be extremely high. Unfortunately these geological factors are hardly considered during the planning of most urban development in the Klang Valley. Some of these factors are highlighted below.

Karst Bedrock

Nearly half of Kuala Lumpur is situated on an alluvial plain underlain by limestone karstic bedrock. The major problem encountered in building on karstic bedrock are the presence of highly irregular pinnacled surfaces and the common occurrences of cavities in the rock. The pinnacled surfaces present considerable problems for foundations utilizing hammer piles and as much as 60 percent of the piles may be lost due to their failure to be seated on these jagged rocks (Tan 1986). Other problems include possible collapse of the roof of the subterranean caverns by the imposition of the load of the overlying man-made structure, and land subsidence due to the collapse of overlying soils above limestone cavities under the influence of groundwater fluctuation.

Mining Land

Kuala Lumpur owes its origin and growth to the tin mining industry. The major part of Kuala Lumpur is on tin-bearing alluvium and in some areas mining is still going on at the present time. Urbanization and mining requirements are often in conflict over land-use policy and the compromise often takes the form of giving the mining industry a limited number of years to complete the mining activities, and then reassigning the land over for urban development. One common problem in Kuala Lumpur is that the mining method commonly practiced is open-cast and is located close to the urban centres. This method involves the creation of deep pits which have to be continuously dewatered thereby creating instability to the adjacent land. Buildings close to mining areas have always been prone to risk of subsidence and slope failure.

Because of the presence of large tracts of mining areas, reclamation of these former mining land is especially important for urban development in Kuala Lumpur. Ex-mining land is normally left with deeply scarred landscape and poor soil conditions. Some of the problems related to the reclamation of this land are differential settlement, subsidence and slope failure. Reclamation of mining ponds usually involves dewatering before the emplacement of the fill material. The potentially serious consequence of such reclamation works on the adjacent land was demonstrated by the major landslide in the Taman Cheras Indah housing development scheme in early 1984, where a row of newly completed two-story residential houses was totally damaged (Tan 1986).

Hilly Terrain

The high demand for residential properties on elevated land has led to the extensive development of many of the hilly terrain at the northern periphery of Kuala Lumpur. High rainfall and the nature of deeply weathered terrain make the development on hilly terrain susceptible to severe erosion and slope failure. Other factors contributing to slope failure are unfavourable joint orientation, soil-rock interface, thin residual soil cover and seepage. Some of the cases of slope failures in Kuala Lumpur have been discussed by Tan and Ibrahim (1990) and Ibrahim (1997a).

LAND DEGRADATION CAUSED BY URBAN GEOHAZARDS

Geohazards, defined as a hazard of geological, hydrological or geomorphological nature which poses a threat to man and his activities, have always been a major issue in the Klang Valley, but in the last five years the problem has become critical. Both natural and human-induced geohazards, or the combination of both, have occurred in Kuala Lumpur, triggering heated public debate. The most common types of geohazard in the Klang Valley are river flooding and flash flood, landslides and slope failures, erosion and siltation, river bank erosion and ground

subsidence, all of which contribute to accelerated and severe land degradation. Figure 3.3 shows the distribution of geohazard events in the Klang Valley region as describe in the following section.

River Flooding and Flash Flood

Flooding events are common in the Klang Valley in general and the Kuala Lumpur areas in particular. River flooding occurs during extreme monsoon periods, while flash floods, which are more common events, occur during intense thunderstorms anytime of the year. The city of Kuala Lumpur has always had flooding problems, aggravated by extensive development and tin mining activities. Efforts to mitigate the problems started as early as 1915 and are still continuing until today.

Several major flooding events had cost extensive damage to property and the environment. The 1926 Flood event triggered urgent mitigating measures: Large scale flood mitigation works were carried out in the centre of Kuala Lumpur, with the works consisting of the deviation and channelization of the Sungai Klang from its confluence with the Sungai Gombak to the centre of the town downstream for about 5 km. One of the worst flood events occurred in 1971 causing damages worth more than RM 34 million. This event demonstrated the inadequacy of the Klang channels and pointed to urban development as the most likely cause of the aggravated situation (Douglas 1984). Mitigating programmes included further channelization of the Sungai Klang, Sungai Gombak and Sungai Batu. The construction of the Sungai Batu Dam provided a major flood mitigating facility.

River flooding in the Klang Valley still persist. In 1985 for instance, more than 5,500 people were evacuated; in 1987, 4 people lost their lives and more than 8,000 people were evacuated, and in 1988, more than 14,000 people were evacuated. The flood which occurred on in 22nd December 1995 was the worst event since 1971. Continuous heavy rain for more than 15 hours was the major factor contributing to flooding on almost all low-lying areas and flood-plains along Sungai Klang and its tributaries. Daily rainfall records from several station in the Klang Valley showed values ranging from 95.0mm to 190.5mm which exceeds the 100-year return period (Jabatan Pengairan dan Saliran 1995). During this flooding event, one person was killed, about 9,000 people were evacuated, and there was severe damage to property and extensive disruption of the transportation system. The worst hit residential area was Taman Sri Muda in Shah Alam, where the water level passed the two-meter mark, forcing more than 3,000 people out of their homes, and estimated loss of property was close to RM 200 million (The Star 1995).

Flash-floods are the most common geohazard in the Kuala Lumpur area and more than 100 separate incidents have been reported over the past five years. The events are normally localised and usually occur with little or no warning after heavy rain and can reach peak level in a short time. Damage to properties are difficult to estimate due to the lack of proper survey, however, flash-flood events usually interrupt traffic-flow and cause inconvenience to urban dwellers. Major causes of flash-flood in the Kuala Lumpur area are increased surface impermeability due to an increase in the built component, increased accelerated erosion from exposed surfaces resulting in severe siltation downstream, poor maintenance of drainage facilities, and an increase of the peak flow and runoff volume of rivers and streams due to increase in built-up area.

The magnitude of change in surface water characteristics and the environmental implications of these changes have been studied in the Kuala Lumpur area by Fricke and Lewis (1976). The analysis of the data revealed that urbanisation in Kuala Lumpur caused an increase of the peak flow by an average factor of 4.23, and the runoff volumes by an average of 252% which explain the frequent occurrences of flash-flood. Table 1.3 shows the increase of runoff coefficient as the land-use changes.

Table 3..3: Runoff Coefficients for Urban Centres in Peninsular Malaysia

Type of Land Use	Runoff Coefficient
Jungle (normally steep)	0.35
Rubber estate	0.45
Parks (normally flat)	0.30
Mining land	0.10
City areas (fully built-up)	0.90
Industrial areas	0.80
Residential	
4-8 houses/acre	0.65
8-12 houses/acre	0.75
Pavement	0.95

Source: Fricke & Lewis 1976

Landslide and Slope Failure

The combination of heavy rainfall, steep slope and the nature of deeply weathered rocks results in landslides or slope failures in hilly terrain, mining areas and cut and fill slopes along roads and residential areas in the Kuala Lumpur. The total number of occurrences and estimated cost of

damages to property and public utilities is not known. Landslips cause a disruption of the transportation system and also massive traffic jams. Landslide and slope failure events in Kuala Lumpur have not been handled systematically by the relevant government agencies. There is no proper monitoring system and no landslide survey has been carried out to estimate the extent of this hazard, making it difficult to manage and control. However, some of the landslide and slope failure events that result in loss of lives, and large property damage, trigger public concern and they receive government attention and in such a case an investigation by the Institute of Public Works Malaysia (IKRAM) and Geological Survey Department will be carried out. Several slope failures in Kuala Lumpur have been reported by the local press: Between 1990 to 1996, there were 21 cases which had severe impacts on human activities (Pereira and Ibrahim 1997).

Perhaps the first major incidence which brought about a public awareness of the dangers posed by landslide occurred in January 1981 at one of the open-cast mining area near Puchong. The multiple sliding that occurred which was followed by a mudflow involving the mine bank, 150m in length, 20m thick and 200m wide, took several hours to complete its entire sliding sequence. In this incidence a number of residential houses nearby were caught in the landslide and a total of 18 lives were lost (Ibrahim 1989).

In more recent years Kuala Lumpur saw the horrendous result of land degradation caused by land clearing which led to slope failure which eventuated in tragedy. At about 1.30 pm. on Saturday 11th December 1993, Block 1 of the Highland Tower Condominium at Ampang Jaya suddenly collapsed. Based on the MPAJ (1994) report, four retrogressive landslides occurred behind Block 1. The resultant debris imposed surcharge loading on the terrace. A fifth slip plane propagated around the pile foundation of the tower, destroying the front retaining wall. This resulted in a loss of lateral support for the front row piles, causing the piles to break and the building. This caused further structural failures which led to the collapse. Obviously the collapse of the Highland Tower was initiated by the landslide which occurred on the cut slope behind the block. The landslide was 120m long and about 90m wide, involving approximately 40,000 cubic meters of debris. In this tragedy 48 lives were lost.

While the just described event was almost entirely man-induced the second event which took place on the late afternoon of 30th June 1995 was largely due to natural causes. After a spell of heavy rain throughout the Klang Valley region, a massive debris flow originating from the Genting Sempah catchment area swept over the Genting Highland sliproad, killing 21, injuring 23 and damaging vehicles. Intense and heavy rain saturated the residual soil, triggering at least two major landslips upstream of one of the tributary of Sungai Gombak. The landslip material entered the stream forming a debris flow which subsequently uprooted trees and excavated top soil and

boulders in its path downstream. Gravity increased the momentum of the debris flow thereby increasing the power of scouring. The debris flowed over the length of approximately one kilometer with an estimated amount of material of about 3,000 cubic meters. The scaring resulting from the landslide degrades the utility of the area.

Erosion and Siltation

The most prevalent form of land degradation in the humid tropic is due to erosion and siltation. In Kuala Lumpur bare eroding slopes and drains choked with sediment can often be observed on building sites. Several studies carried out indicate that massive amounts of sediment are transported from development sites. Instantaneous stream suspended sediment concentrations from storm discharges, ranging from 15,000 mg l^{1} to 80,000 mg l^{1}, have been recorded from streams draining catchments undergoing development in Kuala Lumpur (Douglas 1978 and Leigh 1982). Excessive soil losses have been observed from construction sites and from sites cleared of vegetation but awaiting development.

Highland development concentrated at the northern rim of the Federal Territory gives rise to severe soil erosion which is then followed by siltation downstream, degrading surface water quality through sedimentation. Kuala Lumpur experiences heavy rainfall of high intensities. The rainfall intensities often exceed 100 mm per hour and are therefore extremely erosive. Chan (1997) has shown that the rate of soil loss in hilly areas in Penang and Kuala Lumpur is alarming. His study in the Penang Hill area, for example, indicates that an average slope of 30 degrees can give rise to a 50-fold increase in surface runoff and soil loss of between 700 to 10,000 tonnes/ha/year (very severe erosion).

In Kuala Lumpur area the study by Balamurugan (1991) cited in DOE (1996), showed that the total suspended sediment of the Sungai Klang is estimated to be about 250-550 m^3/km^2/year. The extremely high concentration of sediments in rivers usually result soon after land clearing activities. In fact, Douglas (1978) found a maximum concentration of suspended sediments of about 81,200 mg/l in the Sungai Anak Ayer Batu after a rainfall of only 75mm in a 45-minute spell.

Urban sediment yields in Kuala Lumpur indicate that an area undergoing construction usually experience sediment yields 2 to 3 orders of magnitude greater that those under natural forest. Furthermore, in a built-up area like Kuala Lumpur, the importance of extreme events is often more marked than under natural conditions. In Penang, between 35 to 80 percent of the annual load is carried in a single month during the rainy season.

Small bare areas such as urban construction sites on deeply weathered rocks, particularly granites, yield huge quantities of sediment in short periods of time. Mykura (1989) cited in DOE (1996), studied a bare site at Mengkuang Heights in Ulu Klang, Kuala Lumpur, and found that the rate of average sediment yield at this area was 330,821 tkm^{-2} y^{-1}. Sediment yields found for the various urban land-uses are listed in Table 3.4.

Table 3.4. Estimate of Sediment Yield Under Different Types of Landuse in Kuala Lumpur. (* Cited in DOE 1996)

Catchment	**Land use**	**Sediment Yields [$tkm^{-2}y^{-1}$]**	**Source**
Sungai Jinjang	Newly urbanising	1056	Balamurugan (1991) *
Sungai Klang	Newly urbanising	1480	Balamurugan (1991)*
Sungai Batu	Forest & Urban	1265	Balamurugan (1991)*
Sungai Gombak	Forest & Urban	1157	Douglas (1978)
Sungai Air Batu	During construction	38,500	Leigh (1982)
Sungai Air Batu	During construction	10,000	Douglas (1984)
Sungai Jinjang	Mining & Quarrying	2,282	Balamurugan (1991)*

River bank erosion is also a common problem along the Sungai Klang and its tributaries. Detailed monitoring of the occurrence of the events and a study on the level of risk to the public have not been conducted by any agency. Based on newspaper reports, between 1990 to 1996 there were at least 21 incidents of river bank erosion which had severe impact on urban dwellers: River bank erosion resulted in the destruction of at least 3 bridges and 14 houses in seven separate incidents. In addition, several squatter settlements located in hazardous locations along the Sungai Klang were in danger of collapsing into the river.

Subsidence and Sinkhole Occurrence

Another factor contributing to land degradation is land subsidence. Subsidence and sinkhole occurrences are common in the Klang Valley, particularly in the Kuala Lumpur area where limestone forms the predominant bedrock. This phenomenon has not been systematically documented, except when it affects humans, at which point these events will make it to the pages of the local press. Subsidence or depression of the land surface is mainly related to the lowering of the groundwater table and appears to be strongly correlated with the formation of sinkholes.

Subsidence in the Batu Arang area several years ago was attributed to the collapse of an old underground coal mine (Mohamad Ali 1992). Sinkholes in Kuala Lumpur have similar physical characteristics: they have circular outlines at the surface and have steep side walls which are funnel-shaped. They normally occur suddenly without giving any warning of impending collapse.

Most sinkholes in the Klang Valley are formed by the dissolution of limestone by groundwater. The action leads to the formation of solution channels within the limestone bedrock. These channels eventually will enlarge creating a network of tunnels and caverns. Under certain conditions, either naturally or externally induced, the roof rock of a cave may collapse and leave a void above it. The soil materials above the roof may in turn fall in, so that the void space propagates upwards. When it approaches the ground surface a critical stage is reached whereby the affected land collapses and a sinkhole is formed. The surface collapse could be triggered off by some externally induced processes. The main contributing factor is usually rapid downward percolation of groundwater which is often related to a lowering of the water table through pumping activities.

Only a few studies have been conducted on subsidence and sinkhole events in the Klang Valley area. One of the work was carried out by Shu (1986) who investigated an event which occurred at the Sungai Besi - Serdang area. This area forms part of the Kuala Lumpur alluvial plain overlying the limestone bedrock. Sinkhole events have occurred on several occasions in the past in this area but were not reported because of negligible impact to human activities. Around December 1977, a small sinkhole (1m diameter) developed adjacent to a stream. Subsequently, this stream disappeared underground through the sinkhole which gradually increased in size. Following the formation of this sinkhole, there was a gradual lowering of the water table in the wells in the surrounding area, as well as the formation of several other sinkholes. Consequently, general land subsidence in the area was observed when cracks appeared on the floors, walls and ceilings of several houses. The subsidence also affected the Kuala Lumpur - Seremban Highway where a partial collapse of the road had to be repaired. In this case, the occurrence of the sinkholes followed by general land subsidence of the area were related to the lowering of the groundwater table, probably due to the dewatering processes taking place at the adjacent open-cast tin mine.

DEGRADATION OF SURFACE WATER RESOURCE

The Sungai Klang drains an area of 1,200 sq.km extending from the headwaters in the steep mountain forests of the Main Range of Peninsula Malaysia, to the river mouth for a total length of 120 km. The main tributaries of Sungai Klang are Sungai Keroh, Sungai Gombak, Sungai Jinjang,

Sungai Batu, Sungai Kerayong, Sg Penchala, Sungai Kuyoh, Sungai Damansara and Sungai Ampang. The river system drains all the major urban centres in the Klang Valley, viz. Kuala Lumpur, Petaling Jaya, Subang Jaya, Shah Alam, Klang and Port Klang.

The effective catchment areas of Sungai Klang, Sungai Batu, and Sungai Gombak which drain to the Kuala Lumpur area are relatively small. As a result of the mountainous nature of the upper reaches and the rapid development ongoing within this watershed areas, extreme high flows can be experienced at any time during the rainy season and even in the remainder of the year during the thunderstorms. The Klang Gates Dam has significantly reduced the natural flow in Sungai Klang. At present, no flows are released from this dam to compensate for reductions in dry weather flow caused by the dam, except for overflows released because of heavy inflows during the rainy season.

The Batu Dam, which became operational in 1988 further reduced the natural flow of the Sungai Batu and Sungai Klang (downstream of the Sungai Gombak confluence). The variation between maximum and minimum peaks is substantial, and the magnitude of average flows shows that storms in the watershed area contribute to sudden surges of flow in all river systems. Sungai Klang is tidally below the Puchong weir up to the river mouth.

The flow data shows that the Sungai Klang flow quantities are relatively small compared to the degree of development in the Klang Valley region. This situation simply means that maintaining an acceptable level of water quality in the Klang Valley will always be a difficult problem and that an acceptable minimum water quality level can be maintained only if careful attention is paid to planning and implementation of water pollution control facilities. The importance of this finding can scarcely be overemphasized.

All urban communities in the Klang Valley are served by a common water supply, which is handled by Klang Valley Water Supply and Distribution System. At present the Klang Valley is the service area, supplied by water taken mainly from storages in the upper reaches of the Sungai Klang and Sungai Langat (Klang Gates, Batu, Langat and Semenyih Reservoirs). In the future, the demand for water supply will be solved by developing water resource from Sungai Selangor.

DEGRADATION OF GROUNDWATER RESOURCE

Groundwater is a major resource of the Kuala Lumpur area which to date has been exploited to a limited extent only. This is because its potential for development is highly variable and depends to a large extent on the local geology at each site. Groundwater use has been limited mainly to

individual well water supplies in villages and to tin mining operations. However, some industries have recently been encouraged to develop groundwater supplies for their own use.

The Klang Valley has significant amounts of groundwater resource for domestic and industrial uses. The GOM (1987) report indicated that three geological formations have the greatest potential for development of groundwater, namely,

- Kenny Hill Formation (yields up to 1.3 mld per well have been estimated)
- Kuala Lumpur Limestone (yields up to 8.7 mld per well have been estimated)
- River Alluvium (yields up to 8.7 mld per well have been estimated)

From the studies carried out Kuala Lumpur appears to have sizable groundwater resources which can be widely utilised in the future. The main reasons for the lack of interest in using groundwater for municipal purposes are the fact that there is an abundance of surface water and there is a large variability in groundwater geology, resulting in a difficulty in estimating safe yields.

The study by Nasiman and Nazan (1996) shows that groundwater in the Klang Valley is currently under severe threat of pollution from contamination of leachate generated by municipal landfills, untreated or partially treated wastewater and polluted storm water. Mining activities, particularly tin and sand in the alluvial plain, have resulted in the removal of top soil and clay layer, and large amounts of aquifer materials have been excavated and displaced during these mining operations which resulted in the creation of pits and artificial lakes. The study further shows that the major effect of the removal of top soil and clay layer is to create direct pathways of pollutants to enter the aquifer thus degrading the quality of underground water. Recharge into the aquifer of pollutants and others would further increase due to infiltration of rainwater and runoff into the excavated lands. To make matters worse, because they are not suitable for other land-use they are often used as landfills such as those at Sungai Besi, Jinjang and Kelana Jaya. These landfills introduced solid wastes in the groundwater zone thus permitting large quantities of leachate to flow freely into the alluvial sand aquifer thereby permanently damaging a large volume of underground water resource.

KUALA LUMPUR'S NATURAL LANDSCAPE IN THE EARLY YEARS

Kuala Lumpur was founded around 1857 out of a small tin mining camp carved out from a small Malay village at the confluence of Sungai Gombak and Sungai Klang by tin miners and prospectors. In the process of mining in and around the Ampang area it is natural to assume that patches of natural riparian forests along the rivers and in the vicinity of the confluence and

particularly in the Ampang area were cleared for mining and settlement purposes. Much of the surrounding areas, however, especially in the Kg. Batu, Kg. Pandan, Gombak, Setapak, Damansara, Weld Hill (now Federal Hill), Kenny Hills (now Bukit Tunku), Seputih and others were left under pristine forest cover. However, sometime in 1867 much of the mining village was destroyed by fire and arson due to rivalries between miner factions and the mining areas were left idle and later swamps developed without much vegetation (Nik Anuar Nik Mahmud 1995).

There were very little records of the vegetation and plants of Kuala Lumpur area prior to Henderson (1928) . In this pioneer publication on the greens of Kuala Lumpur he described the various types of natural vegetation of Kuala Lumpur which consists of luxuriant lowland dipterocarp forests straddling some low lying areas and small hills as well as some limestone hill outcrops with stunted forests. More than a thousand plant species were listed by families as occurring in the Kuala Lumpur area then. Some of them included, *Impatiens ridleyi* (Ridley's balsam), *Ophiorrhiza fruticosa, Pavetta pauciflora, Psychotria lanceolarium, Hoya occlusa, Boea verticellata, Justicia microcarpa, Phyllanthus erythrocarpus, Ranalisma rostrata, Raphidophora burkillianus* and *Pothos lorispatha* which are endemic to the Batu Caves. The Ampang area, in particular the Bukit Belacan Forest Reserve and Ampang Ridges, the Bukit Nenas Forest Reserve and Weld Hills, contain many plant species of scientific interests.

Beginning of Urbanisation

Basically the green areas in Kuala Lumpur before urbanisation took place could be categorised as follows:

Primary Lowland Forests

It is assumed that much of the Kuala Lumpur areas were covered with lowland dipterocarp forests similar to most part of Selangor and Peninsular Malaysia. Kuala Lumpur then was both the commercial capital of Selangor and administrative capital of the Federation of Malaya and later Malaysia. As development and urbanisation took place must of these forest areas were cleared and destroyed. It is interesting to note that urbanisation took place in the direction of Sungai Klang through Petaling Jaya, Shah Alam towards Klang. Hence much of the forests in that belt suffered, whereas the forests north of Kuala Lumpur towards Kepong and Rawang, south towards Sungai Besi and Kajang, and east towards Hulu Langat were left undisturbed for quite a long time. Remnants of these natural forests are to be seen presently at Bukit Nenas Forest Reserve, Bukit Belacan Forest Reserve, Seputih Forest Reserve and Sungai Putih Forest Reserve, although without the most dominant components of the forests, the dipterocarp trees. Henderson (1928) listed the species components of these forests. However, with the vast development that had taken place the density of these species has decreased tremendously.

Today it is still possible to view the much smaller remnants of these forests in places like Bukit Tunku, Seputih residential areas, Ulu Klang residential areas, Damansara Heights and others.

Limestone Hill Forests

Much of the present Kuala Lumpur is sitting on a limestone formation. Batu Caves is probably the only limestone hill that has survived the onslaught of development in the city, even though quarry activities have continued in the last 20 years. This place survived probably due to the use of the caves by the Hindus in their annual religious festival of Thaipusam. Every year thousands of pilgrims and tourists visited this sacred place. Many endemic and scientifically interesting plants are still to be found on this hill including *Cissus javana*.

After Independence urbanisation set in and Kuala Lumpur experienced tremendous changes in its landuse patterns and infrastructures. As population increased demand for commercial centres, office spaces, housing estates and other amenities rose. To facilitate these changes old roads were widened and extended and new roads constructed to make way for increasing traffic. The existing railway networks were also improved, new industrial areas were identified, old commercial areas dilapidated and new ones established, new educational and government institutions established, government department buildings erected and many new recreational areas established. All these development processes took place at the expense of green areas, notably the vast secondary forests.

As a result the vegetation of Kuala Lumpur changed to the following categories:
Remnants of Lowland Dipterocarp Forests. These remnants are still visible to-day. It makes one wonder for how long they can survive the onslaught of the city development

Limestone Hill Vegetation at Batu Caves. As claimed above this site may survive on religious grounds.

Secondary Forests. As a result of intensive clearing of primary forests for development secondary elements came in as pioneer species. Stands of *Macaranga gigantea, M. triloba, M javanica, Mallotus paniculatus, Trema orientale, Saccharum spontaneum* are prominent. Where the primary forests were partially destroyed, forest gaps were formed and pioneer species came in later to amalgamate with the natural vegetation. In addition, many species of weeds also came in when lands were exposed for a long time without development. Many areas around the Damansara, Sungai Besi, Sentul, Kg. Pandan and Ampang areas show evidence of such mixture of primary and secondary forest components. Nevertheless, they are also green

areas even though impoverished.

Village Orchards. The city of Kuala Lumpur still possess some isolated Malay villages with dominant orchards. These remnants of old lands that are maintained generation after generation without much disturbances to the natural landscapes. Many such villages can still be found in the Setapak, Gombak, Kepong, Kg. Pandan, Cheras, Ulu Klang, Sungai Besi, Sentul, Kg. Baru and Batu areas. In Kg. Baru, Setapak and Gombak the Malay villages still exist in the original settings. Among the plant components of these vegetation are mangosteen, (*Garcinia mangostana*), durian (*Durio zibethinus*), langsat (*Lansium domesticum*), rambutan (*Nephelium lappaceum*), pulasan (*Nephelium ramboutan-ake*), bananas (*Musa* spp.), papayas (*Carica papaya*), cermai (*Phyllanthus acidus*), jackfruit (*Artocarpus heterophyllus*), pomelo (*Citrus grandis*), coconut (*Cocos nucifera*), pomegranates (*Punica granatum*) and other minor commodity species. There were talks a few years ago of a proposal to convert the vast lands in Kg. Baru into a commercial area but nothing eventuated.

Introduced Plants. Many foreign and exotic plant species are being introduced to the city for landscape beautification purposes. It is estimated that more than 400 plant species have been introduced and with an extensive programmes of multiplication or propagation carried out by the Kuala Lumpur City Council, these alien species continue to proliferate. The dominant species include *Acacia auriculiformis, A. mangium, A. richii, Samanea saman, Delonix regia, Pithecellobium dulce, Araucaria cunninghamii, Filicium decipiens, Hura crepitans, Tabebuai pallida, T. rosea, Bixa orellana, Pachystachys lutea, Sanchezia speciosa, Agave americana, A. angustifolia, Eucalyptus deglupta, Sanseviera trifasciata, Allamanda cathartica, Thevetia peruviana, Lagestroemia indica,* and *Heliconia* spp. and many more.

Other than the alien species, local plants of beach vegetation origins have also been introduced into the city for the same purpose. These include *Pongamia pinnata, Eugenia grandis, Craeteva magna, Casuarina equisetifloia, Fagraea racemosa, Pterocarpus indica Pandanus tectorius* and *Cycas rumphii.* Other local species of forest origin include *Milletia atropurpurea, Cinnamomun iners, Dillenia suffruticosa, Ficus benjamina, F. elastica, F. religiosa, Bombax ceiba, Lagerstroemia speciosa, Ixora javanica, Cyrtostachys renda, Pinanga malayana, Tacca palmata, Vitex trifolia* and many more.

Most, if not all, of the problems of urban green depletion arise from the great increase of population, from the concentration of this population in much restricted areas, and from the increased requirements for basic amenities such as water, electricity, housing, transport and

disposable products brought on by an increasing standard of living. In essence, these are the similar experiences that most cities went through, though in somewhat different magnitude depending on the planning by the respective city councils. It is a well known fact that the concentration of people and industries in urban areas has already created highly complex problems in the existing green areas. As green areas are always viewed as less productive, less valuable and economic they tend to lose out to developers.

It is ironic that trees and forests have served mankind since the dawn of history. And yet the first thing that an urbanite man wishes is to cut a tree or clear the remaining forest. It is also known that a vast majority of the decision makers in the city are people who have originated from the villagers who had in their early years appreciated the pristine rural landscapes. However, when these people became decision makers they seem to forget their origin and tradition. In the days of the British administrators trees were planted along the roadsides for both shade and beauty in the tradition of the British. As such before the independence, gardens, parks and forests for man's enjoyment became the interest of many of the nobility, aristocrats and colonial officers who were the landowners.

KUALA LUMPUR'S LANDSCAPE AFTER URBANISATION

The natural landscapes of Kuala Lumpur have changed tremendously even before its proclamation as the Federal capital on 1st February 1973. With that proclamation a total of 243 sq. km was declared a Federal Territory and at that time 70% of the area had already been developed. With an average population growth rate of 4%, the ever-increasing urban population has been putting great pressure on undeveloped areas which were only unofficially classified as green areas. At the same time there was a significant number of rural people coming to the city to search for a better living and these people became squatters, exerting similar pressure on the remaining green areas. From its formative years to about 1945 the population of Kuala Lumpur increased by about 4,200% and from 1960 to 1990 the increase was about 200%. The number of concrete buildings increased by about 2000% from 1884 to 1945 and from 1960 to 1991 the increase was about 40,000%. As a consequence today Kuala Lumpur can be viewed as a concrete jungle (Sham *et al*. 1983). It has been reported that it has about 0.4 ha of open space per 1000 population and the world's standard is 1.6 ha per 1000 persons and it is expected that this ratio will become even smaller in the future.

Today Kuala Lumpur has more than 1100 km of roads and efforts have been made to increase more and widen the existing ones into expressways. The present railway system has been expanded for the commuter trains and light rail transit systems are under way. All these transport modes exert pressure on the existing greenbelts on both sides of the roads and railway

lines.

At the time of rapid urbanisation and infrastructural development Kuala Lumpur was considered fortunate to inherit three small pockets of forest reserves, namely, Bukit Nenas Forest Reserve, Seputih Forest Reserve and Sungai Besi Forest Reserve. These three areas constituted important green lungs and small watersheds for the urbanised area which were significantly conserved (Ayoub 1989). However, all these forest reserves have been subjected to development pressure recently and are already depleted. At the Bukit Nenas Forest Reserve the nations's highest telecommunication tower was built. Some of the Seputih Forest Reserve have been excised for housing estates while a bigger portion of the Sungai Putih Forest Reserve near Cheras has been cleared, apparently without permission from the City Hall. With these development the forest reserves have ultimately become even smaller island forests that are unable to function as watershed areas, let alone be the refuge of the remaining wildlife and flora in the city.

Pockets of these kind of forest also existed as green corridors and zones such as the Damansara, Bukit Kiara, Taman Tasik Perdana, Bukit Tunku and Pencala-Segambut forest corridors. These green areas attracted a significant amount of animal diversity, particularly birds from the areas outside of Kuala Lumpur, in addition to hosting many original plant species. A cursory investigation today will reveal that a large portion of these forests are now golf courses or residential areas. The percentage of areas of Kuala Lumpur which are considered green are slowly depleting as can be seen from Table 3. 5.

Table 3.5: Percentage of Green Area in Kuala Lumpur

Year	Estimated % of green areas
1950	60.0
1966	52.9
1974	46.9
1985	34.3

The depletion of urban green areas include the consistent and constant loss of existing forests of all types, including vegetable gardens, village orchards, playing fields, turfs and other grounds that are covered with trees or grasses. A good example is the loss of the Ampang Turf Club to developers a few years ago.

In the early formative years of the Federal capital, greening of land and landscaping were not given much emphasis in the structural plans of various built-up areas in the capital as concepts and awareness were lacking. In addition there were no specific policies and guidelines to green the capital and to conserve the existing green areas. With the establishment of the Federal Territory Planning Act 1982 policies pertaining to urban landscaping and nature conservation were instituted (Khuzaimah 1989). Many programmes of tree planting and the establishment of thematic parks and gardens were initiated. By the year 1989 an urban forestry policy was formulated and a total of 257,400 trees were planted for different ethnobotanical reasons, such as medical and aromatic plants, fruits trees and exotic ornamental plants, in various places. In addition, some of the original species have been able to remain intact, albeit in small scattered populations (Latiff 1986). Even though isolated by tall buildings and other built-up areas, these populations of original species of plants together with many introduced exotic species represent the present urban plant diversity (Ng 1982).

Impacts of Green Areas

As the city develops further threats to existing forest reserves and other green areas will became more acute. More and more primary vegetation will change to secondary vegetation and the remaining secondary vegetation will make way for more built-up areas. Very soon the existing natural forest remnants will be gone forever.

Lately DBKL introduced the concept of urban forestry and embarked on intensive tree planting as well as established new parks and green spaces. Before Independence the Lake Garden (now Taman Tasik Perdana) was the only park in the city. However, today the DBKL can boast of a few additional ones such as Taman Titiwangsa and the Bukit Belacan recreational site (Tho *et al*. 1983).

Trees in the city was are known to affect microclimate : air temperature, humidity, wind, precipitation, solar radiation and longwave radiation are all affected by vegetation. As the city is a complicated agglomeration of many types of natural and man-made structures, tall buildings, low buildings, factories, streets, parking lots, courtyards, parks, hills, lakes and rivers, each location has its own microclimate (Yap and Adnan 1989). Each of this location is affected by the vegetation it contains.

No doubt the old cliché that beauty lies in the eye of the beholder is well known and the appreciation of trees as well as landscaping is subjective. The colonial officers who developed Kuala Lumpur were conditioned by history and ecology. But while very old trees are objects of

veneration for some, they are regarded as nuisance by others. Those who like to see more green areas are inspired chiefly by the concepts of conservation movements but development is motivated primarily by economics and monetary gains. To compound the problem, the planning by the authority or local government was preoccupied with just improving housing and commercial centres without due consideration being given to vegetation.

One of the effects of depleting the remaining green areas is to increase the water yield. Therefore, converting the green environment into a concrete jungle affects the water retention drastically (Soepadmo 1984). As urbanisation reduces interception, infiltration, soil moisture storage and evapotranspiration, overland flow and runoff will increase leading to erosion and siltation, flooding and flashfloods. All these geohazards have cost us lives and extensive property damage. As long as the problem is not overcome, Kuala Lumpur will continue to be beleaguered by such hazards. Hence, the urban green issue is not just an issue of aesthetics but of urban survival.

Figure 3.1: Hierarchy of urban centres in the Klang Valley (Kuala Lumpur Structure Plan 1984).

Figure 3.2: Arterial system of the Federal Territory of Kuala Lumpur.

Figure 3.3: Geohazard map of the Klang Valley.