Andy Russel Immit Mojiol

Ecological Landuse Planning and Sustainable Management of Urban and Sub-urban Green Areas in Kota Kinabalu, Malaysia

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Ecological Landuse Planning and Sustainable Management of Urban and Sub-urban Green Areas in Kota Kinabalu, Malaysia

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by
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By means of trees, wildlife could be conserved, pollution decreased and the beauty of our landscapes enhanced. This is the way, or at least one of the ways, to spiritual, moral, and cultural regeneration.

E.F. Schumacher
(16 August 1911 - 4 September 1977)

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TABLE OF CONTENTS

Acknowledgements i

Table of contents iii

List of abbreviations vii

List of tables viii

List of figures xi

1.0 Introduction

1.1 General background 1

1.2 Malaysian Constitution: land is a state matter 3

1.3 Sabah Forest Decline 4

1.3.1 Shifting cultivation 5

1.3.2 Logging 7

1.3.3 Agricultural expansion 8

1.3.4 Mining and quarrying 8

1.3.5 Infrastructure development 9

1.4 Problem statement and objectives 9

1.5 Structure of the study 11

2.0 Background Information on the Study Area

2.1 General Information on the State of Sabah 12

2.2 Population and ethnicity composition 13

2.3 Land Use 15

2.4 Protected Areas in Sabah 17

2.4.1 Forest Reserve Area 17

2.4.2 Parks and Other Recreational Areas 18

2.4.3 Wildlife Reserves and Sanctuaries 20

2.4.4 Water Catchment Management Area 21

2.4.5 Plantation forestry 22

2.5 Climate of Kota Kinabalu 23

2.5.1 Temperature and Rainfall Distribution 23

2.5.2 Wind 25

2.5.3 Relative Humidity 28

3.0 Materials and Methods

3.1 Procedure and Methodology 29
3.2 The Research area 30
3.3 Research Design 32
3.4 Tree inventory and analysis 33
3.4.1 Tree inventory/ survey 33
3.4.2 Stand structure analysis 36
3.4.3 Stand basal area 41
3.4.4 Stand volume 41
3.4.5 Accuracy and error of vegetation assessment 43
3.4.6 Floristic analysis 43
3.5 Bird Survey/ Observation and Analysis 49
3.5.1 Bird Survey 49
3.5.2 The Detection Function and Assumptions 51
3.5.3 Bird Data Analysis 52
3.6 Sociology Survey and analysis 53
3.6.1 Sociology Survey 53
3.6.2 Sociology Data Analysis 56
3.7 Classification of Land Cover and Urban Forest Functions 56
3.7.1 Land cover classification 57
3.7.2 Suburban Forest Function Classification 59

4.0 Tree Survey and Stand Analysis in Kota Kinabalu

4.1 Species area curve 62
4.2 Mean diameter 64
4.3 Diameter distributions 66
4.4 Stand height 69
4.4.1 Mean height and Top height 72
4.5 Stand density 73
4.5.1 Stand basal area 73
4.5.2 Stand volume 74
4.6 Accuracy and error of the vegetation assessment 75
4.7 Floristic analysis 76

4.7.1 Species composition 76
4.7.2 Species diversity 79
4.7.3 Species similarity 81
4.7.4 Species richness 82
4.8 Regeneration potential 84

5.0 Bird Survey and Analysis

5.1 Development of birdlife in Kota Kinabalu 91
5.2 Present birdlife observed in Kota Kinabalu 92
5.2.1 Bird categories 92
5.2.2 Bird families 94
5.2.3 Bird presence/ persistence 95
5.2.4 Overall population density and abundance 95
5.3 Bird Habitats in Kota Kinabalu 97
5.4 Potentially important bird areas in Kota Kinabalu (IBAK) 105
5.5 Basis for birdlife protection in Kota Kinabalu 109
5.5.1 Conditions of legal wildlife protection in Sabah (appendix 23) 109
5.5.2 Present condition of wildlife protection in Kota Kinabalu 113

6.0 Public Perception of Urban Green in Kota Kinabalu

6.1 Demographic profile of survey respondents 118
6.2 Perception of urban green areas in the town zone 122
6.2.1 Importance and benefits of urban green areas 122
6.2.2 Recreation activities for visiting urban green areas 123
6.2.3 The significance of conserving urban green areas 125
6.2.4 The perception of tree management in Kota Kinabalu 126
6.3 Village zone: Perception of forest areas 129
6.3.1 Importance and benefits of the forests 129
6.3.2 Dependence upon forest resources 129
6.3.3 Perception and opinion towards conservation 131
6.3.4 Wildlife species found in the forest 132
6.3.5 Interesting nature resources in the villages 133
6.3.6 Problems given by the forest in the villages 135
6.4 Obvious differences between town and village people perceptions 136

7.0 Classification of Urban Forest and Green Spaces Functions

7.1 Landform and Soil Classification 140

7.2 Vegetation Zones 145

7.3 Agriculture Capabilities 148

7.4 Land Use and Biotope Classification 152

7.5 Classifying urban green spaces and forest functions in Kota Kinabalu 173

7.5.1 Bird habitat function 174

7.5.2 Nature conservation function 182

7.5.3 Protection function 188

7.5.4 Recreation function 206

7.5.5 Utility function 211

8.0 Interpretations, discussions and recommendations

8.1 Tree stands 217

8.2 Bird life 220

8.3 Public perception 225

8.4 Biotope and land use 228

8.5 Green area and forest functions 230

8.6 Conclusions and recommendations 232

9.0 Summary 237

References 245

Appendices 253

Curriculum vitae

LIST OF ABBREVIATIONS

CIR	Color Infra-red Picture
EIA	Environment Impact Assessment
FAO	Food and Agriculture Organization
GIS	Geographic Information System
GPS	Geographic Position System
GTZ	Deutsche Gesselschaft für Technische Zusammenarbeit (German Technical Assistant/ Cooperation)
Ha	Hectare
IBA	Important Bird Areas
ITTO	International Tropical Timber Organization
IUCN	International Union for Conservation of Nature and Natural Resources
JICA	Japan International Cooperation Agency
Kg	Villages (Kampung)
KKCBS	Kota Kinabalu City Bird Sanctuary
KKIP	Kota Kinabalu Industrial Park
Mio	Million
Mt	Mountain (Gunung)
NGO(s)	Non-Governmental Organization (s)
NP(s)	National Park(s)
NWFP	Non Wood Forest Product
PFE	Permanent Forest Estate
SPSS	Statistical Package of Social Sciences
SPOT	System Pour I´Observation de la Terre
SWD	Sabah Wildlife Department
UMS	University Malaysia Sabah
UPM	University Putra Malaysia
UNCED	United Nation Convention for the Environment and Nature
WWF	World Wide Fund for Nature

LIST OF TABLES

Tab.	1	:	Distribution of Major Forest Types in Malaysia, 1998 (Million ha) ...…	3
Tab.	2	:	Ethnic composition of Sabah by administrative district ………..........	14
Tab.	3	:	Sabah Permanent Forest Estate (PFE)	18
Tab.	4	:	State parks in Sabah	19
Tab.	5	:	Wildlife Reserves, sanctuaries and conservation areas	20
Tab.	6	:	Summary of Forest Cover in Sabah	22
Tab.	7		Average of Monthly Mean Rain days for Kota Kinabalu station (1995 – 2004) ………………………………………………………………	24
Tab.	8	:	The Beaufort Scale and Wind Speed Intervals in Sabah	26
Tab.	9	:	The Frequency (%) of Wind Speed (m/s) and Direction - Period I (January), Period II (May – September), Period III (October) and Period IV (November – March), Kota Kinabalu	27
Tab.	10	:	Average of Monthly Mean Relative Humidity (%) for Kota Kinabalu, (1995 – 2004)	28
Tab.	11	:	Equations tested to fit height curves of disturb forest stands in Kota Kinabalu	40
Tab.	12	:	Frequency classes as used in frequency diagrams according to Raunkiaer (1934)	44
Tab.	13	:	The function and subfunctions applied for classifying urban forest function in Kota Kinabalu	60
Tab.	14	:	Examples for scoring criteria of conservation function	61
Tab.	15	:	Mean diameter ($\bar{d}$) and mean diameter based on basal area (d_g) of four distinguished vegetation types in Kota Kinabalu, with tree dbh$\geq$10cm ...	65
Tab.	16	:	Stem number distribution according to 10 cm diameter classes	68
Tab.	17	:	Mean height ($h_{\bar{d}}$, h_g, h_L) and top height (h_H, h_{100}) of disturb forest stands in Kota Kinabalu, with tree dbh$\geq$10cm	72
Tab.	18	:	Stand basal area and stand volume of forest stands in Kota Kinabalu, with tree dbh$\geq$10cm	74
Tab.	19	:	Standard error of plot basal area ($S_{\bar{g}}$%) of different vegetation types in Kota Kinabalu	75
Tab.	20	:	The most common tree species in the four distinguished forest types ranked by their Important value Index (IVI)	77
Tab.	21	:	Tree species diversity calculated in some different index (dbh ≥10cm)…	80

Tab. 22 : Coefficient of similarity (*K*) in pair comparisons of different stands, based on number of species (K_s), dominance of species (K_d), and important value of species (K_{IVI}) of Kota Kinabalu (dbh ≥ 10 cm) 81

Tab. 23 : Number of species and family in four forest stands (dbh ≥ 10 cm) in investigated area Kota Kinabalu 83

Tab. 24 : The most common families of trees in four different vegetation stands according to theirs number of species and cover, (dbh ≥ 10 cm) 84

Tab. 25 : The most common regeneration species in secondary re-growth stands ranked according to their IVI 86

Tab. 26 : The most common regeneration species of mixed horticulture stands ranked according to their IVI 88

Tab. 27 : The most common regeneration species of mangrove stands ranked by their IVI 89

Tab. 28 : Population density and abundance of birds in Kota Kinabalu 96

Tab. 29 : Green corridor area for birds in Kota Kinabalu classified from SPOT setellite images 97

Tab. 30 : Important bird habitat categories in Kota Kinabalu district 99

Tab. 31 : Important tree species that attract insects and provide food for birds 104

Tab. 32 : Bird density criterion for analyzing potentially Important Birdlife Areas in Kota Kinabalu (IBAK) 106

Tab. 33 : Important birdlife areas in Kota Kinabalu (IBAK) based on study plots . 107

Tab. 34 : Accounted bird species in 32 representative sampling plots and their legal protection status 113

Tab. 35 : Ethnic background of respondents 118

Tab. 36 : Religion background of respondents 118

Tab. 37 : Age group of respondents 119

Tab. 38 : Educational attainment of the respondents 119

Tab. 39 : Occupations of the respondents 120

Tab. 40 : Income level of the respondents (RM/Month)* 121

Tab. 41 : Respondents perception on the benefits of trees in town 123

Tab. 42 : Respondents perception and opinion towards conservation of green spaces 125

Tab. 43 : Respondents perceptions and opinions on the management of Kota Kinabalu 128

Tab. 44 : Village people dependent upon forest resources in their daily life 130

Tab. 45 : Village people’s perceptions towards participation and decision making. 132

Tab.	46	:	Summary of interesting nature resources found in each village	134
Tab.	47	:	Main Parent Materials of Soils in Sabah	141
Tab.	48	:	Terrain Classes based from amplitude	142
Tab.	49	:	Soil Suitability Groups for Agriculture	149
Tab.	50	:	Agriculture Capability Assessment Related to Soil Associations	151
Tab.	51	:	Biotope and land-use types in Kota Kinabalu	156
Tab.	52	:	The functions and corresponding assessment criteria applied for classifying urban forest function in Kota Kinabalu	174
Tab.	53	:	Classifying bird habitat function areas in different locations in Kota Kinabalu, Malaysia	178
Tab.	54	:	Proposed map legend for bird habitat function areas in Kota Kinabalu, Malaysia ……………………………………………………………....	179
Tab.	55	:	Classifying nature conservation function areas in different locations in Kota Kinabalu, Malaysia …………………………………………………....	185
Tab.	56	:	Proposed map legend for nature conservation function areas in Kota Kinabalu, Malaysia	186
Tab.	57	:	Proposed map legend for protection function areas in Kota Kinabalu, Malaysia ……………………………………………………………....	196
Tab.	58	:	Classifying protection function area based on different locations in Kota Kinabalu ……………………………………………………………....	200
Tab.	59	:	Classifying recreation function areas in different locations in Kota Kinabalu, Malaysia ……………………………………………………....	208
Tab.	60	:	Proposed map legend for recreation function area in Kota Kinabalu, Malaysia	209
Tab.	61	:	Classifying utility function areas in different locations in Kota Kinabalu, Malaysia ……………………………………………………………....	213
Tab.	62	:	Proposed map legend for utility function areas in Kota Kinabalu, Malaysia	214

LIST OF FIGURES

Fig.	1	:	Map of Malaysia …………………………………………………	2
Fig.	2	:	Declining of Virgin forest area in Sabah from 1970 to 1995.................	6
Fig.	3	:	Map of Sabah, Malaysia	12
Fig.	4	:	Agriculture Land Use in Sabah West Coast from 1976 – 1991)	16
Fig.	5	:	Mean monthly rainfall and temperature in Kota Kinabalu station (1995 – 2004)	24
Fig.	6	:	Procedural Steps of the Research	29
Fig.	7	:	The spatial model for the collection of field data ……………………...	30
Fig.	8	:	Location of the study area and exemplary study plots (red circle)	31
Fig.	9	:	Research design and methodology	32
Fig.	10	:	Circular Plot for detailed vegetation structure analysis and natural regeneration	33
Fig.	11	:	Detailed point transect sampling plot for bird survey	50
Fig.	12	:	The flow of questionnaires distribution in Kota Kinabalu district	55
Fig.	13	:	Species-area curve in three different vegetation types in Kota Kinabalu	63
Fig.	14	:	Diameter distribution in four vegetation types of the study area. Observed values (points) and curves fitted with negative exponential function $n = k \cdot e^{-a.d}$ (dotted line) and logarithmic J-shape function $n = e^{(k.e^{-a.d})}$ (full line)	67
Fig.	15	:	Height curves of four distinguished vegetation types; tree ≥ 10 cm dbh, all species	70
Fig.	16	:	Frequency diagrams and number of tree species (dbh ≥ 10 cm) per frequency class in four disturb forest stand of Kota Kinabalu (Plot size of 2048 m²)	79
Fig.	17	:	Number of individuals per species of natural regeneration in secondary re-growth stands of Kota Kinabalu	85
Fig.	18	:	Number of individuals per species of natural regeneration in mixed horticulture stands of Kota Kinabalu	87
Fig.	19	:	Number of individuals per species of natural regeneration in mangrove stands of Kota Kinabalu	89
Fig.	20	:	Pattern of bird species recorded from years 1986 – 2005 in Kota Kinabalu	91
Fig.	21	:	Categories of bird species recorded in Kota Kinabalu in 2005	93

Fig. 22 : Families of birds species, recorded in Kota Kinabalu in 2005 94

Fig. 23 : Number of resident and migrant birds recorded in Kota Kinabalu in 2005 95

Fig. 24 : Detection probability of all birds recorded using point transect sampling method in Kota Kinabalu 96

Fig. 25 : Kota Kinabalu spatial pattern derived from SPOT Image data with proportion of 64.14% green areas (Scale 1:50,000) …………………... 98

Fig. 26 : Numbers of spotted bird species in different habitat categories in Kota Kinabalu ……………………………………………………………… 102

Fig. 27 : Bird habitat categories in Kota Kinabalu (further description see table 30) Scale 1:50,000 ……………………………………………….. 103

Fig. 28 : Potentially Important Birdlife Area in Kota Kinabalu (IBAK) based on dominating land-use and bird survey assessment 108

Fig. 29 : Major roles of the importances of trees and green spaces in town 122

Fig. 30 : Town public reasons for visiting the green spaces or forest 124

Fig. 31 : Distances (km) from homes to nearby green areas or parks in town 124

Fig. 32 : People's perceptions towards tree management in Kota Kinabalu 127

Fig. 33 : Village community opinion on the important forest resources in their area 129

Fig. 34 : Type of forest resources and non wood forest product (NWFP) used by the villager 131

Fig. 35 : Village community opinion on the presence of wildlife species found in their area 133

Fig. 36 : Interesting nature resources derived from the forest based on people's opinion in their places (recreation resources) 134

Fig. 37 : Village people perception on the problems stemming from the forest area 135

Fig. 38 : Village people perception of present threats faced by the forest 136

Fig. 39 : Characteristics of terrain classes in Kota Kinabalu (scale 1:50,000) 143

Fig. 40 : Soil association classes in Kota Kinabalu (scale 1:50,000) 144

Fig. 41 : Vegetation Classification of Kota Kinabalu 145

Fig. 42 : Aerial photograph 2000 (left) and SPOT image satellite 2002, (band 4:3:2 right) of Kota Kinabalu (Scale 1:50,000) was used for visual interpretation and analysis of land cover classification 154

Fig. 43 : General land classification derived from remote sensing SPOT satellite image data (scale 1:50,000) 155

Fig. 44 : Land-use map described in mapping codes derived from biotope and land-use types as classified in table 51 ……... 158

Fig.	45	:	Seven most important land-use/biotope types in Kota Kinabalu	159
Fig.	46	:	Proposed bird habitat function map in Kota Kinabalu, Malaysia ……..	181
Fig.	47	:	Proposed nature conservation function map in Kota Kinabalu, Malaysia …………………………………………………………….	187
Fig.	48	:	Proposed watershed protection forest in Kota Kinabalu, Malaysia …...	201
Fig.	49	:	Proposed soil protection forest in Kota Kinabalu, Malaysia …………..	202
Fig.	50	:	Proposed climate protection forest in Kota Kinabalu, Malaysia ………	203
Fig.	51	:	Proposed noise protection forest in Kota Kinabalu, Malaysia ………...	204
Fig.	52	:	Proposed immission protection forest in Kota Kinabalu, Malaysia …...	205
Fig.	53	:	Proposed recreation function map in Kota Kinabalu, Malaysia ……….	210
Fig.	54	:	Proposed utility function map in Kota Kinabalu, Malaysia …………...	215

1.0 Introduction

1.1 General Background

Malaysia has been identified as one of the world's mega diverse countries being extremely rich in biodiversity. Tropical rainforests, the oldest and most biologically diverse ecosystems on earth cover an average 60 % of the country (Soepadmo, 1998). Malaysia rainforests are estimated to contain about 12,500 species of flowering plants, and more than 1,100 species of ferns and fern allies (Ministry of Science, Environment and Technology, 1998). The dominating plant family is dipterocarp trees, many of which produce commercial timber and native to Borneo (and also to Peninsular Malaysia, Indonesia, Philippine, Thailand etc). Large portions of these species are endemic and unique to the Malaysian archipelago.

There is also great diversity in fauna, including about 300 species of wild mammals, 700-750 species of birds, 350 species of reptiles, 165 species of amphibians and more than 300 species of freshwater fish. Endemism in fauna is also high, and much of the traditional knowledge about the endemic flora and fauna are heritage of many traditional societies and communities that are dependent on them for their very survival (Soepadmo, 1998).

In line with the Malaysian economic development, native plant resources have been tapped and new plants are introduced to support certain industries. Rubber and oil palm, for example, are both introduced and became the two most commercially important crops. In term of land coverage, Malaysia covers an area of about 32.86 million hectares, these include Sabah, with an area of 7.37 million hectares, and Sarawak, with about 12.33 million hectares, bordering Indonesia's Kalimantan territory. Peninsular Malaysia covers an areas of about 13.16 million hectares bordering Thailand in the north and Singapore to the south.

Figure 1: Map of Malaysia *(Sources: Anonymous, 1999)*

With the population of approximately at 25.6 million in 2004, Malaysia is a multi-racial country comprising main racial groups of Malays, Chinese, Indians, and a very diverse group of indigenous tribes. Sabah's indigenous groups include the Kadazandusun, Bajau, Murut, Rungus, Lotud, Orang Sungei, Kadayan, Bisaya and many other subgroups. While in Sarawak, the Ibans forms the largest indigenous group with others such as the Bidayus, the Melanaus and the Orang Ulu’s. Meanwhile in Peninsular Malaysia, the Orang Asli are the aborigines with an estimated population of over 60,000 peoples. Bahasa Malaysia (or Malay Language) is chosen as the national language eventhough English is widely spoken by the people. Islam is the national religion, but the Malaysian Constitution guarantees freedom of worship to all Malaysians.

1.2 Malaysian Constitution: land is a state matter

Since Malaysia is a federation, the reservation and revocation of the protected and conservation areas are effected by state legislation. However, the relevant federal authorities provide technical advice and guidance while the harmonization of state legislation and policies are achieved through the National Land Council and the National Forestry Council. In this context, the National Forestry Policy, 1978 (Revised 1992) and the National Forestry Act, 1984 (Amended 1993) provide the basis for systematic management, development and conservation of the forest resources as the latter stipulates the preparation of forest management plans and the classification of forest into various functions (Chin, 1999). Table 1 shows the distribution and extent of major forest types in Malaysia.

Table 1: Distribution of Major Forest Types in Malaysia, 1998 (Million ha)
(Source: Ministry of Primary Industries, 1998)

Region	Land Area	Dipterocarp Forest	Swamp Forest	Mangrove Forest	Plantation Forest	Total Forested Land	Percentage Total of Forested Land
Sabah	7.37	3.80	0.19	0.34	0.13	4.46	60.5
Sarawak	12.44	8.84	1.25	0.18	0.01	10.28	82.6
Peninsula Malaysia	13.16	5.36	0.30	0.11	0.07	5.82	44.2
Malaysia	**32.97**	**17.99**	**1.74**	**0.63**	**0.21**	**20.56**	**62.4**

Sabah Land Ordinance, Sarawak Land Ordinance and the National Land Code (NLC) of Peninsula Malaysia form the basis of land laws and administration in Malaysia. The Land Capability Classification (LCC), similar in all three regions, was introduced between 1963 and 1976. The LCC divides land use into five categories based on its potential productivity and economic yield: mining, agriculture (wide range of crops possible), agriculture (restricted range of crops possible), forestry and conservation in a declining order of priority.

Malaysia's land use policy is "use-oriented", i.e. designed for maximum utilisation and development. Thus, conversion of land for urbanisation, industrial, agricultural, mining and forestry development have higher priority than that of conservation. This is because it brings a much more higher rate of return on investment.

Since its implementation, the LCC has introduced major land use changes that have been financially rewarding, and have done much to address problems of rural poverty and social inequality. However, the LCC's weakness is its limited application to adequately addressing biodiversity and conservation issues (Ministry of Science, Environment and Technology, 1998).

1.3 Sabah Forest Decline

The rapid development of Malaysia in recent times has resulted in a significant increase in economic growth and the quality of life of people living in urban areas. Yet poverty is still a problem at the root of several environmental problems. Urban expansion has increased the exploitation of natural resources and has changed the land use and land cover patterns. Much of Sabah's natural vegetations has been altered and degraded due to destructive human practices. The existence of this precious natural heritage continues to be threatened. Certain forest types are in danger of being totally lost from Sabah, while many plant species will likely to disappear before they are ever described. The fragmentation of natural forests also threatens the viability of various wildlife populations, including the Sumatran Rhino, Orang Utan, Asian Elephant, Proboscis Monkey and the Hornbill.

Rapid developments are still undergoing, and transformation from rural to urban areas accelerates. Beaman et al. (1985) noted that the establishment of around 2 million ha of mono-cultural oil palm plantation on forest areas have led to considerable losses of natural habitats in Sabah. The threatening of Wildlife is a major concern related to biodiversity conservation in Sabah. Since 1983, forest fires have caused unprecedented damage to Sabah’s forest. At least 1 million hectares were burnt in 1983, of which 85%

was logged-over forest. Less widespread but very damaging fires occurred again in 1987, 1989 and in the early 1990's (Payne, 1997). Fire risk is evidently higher in logged forests than in unlogged forests, due to the presence of more dead wood and enhanced access to people, who accidentally or deliberately start forest fires.

The most important land ecosystems in Sabah are the forests and croplands. The general trend in land use patterns is characterised by deforestation and expansion of cropland. Forest have been converted to cropland and state reserves, and state land to alienated land with 25.6 % and this is expected to continue in the following decades. Figure 2 shows, how the Virgin forest area in Sabah have dwindled by 90% due to excessive cutting and indiscriminate logging practices between 1970 until 1995 (Sabah State Government, 1998).

Humans are said to be the main agents of extinction of the natural environment. They caused it by altering habitats (mainly forests, but also fresh waters and wetlands), overexploiting and introducing exotic species to places where they out-compete or will undermine the growth of the native species. Apart from that, activities such as unsustainable land use practices like shifting cultivation are categorised as the most serious problem threatening indigenous forests from day to day. Other causes threatening the environment are commercial logging, agricultural expansion, mining and quarrying followed by infrastructures development which results in great losses of the natural habitats.

1.3.1 Shifting cultivation

Shifting cultivation is a very common land use practice in Sabah, especially in the upland areas where permanently cultivable land can rarely be found. As estimated by Manshard and Morgan (1985) approximately 44,000 ha of lands are affected which constitute mostly the unclassed and degraded forests.

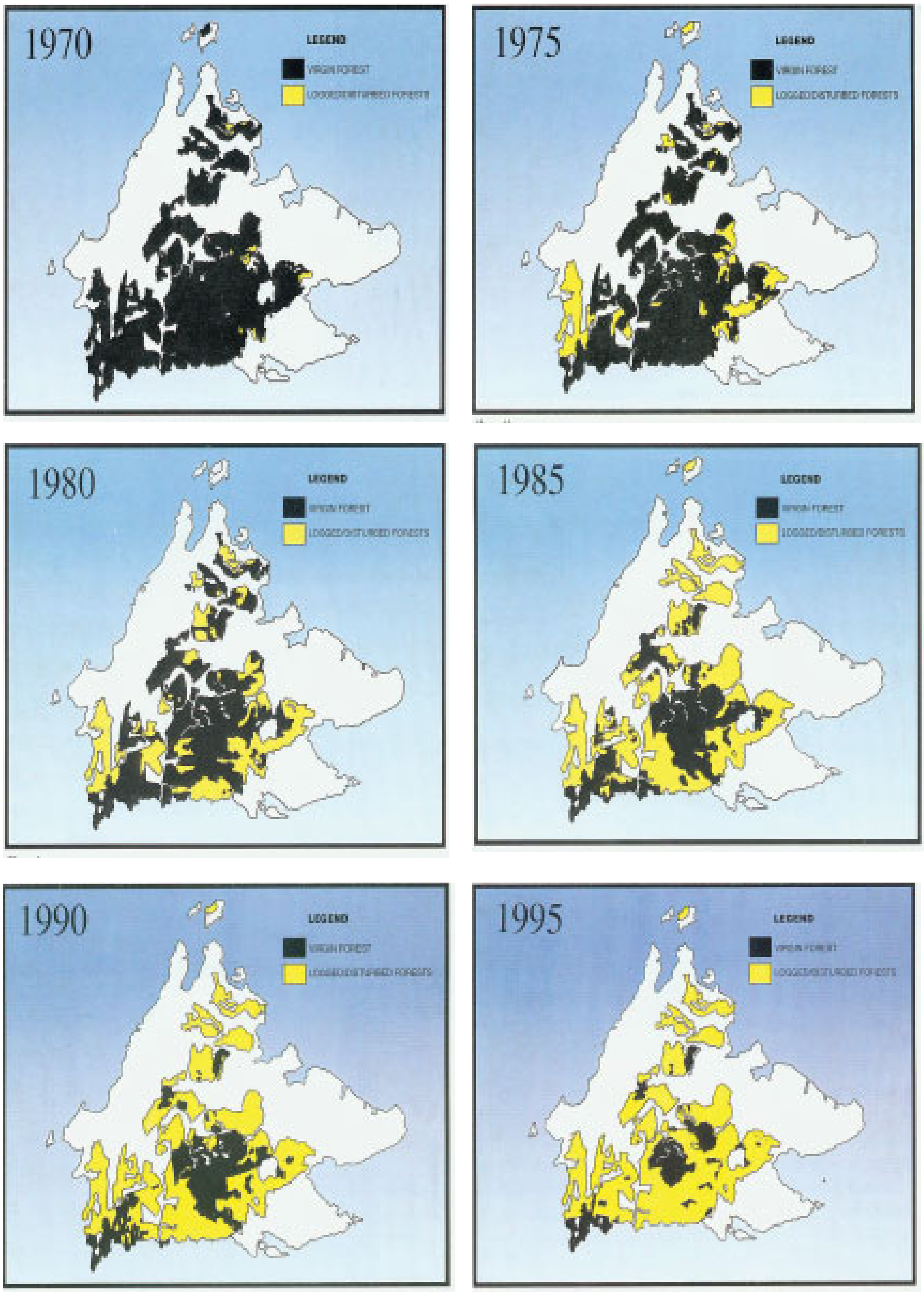


Figure 2: Decline of Virgin forest areas in Sabah from 1970 to 1995
(Source: Sabah State Government, 1998)

This kind of land use has long been considered as a poor system causing permanent deforestation and damaging the environment. According to FAO (1984), the essential characteristics of shifting cultivation are that an area of forest is cleared, usually rather incompletely, the debris is burnt, and the land is cultivated for few years, usually less than five, then allowed to revert to forest or other secondary re-grown vegetation to be cleared and used again.

As the population grows and expands, and the available forest area shrinks, shifting cultivation can lead to a high level of habitat fragmentation, the complete removal of natural forests, and an insufficient period of time for cleared fields to recover before being cut again. All this factors lead to a gradual impoverishment of the ecosystem and to declining percapita yields (Dearden et al., 1996).

1.3.2 Logging

Logging is the source of timber exports, which provide income for the country. Over the past 17 years, forestry in Sabah has contributed an average of RM 2.69 (Euro 0.58) billion per year in terms of foreign exchange earnings through export of forest products, while the revenue from forest resources was at an average of RM 717.5 (Euro 155) million per year (Sabah State Government,1998).

Commercial logging has had a most devastating impact on tropical deforestation worldwide. Along with the direct impact of cutting down trees, commercial logging has an indirect impact because it involves the building of roads. Landless farmers then use the roads to gain access to rainforest areas that they can clear by slashing and burning. The direct physical effects of the removal of logs include damage during felling operations, damage during skidding, clearing for log dumps and the destruction of drainage system during tract construction. In addition, microclimate changes can occur when extensive areas of the canopy are disturbed. This may adversely affect epiphytes, particularly in high altitude logging operations where the greatest diversity of epiphytic plants occurs.

1.3.3 Agricultural expansion

Some forest lands are also clear-felled for the establishment of cash crops plantation of various categories like rubber, oil palm, sugar, banana, coconut, coffee and tea. Intensive and expanding cultivation of cash crops have been a significant cause of deforestation and degradation of land and water. At the end of 2000, a total of about 220,000 ha of agriculture plantations were established in Malaysia. Of this total, about 81,000 ha were established in Sabah (Chan, 2004).

The State development goals of achieving high levels of economic growth have been a major influence on land and agriculture policies, which in turn, impact forest resources. Commercial plantations often do not provide the non-timber forest products of primary forests, particularly the resources used for housing, household items, food, fuel, handicraft and medicines. This results in restrictions on livelihood and people's use of non-timber products, and causes the total extinction of certain species in areas developed as plantations.

1.3.4 Mining and quarrying

Mining and quarrying cause localised deforestation, while access roads and site works associated with this type of industry can cause pollution and more clearance of land. Commercial mining and quarrying often release many toxins into local waterways in the form of metal compounds.

Small-scale mining is often more damaging than the commercial kind. Large areas of land are often cleared by using explosives to gat at the metal ores. This can cause large-scale soil erosion. Large areas of forests have also been removed to allow massive hydro-electric power schemes to be built and valleys containing forests have been flooded in order to create reservoirs. With an ever-increasing population, the demand for water and power has grown significantly.

1.3.5 Infrastructure development

Developing infrastructure such as road networks in areas with tropical rainforest can also lead to increasing deforestation. Most of the clearing occurs within a few miles of major road networks. Cutting roads through untouched rainforest opens them up for development from logging companies and agriculture. Whilst cutting hill slopes can increase the area susceptible to landslides and soil erosion.

1.4 Problem statement and objectives

In order to conserve and manage the remaining biodiversity as best as possible, it is a prerequisite to develop situational familiarity and understanding focused on the individual ecosystem. It is essential to know the composition of at least part of the biodiversity in each geographical area and to recognize that the different elements/compenants of diversity are likely to be affected by limitations of size, shape, surrounding land-use, isolation, fragmentation of populations, and residual influences from past history.

The collection and interpretation of basic data are needed for efficient future management. In addition to inventories, research is needed on the functional interrelationships and dynamics of the ecosystems as a basis for conservation strategies. These are needed both at the national level, and at various subordinate levels, cumulating in the formulation of management plans for specific areas which include biodiversity conservation objectives and the criteria for monitoring their achievement.

In Sabah, most challenges in managing suburban and urban areas usually deals with biodiversity conservation within these areas, wildlife habitat control, habitat improvement, recreation management and urban development. External management problems are mostly coming from local people or so called natural resources dependent people, and also from related agencies. There are conflicts resulting from illegal settlements and agriculture fields in designated buffer zones.

Several causes may be behind these problems, like: lack of spatial management and land-use planning, lack of proper managements direction or technical guidelines, lack of enforcement and information sharing with local communities and administrations, and lack of coordination among relevant administration departments.

To improve natural resources management in urbanizing areas, the remaining woodlands and urban green areas in Kota Kinabalu district have been selected as a case study. This study investigates important aspects, structure and composition of forest vegetation, wildlife habitats, land-use system in peri-urban and urban settlements, socio economic conditions of local communities, as well as people’s perception of the respective areas. The classification system and land use classification from the aerial photograph will be used as a tool for management in urban green Kota Kinabalu.

The specific aim of this study is to develop a concept for ecological landuse planning and sustainable management of peri-urban, woodlands and urban green areas in Kota Kinabalu district. Based on terrestrial and aerial inventory of plants; birds and sociological of the depending communities, the analysis is focused on spatial forest green area functions. The detailed research objectives can be described as follows:

(1) To identify the status of woodlands and green areas by analysing the vegetations structure and tree stands.
(2) To identify the status of bird life in those areas as requirement to support the habitat management.
(3) To identify public and local communities perceptions concerning the importance of urban green area and to document their socio-economic status.
(4) To classify and map the land cover, and to provide a guidelines for the assessment of urban forest functions related to the ecological site condition in Kota Kinabalu.

1.5 Structure of the Study

This dissertation is consequently structured into nine chapters.

- Chapter 1 is the introduction, which consists of general information, practical background, problem statement and objectives.

- Chapter 2 presents a general characterisation of the study areas. It also gives background information about Kota Kinabalu and the status of protected areas in Sabah.

- Chapter 3 explains the procedures and methodologies of the research. The methods used for data collections and vegetation analysis, bird analysis and sociological survey, as well as land cover classification analysis are explained in detail.

- Chapter 4 reports and comments the results of vegetation structures and stands analysis.

- Chapter 5 reports of the results of bird survey and the analysis.

- Chapter 6 deals with the results of the public perceptions and socio-economic analysis.

- Chapter 7 presents the results of biotope classification, analysis and mapping of urban forest functions.

- Chapter 8 gives the overall characterization, final interpretation, discussion and recommendations of the results and to interconnect it between each others.

- Chapter 9 extracts the summary for further highlight the sustainable management activities in Kota Kinabalu.

2.0 Background Information on the Study Area

2.1 General Information on the State of Sabah

SABAH is the second largest state in Malaysia. It is situated at the northern part of the Island of Borneo, the third largest island in the world. It covers an area of 72,500 km² with a coastline of 14,400 kilometers washed by the South China Sea on its west coast, the Sulu Sea on its north-east coast and the Celebes Sea on its south-east coast.

Most of Sabah's landscape is dissected and steep with more than 64% of the areas having slopes of more than 25%. About 6% are tidal swamps and 5% are freshwater swamp areas. Almost all flatlands are subject to water logging and flooding due to the combination of high precipitation and quick run-off from sloping areas.

Figure 3: Map of Sabah, Malaysia *(Source: Anonymous, 2004)*

The West Coast of Sabah is characterised by sandy beaches found from the tip of the Kudat Peninsula in the north to the western part of the Klias Peninsula in the South. In sheltered areas the sand is also mixed with mud. The southern part of the Klias Peninsula hosts one of the few extensive areas of tidal wetlands (Mangroves and Nipah palms) on the West Coast. Freshwater wetlands can be found in the coastal flatlands of the West Coast especially in Beaufort, Papar and Kota Belud. Sabah is known as 'The Land below the Wind' because geographically, it is below the typhoon belt.

2.2 Population and Ethnicity Composition

The state of Sabah had a population of 2,603,485 in 2000 not counting the substantial number of illegal immigrants from Indonesia and the Philippines (Department of Statistic Malaysia, 2001).

The highest population concentrations are found in the major cities, Kota Kinabalu, Tawau, Sandakan, Lahad Datu and Semporna, the five districts accounting for approximately 50% of the entire population. These are also the areas, which attract the majority of illegal and unregistered settlements. However, in terms of land area, the five districts only represent around 22% of Sabah.

This indication of population pressure on the coastal areas is likely to be strengthened and the annual population growth in Sabah between 1991 and 1999 was above 10%, which is much higher as compared to Sarawak (2.3%) and the Peninsula Malaysia (6%) (ICZM, 1999). The urban population growth exceeds the rural growth indicating a net migration towards the towns in Sabah. Kota Kinabalu is the capital of SABAH, formerly known as Jesselton, changed its name in 1968 to Kota Kinabalu. The district of Kota Kinabalu consists of an area of 300 km² and the states capital is also affectionately called "KK" by locals. The population by administrative district and ethnicity group is shown in table 2.

Table 2: Ethnic composition of Sabah by administrative district
(Source: Department of Statistics Sabah, 1998)

Town/ethnicity	Kadazan-dusun	Bajau	Murut	Malay	Other Bumi-putera	Chinese	Indonesian	Others
Kota Kinabalu	171,310	23,742	1,248	19,509	22,899	57,864	7,306	8,215
Penampang	30,745	7,552	537	10,389	7,184	14,129	4,087	1,744
Tawau	3,729	17,094	1,529	11,516	24,946	35,097	55,057	3,727
Lahad Datu	5,497	17,351	83	4,710	13,710	8,080	12,503	1,801
Semporna	398	42,156	23	1,657	5,309	1,149	3,587	556
Sandakan	8,449	20,201	243	14,922	35,252	45,637	24,445	6,235
Kinabatangan	3,817	577	342	664	15,217	850	4,965	545
Beluran	13,773	2,727	69	1,118	15,240	883	2,941	533
Ranau	40,334	479	67	676	1,619	1,058	664	286
Kota Belud	26,010	19,912	37	1,319	8,509	703	491	362
Tuaran	31,323	18,478	135	1,822	3,424	3,865	1,164	541
Papar	17,212	9,542	128	15,001	3,565	4,866	3,217	1,034
Kudat	3,282	4,919	76	1,592	34,562	6,323	1,018	1,800
Kota Marudu	25,597	5,335	14	1,017	6,150	1,349	338	503
Pitas	3,107	2,289	47	291	16,641	268	501	172
Beaufort	7,622	824	1,196	10,244	18,036	3,544	3,083	811
Kuala Penyu	5,415	1,335	19	2,550	4,055	200	193	63
Sipitang	2,283	460	2,355	3,332	8,545	1,302	1,646	577
Tenom	4,502	751	17,787	1,367	2,950	4,304	2,101	466
Nabawan	553	91	12,044	126	455	660	729	84
Keningau	38,510	1,487	12,121	2,043	3,661	6,906	3,263	1,384
Tambunan	17,630	180	83	272	439	283	122	63
Kunak	549	5,975	72	603	3,187	716	5,322	708

Note: Bumiputera (Sanskrit, translated literally, it means "princes of the Earth") is an official definition widely used in Malaysia, embracing ethnic Malays as well as other indigenous ethnic groups.

Sabah comprises 32 ethnic groups and other non-indigenous people. The largest ethnic group is the Kadazandusun, making up 1/3 of the total population in the state. They are mostly concentrated in the western part of Sabah. Formerly the main rice-producer of the state, the Kadazandusun are now the major force in SABAH's rapid progress towards urban modernisation.

The Bajau were originally the seafarers of Borneo and many still reside along the coastline with fishing being a major occupation. The Murut reside mainly in the hinterland, with many still living in the traditional long houses.

2.3 Land Use

Sustainable use of the land ensures that its productivity is maintained at an optimal level with minimal adverse environmental impacts. Environmental deterioration includes soil erosion, soil degradation, and deforestation, declining water quality and availability, disruption of hydrological cycles and the loss of biological diversity. Sustainability thus implies the securing of a durable, favourable balance of economic and environmental costs and benefits. The present agricultural methods as practised in Sabah have evolved from indigenous techniques formerly used by the shifting cultivators to large-scale logging, mining and plantation horticulture. The latter has intensified land uses and placed great pressure on poor tropical soils.

One of the fastes growing industries in Sabah is the large scale planting of oil palm. Within a span of 5 years, the cultivated area grew from about 400,000 hectares in 1992 to about 800,000 hectares in 1997. The extensive land clearing and preparation including the construction of terraces and other planting platforms on hilly slopes resulted in excessive runoff and soil loss that ended up in streams and waterways. However, with good protection measures such as the planting of cover crops, the oil palm plantations and other perennial cultivation such as rubber and cocoa can be considered sustainable. Cultivation on marginal or unsuitable land such as on peat soils or steep slopes (>25°) not only requires high inputs but also causes extensive damage to the surrounding area including the loss of bio-diversity. This is clearly unsustainable use of the land.

Other agricultural venture such as vegetable farming occurs only on small pockets of land less than 5 hectares in the highland and has its own set of problems. The main concern here is the widespread abuse of chemicals both, fertilizers and pesticides. Most of the soils have become extremely acidic resulting in very low yield. The uncontrolled spraying of pesticides has given rise to the issue of safe food for consumption as well as the growing resistance of pest organisms to certain pesticides. Such practices are also unsustainable given that the costs of inputs are increasing compared to decreasing output. The distribution of agriculture landuse in west coast of Sabah prepared by the

Town and Regional Planning Department, Sabah from 1976 – 1991 devide into 6 main classes namely: built-up, horticulture, perrenial & tree crops, croplands, grasslands and forest. The agriculture land use is shown in figure 4.

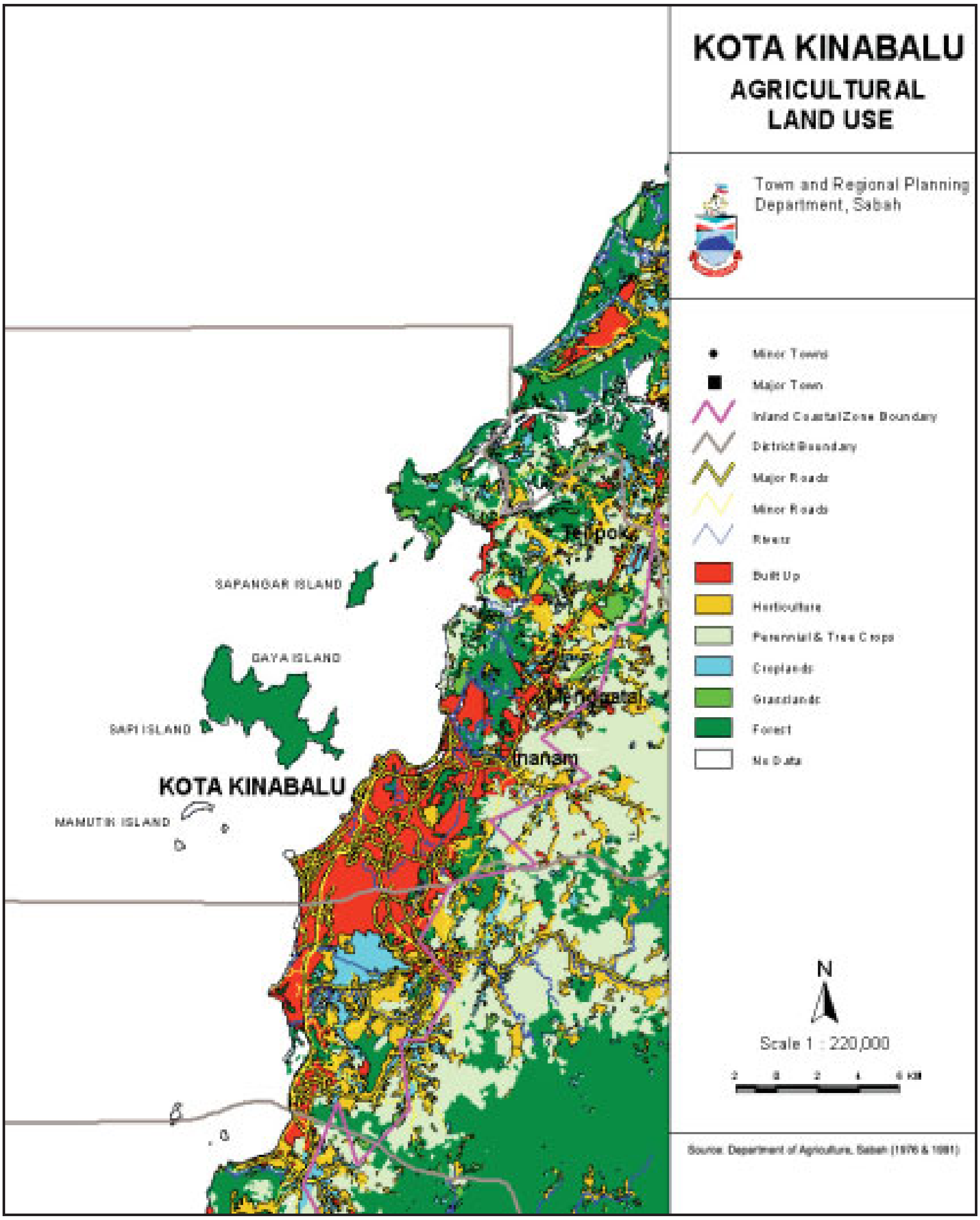


Figure 4: Agriculture Land Use in Sabah West Coast from 1976 to 1991
(Source: Town and Regional Planning Department, Sabah, 1992)

2.4 Protected Areas in Sabah

2.4.1 Forest Reserve Area

Sabah is endowed with vast areas of forest resources. Presently about 56.68% of the total landmass are covered with Tropical Rainforest which is one of the world's oldest heritage. The Forestry Department has been entrusted with more than 48.8 % (3.594 million hectares) of Sabah's total land area which classified as permanent forest estates and administered according to their respective functions. The Permanent Forest Estates (PFE) of Sabah are divided into 7 different classes as shown in table 3. This practice is in line with the National Policy to facilitate forest management.

- Protection Forest Reserves (Class I) are forest areas that are conserved for maintaining the stability of essential climatic, watershed and other environmental factors.
- Commercial Forest Reserves (Class II) are forest areas, which can be logged to extract timber and other forest products. These include lowland, hill Dipterocarp forest and forest up to about 800m.
- Domestic Forest Reserves (Class III) are forest areas for supplying timber and other forest products for local consumption only.
- Amenity Forest Reserves (Class IV) are forest areas for providing recreational sites especially on roadsides.
- Mangroves Forest Reserves (Class V) are forest areas for supplying mangrove timber and other produce. Rhizophora species are most commonly harvested with products ranging from firewood to fishing stakes. The Forestry Department controls commercial harvesting of all mangrove wood products.
- Virgin Jungle Reserves (Class VI) are forest areas conserved intact for research purposes where no logging activities are allowed.
- Wildlife Reserves (Class VII) are forest areas conserved primarily for the protection of wild animal species and presently under the jurisdiction of the Forestry Department.

Table 3: Sabah Permanent Forest Estates (PFE)
(Source: Sabah Forestry Department, 2001)

Class	Forest Reserves	Area (hectares)	Percentage of the state’s total land area
I	Protection	283,000	3,8
II	Commercial	2,740,000	37,2
III	Domestic	7,000	0,1
IV	Amenity	21,000	0,3
V	Mangrove	316,000	4,6
VI	Virgin Jungle Reserve (VJR)	90,000	1,2
VII	Wildlife	132,000	1,8
	Total	**3,589,000**	**49,0**

Sabah's general vegetation may be described as a succession from coastal beach forest and mangrove to lowland dipterocarp forest, hill dipterocarp forest and eventually montane forest. Mangrove Forests (316,000 hectares) cover a greater area in Sabah than in other states in Malaysia. It is concentrated mostly on the east and south-east coast of the state. Mangroves are important for physical protection of the coastline and act as nurseries for the early stages of fish and prawn.

2.4.2 Parks and Other Recreational Areas

The parks cover approximately 2.6% of Sabah’s total land area of 76,115 km². They are managed to provide recreational and scientific facilities while preserving Sabah’s nature heritage for future generations. Currently there are seven parks (Table 4) under the direct care of Sabah Parks, which are fully funded and controlled by the government through a Board of Trustee under the State’s Ministry of Tourism and Research. The Sabah Parks Board of Trustees was constituted with the establishment of Kinabalu "National" Park in 1964 under the National Park Ordinance (1962).

Table 4: State parks in Sabah *(Source: Kollert et al. 2003)*

No	Location & Description	Size (ha)	Year Gazetted
1	Kinabalu Park, Sabah's oldest park, 90 kms, and 2 hours drive from Kota Kinabalu. Special interest areas include the Mount Kinabalu and Poring Hot Spring.	75,370	1964
2	Tengku Abdul Rahman Park, a marine park consist of 5 island and about 10 minutes boat ride from Kota Kinabalu.	4,929	1974
3	Pulau Tiga Park, a marine park consists of 3 islands and about 48 km south of Kota Kinabalu.	15,864	1978
4	Crocker Range Park. This is the Crocker Range, a giant backbone green mountain ridge of Borneo. Accessible through Tambunan – Kota Kinabalu highway.	139,919	1984
5	Turtle Island Park, a marine park about 3 hour's boat rides from Sandakan. Some parts of the parks are bordering the Philippines.	1,740	1977
6	Tawau Hills park, originally conserved for Tawau Water Catchment Area and later managed and developed as an attraction site for tourist and research centre. Located 24 kms from Tawau.	27,972	1979
7	Semporna Island Marine Park, located at Bodgaya east coast of Sabah developed as an attraction site for tourist and research centre. Located 60 kms from Tawau.	29,664	1992
	Subtotal	**295,458**	

The 1962 Ordinance was replaced by the Parks Enactment (1984) and all five "National Parks" existing at that time were reconstituted as "State Parks" to ensure that they remained under the State Legislation rather than Federal control. Such areas are intended for both nature conservation and recreation. The 1984 Enactment also described the procedure by which the State Assembly may establish parks, streamlined the control, management and administration of parks and redefined their boundaries. Land titles to the parks are vested in the Board of Trustees for a period of 99 years, free of all liabilities and encumbrances (Ngui, 1990).

2.4.3 Wildlife Reserves and Sanctuaries

The areas listed in Table 5 are under the control of the Department of Wildlife, except for Likas Lagoon and Kota Kinabalu City Bird Sanctuary (KKCBS) which is under the Likas Wetland Sanctuary Management Committee. The Kota Kinabalu City Bird Sanctuary represents a 24 hectare remnant patch of mangroves is located two kilometres from the centre of Kota Kinabalu while Likas Lagoon is a 22-hectare area of fresh water grassland and open water situated at 1.5 kilometres from KKCBS at Likas Bay. The wetland remains under the management of the Department of Irrigation and Drainage as a floodwater retention pond to be managed jointly with KKCBS for water bird conservation.

Table 5: Wildlife Reserves, sanctuaries and conservation areas
(Source: Kollert et al. 2003)

No.	Location & Description	Size (ha)	Gazetted
1	Tabin Wildlife Reserve (Class VII FR)*	120,521	1984
2	Kulamba Wildlife Reserve*	20,682	1984
3	Sipadan Island Bird Sanctuary	12	1934
4	Lower Kinabatangan Wildlife reserve	27,800	1999
5	Sepilok Orang Utan Rehabilitation Centre*	4,294	1931
6	Gomantong Cave Forest Reserve*	1,816	1984
7	Mantanani Island Bird Sanctuary	61	1960
8	Kota Belud Bird Sanctuary	1,100	1960
9	Likas Lagoon	22	1996
10	Padang Teratak Bird Sanctuary (Klias Peninsular)	2,750	1978
11	Kota Kinabalu City Birds Sanctuary (KKCBS)	24	1998
12	Botanical and Zoological Garden	121	1996
13	Lankayan-Billean-Tegapil Marine Conservation area	30,000	1984
	Subtotal	**209,203**	

*Note: * denotes within Forest Reserve.*

KKCBS plays a major environmental role for Kota Kinabalu not only as a green lung for the city but also acts as flood retention to hold heavy rainfalls, thus prevent possible flooding downstream. Besides flood control, it also helps to recycle nutrients and to remove toxicants and sediments. This mangrove area provides breeding and nursery grounds for many ocean fishes, seashells, prawns and crabs. The Mangrove is also important as a feeding and breeding ground for migratory birds as well as resident birds.

Under the Wildlife Conservation Enactment 1997, protected areas in Sabah are categorized into 3 types. The first type is the Conservation Areas which aim for adaptable, flexible and quick protection of wildlife and their habitats. The second, Wildlife Sanctuaries, is the most effective and reliable in protecting plants, animals and their habitats along with genetic resources. Lastly, the Wildlife Hunting Areas are areas where animal population is controlled through regulated hunting (Kollert et al., 2003).

2.4.4 Water Catchment Management Area

The term "catchment" means the whole of the land and water surface, which contributes to the discharge at a particular point on a stream or river, or contributes water to an aquifer. The whole of Sabah is located in one catchment or another and Water Catchment Management Areas are identified in these catchment for the management of water resources. According to the Water Resources Management Enactment, from 1998, water management areas are divided into two categories, namely Water Protection Areas and Water Conservation Areas (ICZM, 1998). Water Protection Areas are areas created to ensure a source of water, or water resources in a particular body or locality, is adequately protected from reduction in flow, or from pollution or degradation. Water Conservation Areas are areas created to control, limit or modify activities within an area of land, to prevent pollution or degradation of surface water or ground water or the loss of its availability. So far, 16 Water Catchment Areas (e.g. Moyog Area in Kota Kinabalu) have been designated and detailed integrated catchments management studies need to be carried out for further identification. The relevant agency is currently seeking for international funding to carry out the detail studies.

2.4.5 Plantation forestry

The responsibility to plant forest crop in a degraded and deforested land is delegated to the Sabah Forest Department (SFD). It is aimed at achieving sustainable yield of forest resources, environment conservation, and strengthening the foundation of the local timber industries.

Since the establishment of the first commercial plantation in 1974, plantation development has increased annually. The overall summary of forest cover including plantation forest in Sabah is presented in Table 6 below. Sabah still preserves area of 60.7% of its total land area covered with forest.

Table 6: Summary of Forest Cover in Sabah
(Source: Sabah Forestry Department, 2001)

Classification of land	Area (hectares)	Percentage of the State's total land area
Permanent Forest Estate	3,589,000	48,7
Wildlife & Bird Sanctuary	209,203	2,8
State Parks	295,458	4,0
Municipal Water Catchments	10,098	0,1
Plantation Forests	81,000	1,1
State Land	291,414	4,0
TOTAL	**4,476,173**	**60,7**

**Note: Total area of Sabah: 7,371,267 Hectares*

At the end of 2000, an estimated 81,000 ha of forest plantation (including rattans) had been established. The main species planted are *Acacia mangium, Paraserianthes falcataria, Gmelina arborea, Eucalyptus deglupta and Shorea sp*. The total figure above excludes the production of agriculture plantation i.e. the Palm oil (*Elaeis guineensis)* which becomes the major economic force of Malaysia at the present time.

2.5 Climate of Kota Kinabalu

Kota Kinabalu as well as most parts of Sabah experiences a typical equatorial climate, with constant temperature, considerable amount of rain and high humidity. The two prevailing monsoons in Sabah, which characterise the climate in this region, are the Northeast Monsoon and the Southwest Monsoon. Northeast Monsoon predominates the months between November and March, whereas the Southwest Monsoon prevails during the months of May to September. There are also two successive inter-monsoons; from April to May and September to October.

2.5.1 Temperature and Rainfall Distribution

During normal periods, temperature distribution in Kota Kinabalu is constant and fairly high throughout the year. Generally, there is a slight decrease of temperature from July until the end of the year. The average monthly mean temperature values from 1995 to 2004 ranged between 26^{o}C to 28^{o}C.

The temperature variation within a year is small. Relatively, the months between March and July were recorded as the period in which temperatures were the highest (in figure 5). This period coincided with the less rainy Southwest Monsoon. Kota Kinabalu receives a substantial amount of rainfall of 2400 mm per year as recorded at the meteorological station. Figure 5 shows the mean monthly rainfall and temperature in Kota Kinabalu station from the year 1995 to 2004.

Figure 5 shows that the rainfall distribution throughout the year are not constant. The relatively wetter months occure between December and January. Table 7 shows that average values of the monthly mean rain days are also not regularly distributed. The months from September and January experience more days with rain, than other months. This period correspond to the period of the Northeast Monsoon.

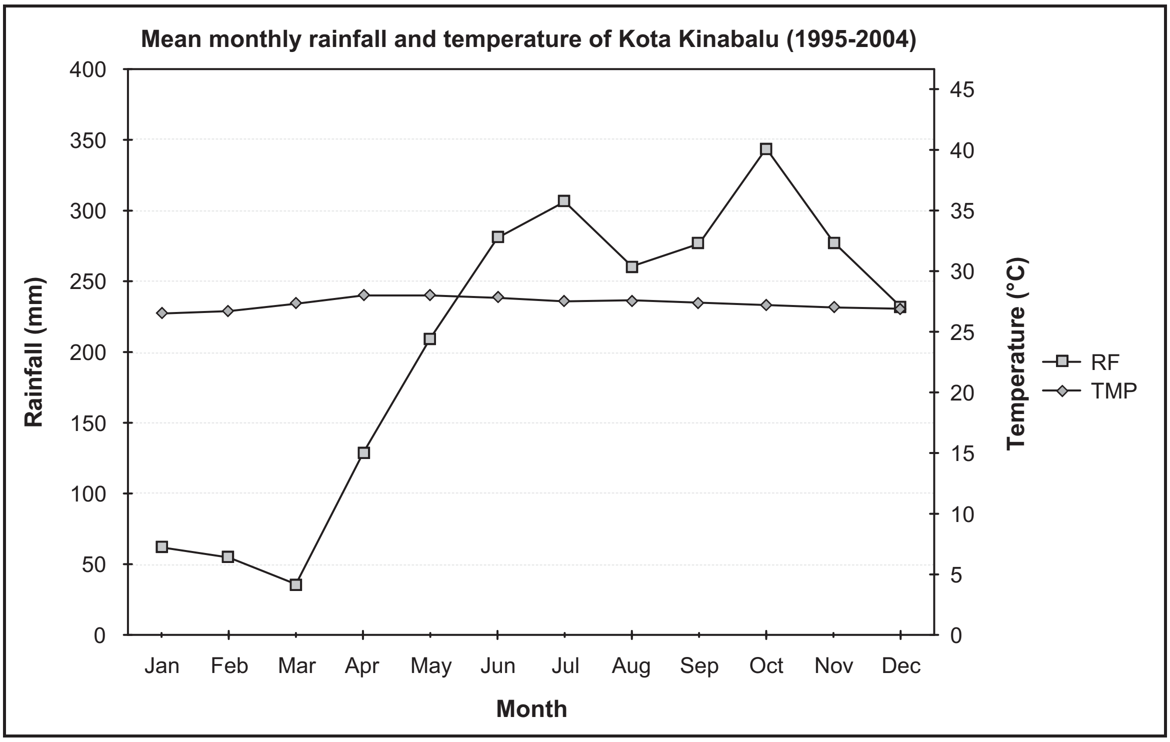


Figure 5: Mean monthly rainfall and temperature in Kota Kinabalu station (1995 – 2004) *(Source: Meteorological Department Sabah, 2005)*

Table 7: Average of Monthly Mean Rain days for Kota Kinabalu station (1995 – 2004) *(Source: Meteorological Department Sabah, 2005)*

Month	Mean rain days
January	8.6
February	8.8
March	7.3
April	11.1
May	16.0
June	15.4
July	15.3
August	15.1
September	15.8
October	20.5
November	19.4
December	14.6
Average	14.0
Standard Deviation	**4.2**

2.5.2 Wind

Wind speed intervals in Sabah are classified in seven categories as shown in Table 8. The table also shows the Beaufort Scale devised in 1805 by Sir Francis Beaufort to indicate the scale and conditions of wind speeds (ICZM, 1998). The system of wind speed intervals used in Sabah conforms to the Beaufort Scale until Force 6, possibly because Sabah seldom experiences extreme wind speeds above 10.7 m/s. The wind data were registered in Kota Kinabalu in four main periods, period I, II, III and IV are January, May-September, October, and November-March respectively. Table 9 shows the wind speed (m/s) and directions from Period I to IV.

As shown in Period I in table 9, the prevailing wind in January was from the north and east directions. The north and east influence is due to the Northeast Monsoon that usually takes place between November and March. The maximum reading ranged between 5.5 and 7.9 m/s. The range of wind speeds gives moderate breeze condition.

During the Southwest Monsoon from May to September (Period II in table 9), the dominant wind blow from the south and west. The prevailing wind speed ranged from 0.3 to 3.3 m/s. Wind conditions during the wind speed interval are between light air and light breeze and the intensity of wind speed between 8.0 and 10.7 m/s.

The inter-monsoon period in October (Period III in table 9) brought wind blowing most of the time mainly from the south and the west. The prevailing wind speed during this period was between 0.3 and 3.3 m/s. The maximum wind speed recorded was between 8 and 10.7 m/s. However, the percentage of the wind speed occurrence was small.

The Northeast Monsoon that occurs between November and March usually brings heavy rain to Sabah. From November to March, the prevailing wind recorded came from the north and east. Wind speed between 0.3 and 5.4 m/s and the dominant wind speed interval gives light air and gentle breeze conditions. Looking at the wind trend of each station from Period I to Period IV in table 9, it can be concluded that the dominant wind speed ranges between 0.3 and 3.3 m/s. Kota Kinabalu, is dominated by the wind from the east most of the time.

Table 8: The Beaufort Scale and Wind Speed Intervals in Sabah
(Source: Anonymous, 2005 and Meteorological Department Sabah, 2005)

BEAUFORT SCALE		SABAH WIND SPEED INTERVALS (M/S)		
Sea Conditions:	**Land Conditions:**	**Force**	**Speed (knots)**	**m/s**
Calm, sea like a mirror.	Calm: Still: Smoke will rise vertically.	0	<1	< 0.3
Light air, ripples only.	Light Air: Rising smoke drifts, weather vane is inactive.	1	1-3	0.3-1.5
Light breeze, small wavelets (0.2m). Crests have a glassy appearance.	Light Breeze: Leaves rustle, can feel wind on your face, weather vane is inactive.	2	4-6	1.6-3.3
Gentle breeze, large wavelets (0.6m), crests begin to break.	Gentle Breeze: Leaves and twigs move around. Light weight flags extend.	3	7-10	3.4-5.4
Moderate breeze, small waves (1m), some white horses.	Moderate Breeze: Moves thin branches, raises dust and paper.	4	11-16	5.5-7.9
Fresh breeze, moderate waves (1.8m), many white horses.	Fresh Breeze: Moves trees sway.	5	17-21	8.0-10.7
Strong breeze, large waves (3m), probably some sprays.	Strong Breeze: Large tree branches move, open wires (such as telegraph wires) begin to "whistle", umbrellas are difficult to keep under control.	6	22-27	> 10.7
Near gale, mounting sea (4m) with foam blown in streaks downwind.	Moderate Gale: Large trees begin to sway, noticeably difficult to walk.	7	28-33	
Gale, moderately high waves (5.5m), crests break into spindrift.	Fresh Gale: Twigs and small branches are broken from trees, walking into the wind is very difficult.	8	34-40	
Strong gale, high waves (7m), dense foam, visibility affected.	Strong Gale: Slight damage occurs to buildings, shingles are blown off of roofs.	9	41-47	
Storm, very high waves (9m), heavy sea roll, visibility impaired. Surface generally white.	Whole Gale: Large trees are uprooted, building damage is considerable.	10	48-55	
Violent storm, exceptionally high waves (11m), visibility poor.	Storm: Extensive widespread damage. These typically occur only at sea, and rarely inland.	11	56-63	
Hurricane, 14m waves, air filled with foam and spray, visibility bad.	Hurricane: Extreme destruction.	12	64+	

Table 9: The Frequency (%) of Wind Speed (m/s) and Direction - Period I (January), Period II (May – September), Period III (October) and Period IV (November – March), Kota Kinabalu
(Source: Meteorological Department Sabah, 2005)

PERIOD I – JANUARY (Meteorological Station: Kota Kinabalu)

m/s	N	NE	E	SE	S	SW	W	NW	CALM
< 0.3	-	-	-	-	-	-	-	-	9.6
0.3 - 1.5	2.1	1.4	14.9	5.3	1.5	1.7	3.8	4.2	0.0
1.6 - 3.3	2.5	1.1	19.5	6.4	1.3	1.7	7.2	5.7	0.0
3.4 - 5.4	2.0	0.2	1.2	0.5	0.6	0.6	1.9	2.2	0.0
5.5 - 7.9	0.3	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0
8.0 - 10.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 10.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PERIOD II – MAY – SEPTEMBER (Meteorological Station: Kota Kinabalu)

m/s	N	NE	E	SE	S	SW	W	NW	CALM
< 0.3	-	-	-	-	-	-	-	-	6.7
0.3 - 1.5	0.9	1.1	10.9	5	2	2.4	3.8	2.5	0
1.6 - 3.3	1	0.7	21.1	8	3.5	3.9	6.2	3	0
3.4 - 5.4	0.6	0.2	4.1	1.6	2.4	2.6	2.3	1	0
5.5 - 7.9	0.1	0	0	0.1	0.6	0.7	0.4	0.1	0
8.0 - 10.7	0	0	0	0	0	0.1	0	0	0
> 10.7	0	0	0	0	0	0	0	0	0

PERIOD III – OCTOBER (Meteorological Station: Kota Kinabalu)

m/s	N	NE	E	SE	S	SW	W	NW	CALM
< 0.3	-	-	-	-	-	-	-	-	6.1
0.3 - 1.5	1.1	1.1	9.6	6	2.2	1.9	3.1	2	0
1.6 - 3.3	1.3	0.8	18.8	9.3	4.2	3.6	6.6	3.3	0
3.4 - 5.4	0.6	0.2	3.4	1.4	3.3	3.1	2.5	1.1	0
5.5 - 7.9	0.2	0	0	0.1	0.9	1.3	0.7	0.1	0
8.0 - 10.7	0	0	0	0	0.1	0.1	0.1	0	0
> 10.7	0	0	0	0	0	0	0	0	0

PERIOD IV – NOVEMBER – MARCH (Meteorological Station: Kota Kinabalu)

m/s	N	NE	E	SE	S	SW	W	NW	CALM
< 0.3	-	-	-	-	-	-	-	-	10.5
0.3 - 1.5	2.1	2.5	15.1	5.8	1.5	1.5	3.1	3	0
1.6 - 3.3	4.2	2.5	15.3	5.4	1.7	1.7	5.3	4.8	0
3.4 - 5.4	4.5	1.2	1.2	0.4	0.9	0.7	1.1	1.2	0
5.5 - 7.9	1.4	0.1	0	0	0.3	0.2	0.1	0.1	0
8.0 - 10.7	0	0	0	0	0	0	0	0	0
> 10.7	0	0	0	0	0	0	0	0.1	0

2.5.3 Relative Humidity

The relative humidity at the meteorological station was fairly high and constant throughout the year within the period of data from 1995 to 2004 as shown in table 10. This characteristic is expected of an area within an equatorial region. In addition to this, the station is located along the coastal area of Sabah.

As shown in table 10 the highest average of monthly mean relative humidity was at 83% in November. The lowest average of monthly mean relative humidity was at 79% (August). However the annual variability of relative humidity from month to month was fairly constant with a standard deviation of 1.2.

Table 10: Average of Monthly Mean Relative Humidity (%) for Kota Kinabalu, (1995 – 2004) *(Source: Meteorological Department Sabah, 2005)*

Month	KOTA KINABALU
January	81.2
February	80.9
March	80.0
April	79.4
May	81.2
June	79.7
July	79.5
August	79.2
September	80.2
October	81.9
November	83.0
December	82.3
Average	80.7
Standard Deviation	**1.2**

For the mean evaporation from 1995 to 2004, the highest rate of evaporation recorded per day occurred between March and May. During this period, it was identified that the average monthly mean sunshine hours were also the highest. The rate of evaporation generally decreased towards the end of the year. The period of decreasing evaporation rate corresponded to the period of Northeast Monsoon, which usually brings a substantial amount of rainfall to most parts of Sabah.

3.0 Materials and Methods

3.1 Procedure and Methodology

The methodology of this study follows a two-step procedure: (1) initial-phase, and (2) advance-phase as shown in figure 6. The objective of the initial phase is to get reliable information about the general problems and reviews of green management in Kota Kinabalu. The advance phase focuses on the analysis of the results and the development of a concept for management and sustainable urban green areas. The detailed research design and methodology is given in figure 9.

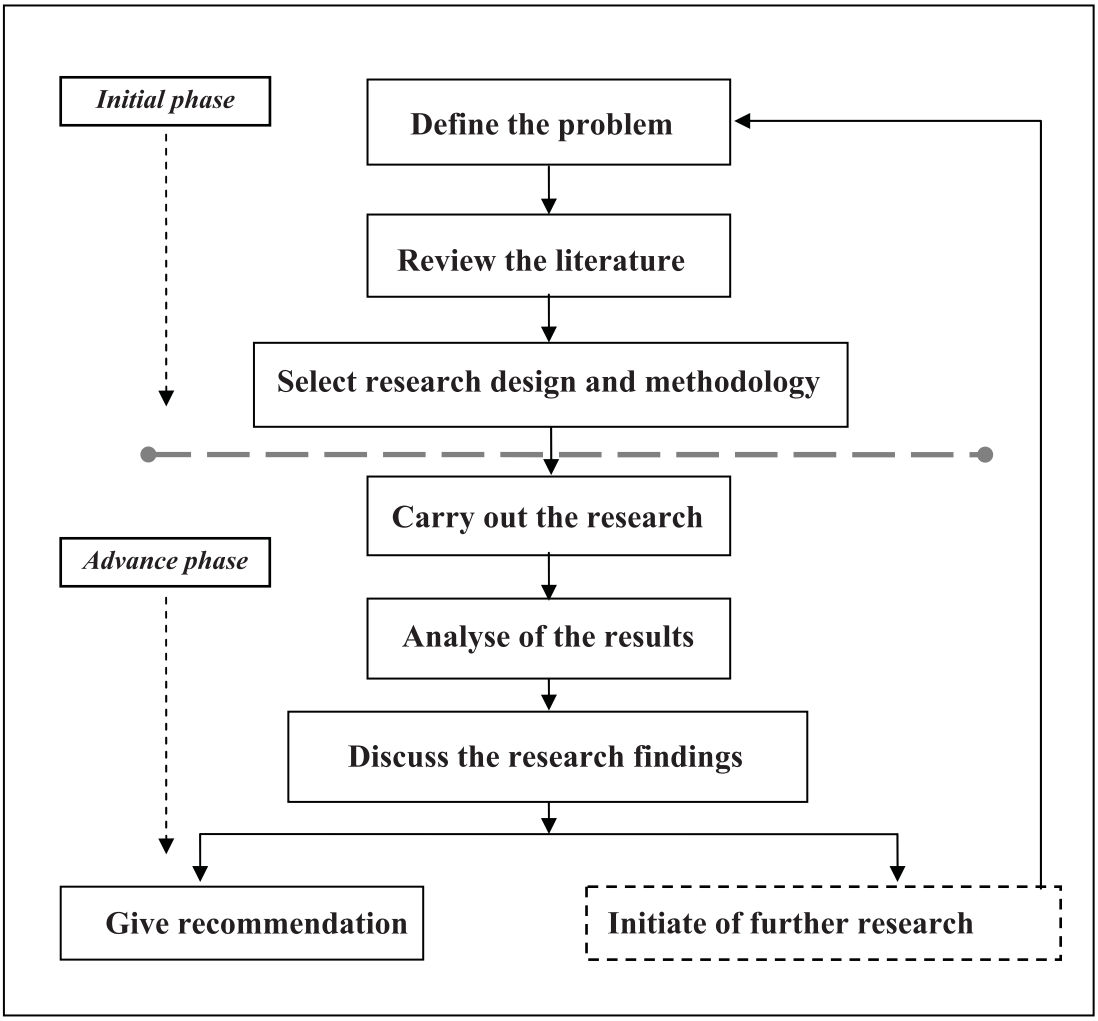
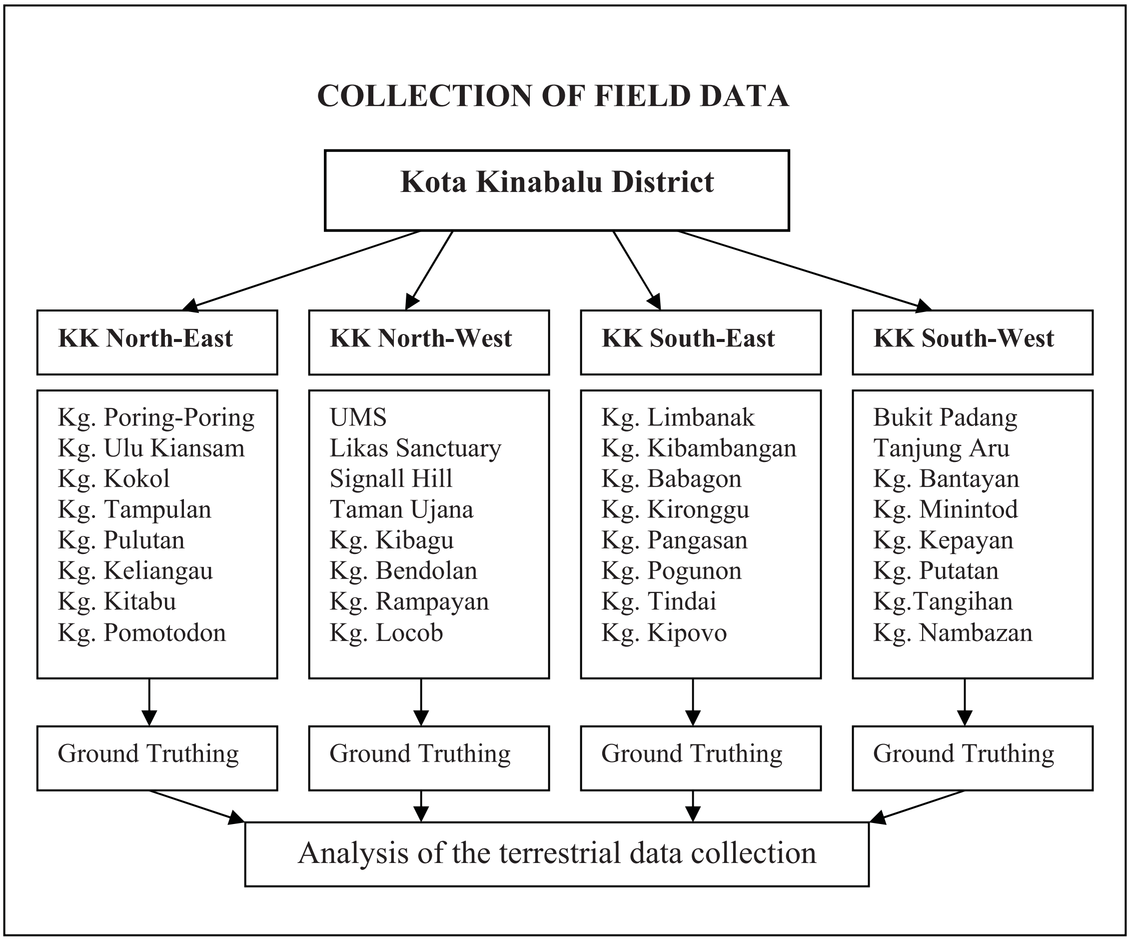


Figure 6: Procedural Steps of the Research
(Source: Modify and adapted from Bryman, 2001)

3.2 The Research area

The research area covers 280 km² and it consists of the Kota Kinabalu capital city and Manggatal, Putatan and Penampang, which constitute the suburban areas of Kota Kinabalu district. For the choice of sampling plots, the study area has been stratified into four zones based on the nearest locality of the town and villages, namely (1) KK North-East, (2) KK North-West, (3) KK South-East, and (4) KK South-West. During the data collection period from May until December 2005, 32 exemplary plots of about 2048 m² each have been established randomly to facilitate the terrestrial data collection and surveys. The spatial model for data collection and location of research areas is illustrated in figure 7 and 8.



Note: 'Kg' or 'Kampong' is a Malaysian word means 'Village'

Figure 7: The spatial model for the collection of field data.

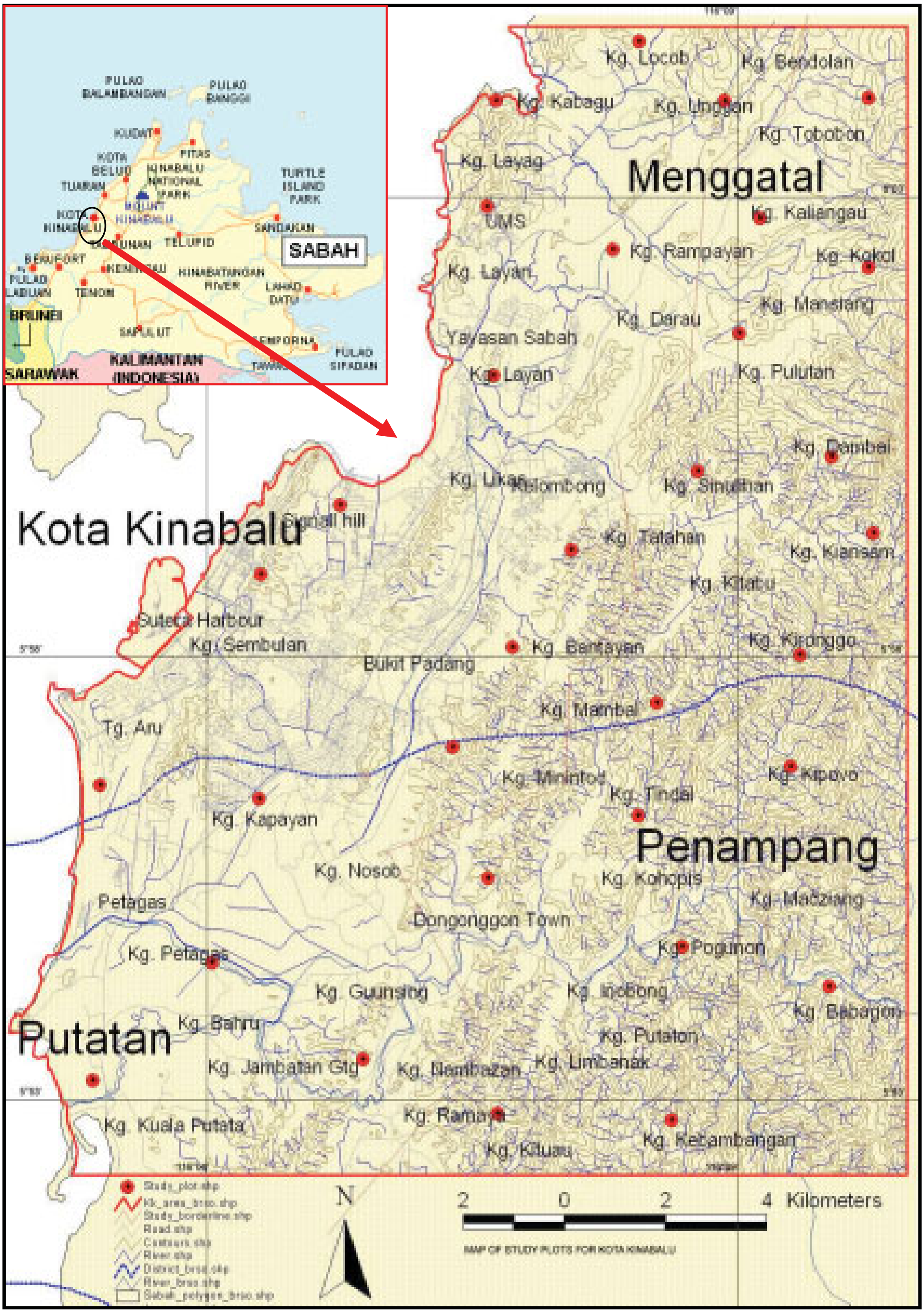


Figure 8: Location of the study area and exemplary study plots (red circle). Scale 1:50,000 *(Source: Own presentation)*

3.3 Research Design

Following is the research design based on Figure 9. The terrestrial data collection through surveys comprises four fields: (1) tree inventory, (2) bird survey, (3) sociogical survey, and (4) classifying urban forest functions.

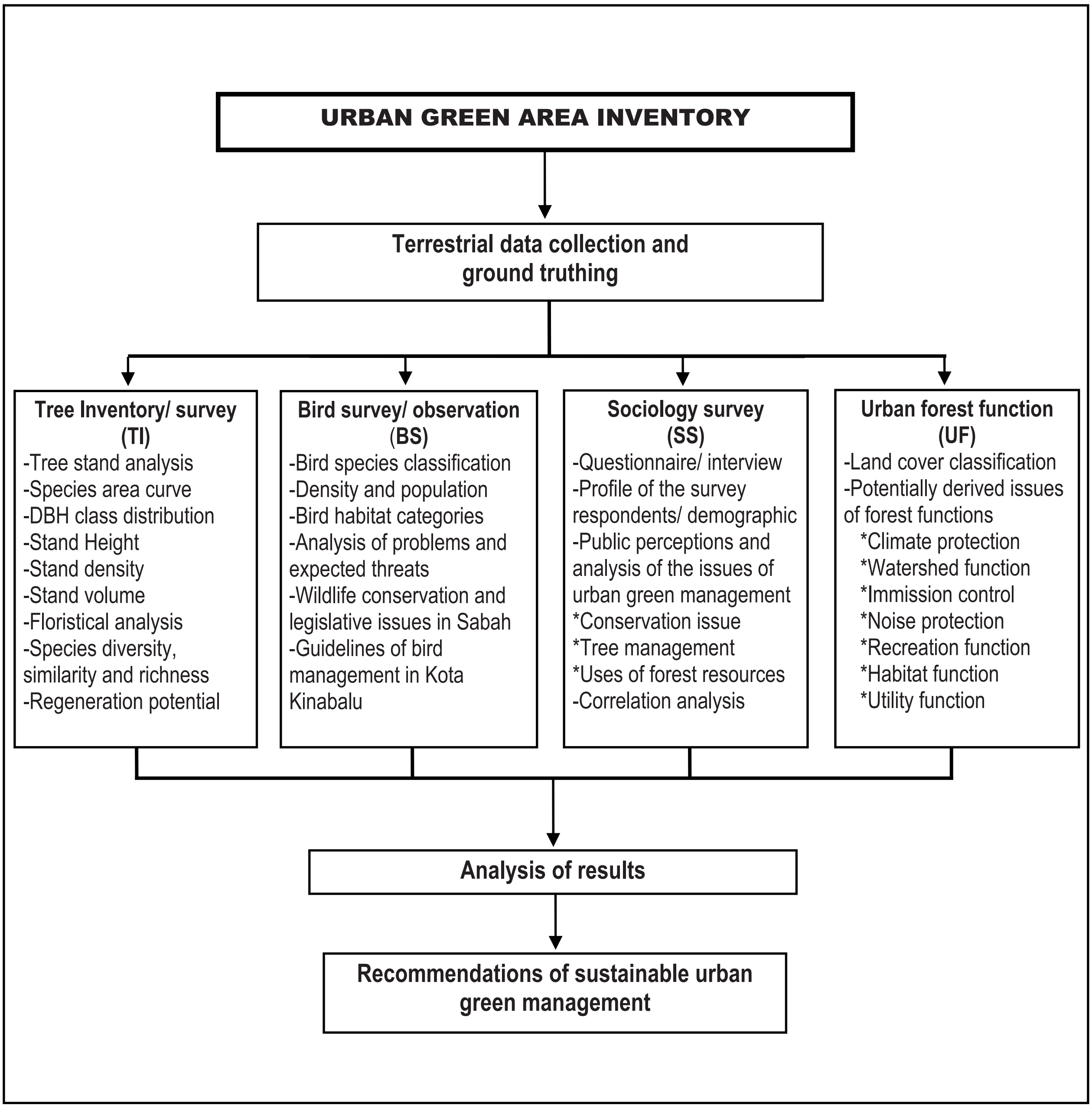


Figure 9: Research design and methodology

3.4 Tree inventory and analysis

3.4.1 Tree inventory/ survey

The inventory and assessment of the tree flora of a large area on the basis of a complete study is usually beyond practical feasibility. Systematic sampling also produce reliable data, but with reasonable effort. A complete survey of all tree species would require a disproportionate amount of time and labour, and therefore is usually not attempted.

A study by San Oo (2006) shows that the minimum area to investigate the plant community of a chosen forest type was 2048 m², with the respective diameter of the circular plots arising at 51.06 m which equals of 25.53 m radius. The goal of the detailed plot analysis was to conduct an exemplary and more detailed vegetation structure and natural regeneration among the chosen representative stands. The detailed exemplary plot design for the vegetation structure analysis and natural regeneration is shown in Figure 10.

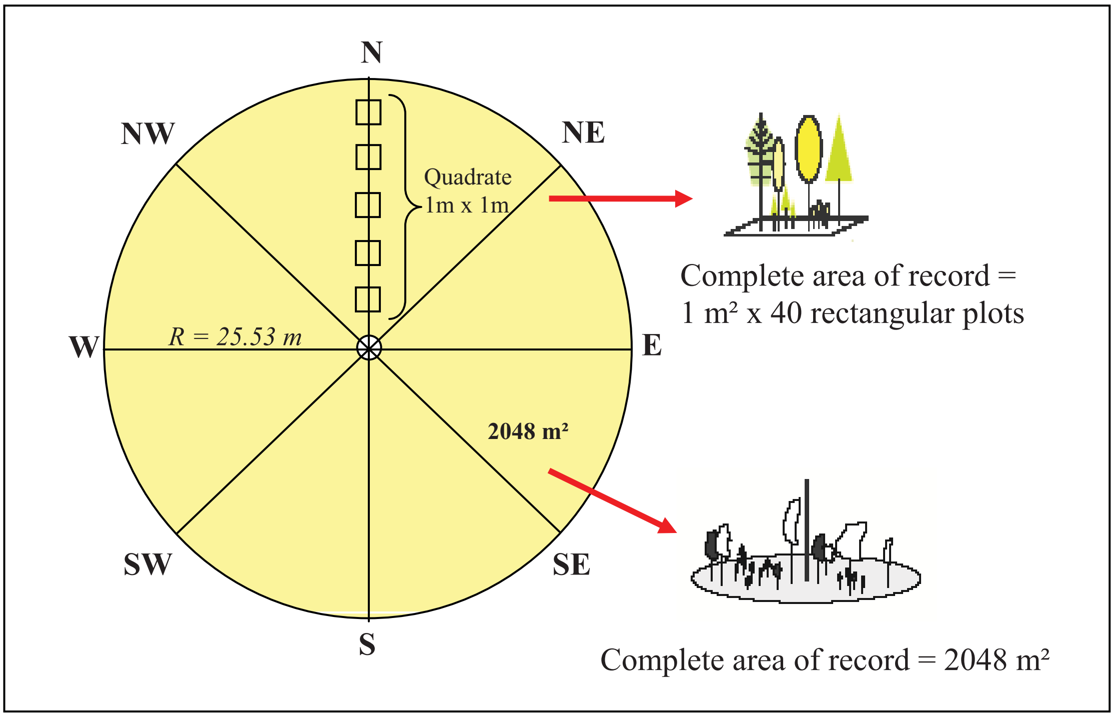


Figure 10: Circular Plot for detailed vegetation structure analysis and natural regeneration

Within a circular plot, all trees with diameter at breast height greater than 10 cm were selected and the diameter at breast height as well as the height of the trees were measured. The quantity of natural regeneration of the tree species was also recorded per m^2 in distances of 5 m, 10 m, 15 m, etc. and directions of North, Northeast, East, Southeast, South, Southwest, West and Northwest. Data of detailed vegetation structure and of the natural regeneration were recorded on different sheets (refer to appendices no.1 - 4).

The total number of circular plots is 32, including 16 in Secondary re-growth stands, 12 in Mixed-Horticulture stands and 4 plots in Mangrove stands. While for the town stand, no sampling plot has been established and all respective tree inventory data have been taken from Kota Kinabalu City Hall.

The sampling locations have been choose randomly and the characteristic type of vegetation has been identified in appropriate and representative circular plots as described in figure 10 during the field investigation. The recorded data of each record unit 2048 m^2 are:

- Trees $\geq$ 10 cm diameter at breast height (dbh). Record parameters include: Species, family, dbh and height
- Natural regeneration 40 x 1 m^2 rectangular plots at each 5 m distance from the plot center. Recorded parameters include: Species, family and quantity of regeneration

For the identification of plant species (vernacular names and scientific name) references of "Preferred Check-List Trees of Sabah" (Lee, 1998) and "Tree Flora of Malaya" (Whitmore, 1983) were used.

Based on the results of the sampling plots, the vegetation types were classified into four clusters namely: (1) secondary re-growth, (2) mixed-horticulture, (3) mangroves and (4) town area vegetation. All vegetation types were categorized as disturbed forest areas, which have been cleared and used several times. The definition of each vegetation type is as follows:

a) **The secondary re-growth** (16 plots) refers to a forest or woodland area, which has regrown after having been deforested, undergone shifting cultivation or used for agriculture. Natural succession processes characterize these areas, leading to secondary vegetation. The category comprises areas of scrub, grassland, old grown plantations, former shifting cultivation areas, left behind areas, and idle land with mixed tree species.

b) **The mixed horticulture** (12 plots) occures on areas with more intensive human influences. Usually some land was owned by individual people from the government and some lands were reserved as village's area (Kampong reserve). People usually develop these areas as a horticulture area dwelling with the production of diversified crops for family needs, with the possibility of small surpluses by selling them locally (ICZM, 1988). These products include mixed vegetables, yams, tapioca, chillies, pineapples, fruit trees, bananas, papayas, coconuts, etc. The most common location is along roadsides and riverbanks. Frequently this type of area forms buffer strips between estates and smallholding crops.

c) **The mangrove areas** (4 plots) are usually associated near the coastal areas and riverbanks. This category includes all poorly drained land exhibiting seasonal or permanent water logging. Mangrove areas usually consist of tree species from the Rhizophoraceae.

d) **Trees in town and settlement areas** represent an increased density of manmade structures in comparison to the areas surrounding it. In Kota Kinabalu, the studied areas usually consist of trees planted for ornamentals aesthetic purposes, along the highways, near buildings or in small parks. Greens inside the city and street trees are usually managed and maintained by the Kota Kinabalu City Hall (KKCH). Town vegetation is maintained regularly and all respective trees inventory data could thus be taken over from the responsible administration. There were no sampling plots developed for the town area. The town area consists of an approximate 70 ha of the total Kota Kinabalu district (Salmah Apalasin, 2006, pers.com).

3.4.2 Stand structure analysis

The collected data were classified, tabulated and analysed in accordance with the objectives of the study. Below are some of the further trees stand analysis that were used in this study. All of the data were analysed using Microsoft Office Excel 2003 and Statistica 6.0 software.

Mean diameter

The mean diameter was calculated in two ways: (1) as the Arithmetic mean diameter ($\bar{d}$) and (2) as the mean diameter based on basal area *(d_g)*. The Arithmetic mean diameter takes into account the diameter of all trees using the same weight. While d_g is derived from the arithmetic mean of the basal area of all trees at breast height ($\bar{g}$) of the stand, therefore, d_g is often used to estimate the total basal area of the stand if the number of stems per hectare is known (Kramer and Akça, 1995). The most common methods to calculate these two parameters are presented below.

Arithmetic mean diameter ($\bar{d}$)

The arithmetic mean diameter of a stand is calculated as:

$$\bar{d} = \frac{\sum_{i=1}^{N} d_i}{N}$$

where: d_i = diameter of the individual tree

N = total number of individuals

Mean diameter based on basal area (d_g)

The diameter of tree with the mean basal area (*d_g*) that is derived from the arithmetic mean is calculated as:

$$\bar{g} = \frac{\sum_{i=1}^{N} g_i}{N} \quad ; \quad \bar{g} = \frac{\pi}{4} d_g^2 \quad ; \quad d_g = 2.\sqrt{\frac{\sum_{i=1}^{N} \bar{g}}{\pi}}$$

where: g_i = basal area of the individual tree

Besides the mean diameter itself, the standard deviation is very meaningful. Being the square root of the variance, it is a measure of the homogeneity of the diameter distribution. Variance (σ_x^2) and standard deviation (σ_x) of a population, as assessed in the complete diameter recordings of this study, are calculated by means of the following equations:

$$\sigma_x^2 = \frac{\sum_{i=1}^{N}(x_i - \mu)^2}{N} \qquad \text{and} \qquad \sigma_x = \sqrt{\sigma_x^2}$$

Variance as a measure of variability is usually dependent on the mean value. High values tend to have a correspondingly higher variance. To compare the variance of values of different orders of magnitude, the coefficient of variation (σ_x %) is more suitable (Van Laar and Akça, 1997). It is obtained from the equation:

$$\sigma_x\% = \frac{\sigma_x}{\mu_x} \cdot 100 \qquad \rightarrow \qquad \mu_x \neq 0$$

Diameter distribution

The distribution of stem-numbers per diameter class gives an insight into the stand structure (Apel, 1996). These values, which can be easily calculated from the compiled basic data, are usually depicted in graphical form (Lamprecht, 1989).

Several models are used to describe the approximate diameter distribution in a mathematical function, e.g. the Weibull distribution, the Beta distribution or the Normal distribution.

In uneven aged natural forest however, the number of stems increases with a decreasing diameter distributions are usually observed (Brodbeck, 2004). The inverse J-Shape diameter distribution in natural forests can be expressed as a negative exponential function and logarithmic J-shaped function. The two following widely used and accepted models were used to describe the decreasing diameter distribution mathematically:

1) Negative exponential function: $n = k \cdot e^{-a.d}$ (Van Laar and Akça, 1997)

where: n = number of stems

k, a = constants

d = dbh of the trees

2) Logarithmic J-shaped function: $n = e^{(k.e^{-a.d})}$ (Lu, 1999)

Lu (1999), proposed this function as a new form of a negative exponential function for a better representation of trees in larger dbh classes.

Mean height

The mean height of trees is usually used for estimating the stand volume. According to Kramer and Akça (1995), the mean height of a plot or stand can be obtained as the regression height of the stem with the mean diameter. Corresponding to the different mean diameters mentioned above, the following mean heights are used in this study:

$h_{\bar{d}}$ the height of the stem with the arithmetic mean diameter $\bar{d}$

h_g the height of the stem with the mean basal area of the quadratic mean diameter d_g or d_q

The mean height according to Lorey (1878) as cited by Brodbeck (2004) weighs individual trees proportionally to their basal area. It is calculated as:

$$h_L = \frac{\sum_{i=1}^{k} n_i \cdot g_i \cdot h_i}{\sum_{i=1}^{k} n_i \cdot g_i}$$

where: n_i = number of trees in *i*-th diameter class

g_i = basal area for the class midpoint

h_i = regression height for the class midpoint

k = number of diameter classes

In this study, stems were grouped in nine 10 cm diameter classes (from class1: 10.0-19.9cm to class 9: ≥ 90 cm dbh) for calculation of mean heights and top heights. Results are shown in table 19 in chapter 4.

Top height

The mean height as described above is usually used for estimating the stand volume. However, it is easily influenced by disturbances, e.g. thinning, and thus the mean height is not well suited to predict the site index. Therefore, the top height is also often used.

- The top height according to Hart (1928) is defined as the arithmetic mean of (100) tallest trees per hectare (h_H).
- Another approach defines the top height as regression height of the quadratic mean diameter of (100) thickest trees per hectare (h_{100}).
- Unlike the above-mentioned top heights, which use absolute numbers of the highest and/or the thickest stems, the top height according to Weise (1880) (h_0) is defined as the height of the stem with the mean basal area as calculated from 20% thickest stems of a stand.

Stand height

By plotting measured heights over diameters, a point cloud is obtained whose scatter is a measure of the homogeneity of the stand. If means are calculated, in most cases a fit will produce a nearly linear curve (Loetsch et al., 1973). Table 11 shows the equations, described by Schmidt (1968) (equations 1-6), and Van Laar and Akça (1997) (equations 7-12) respectively, that were tested to fit a height curve for the stands in Kota Kinabalu.

Height curves derived form the functions to well fit the observed data had to satisfy the following requirements: the function should be monotone, increasing with increasing dbh; the standard deviation should be as low as possible and the correlation coefficient should be as high as possible (Van Laar and Akça, 1997).

Table 11: Equations tested to fit height curves of disturb forest stands in Kota Kinabalu

Equations	Number	Author/descriptions
$h = b_0 + b_1 \cdot d + b_2 \cdot d^2$	(1)	Parabola
$h = 1.3 + \frac{d^2}{b_0 + b_1 \cdot d + b_2 \cdot d^2}$	(2)	Prodan (1944)
$h = 1.3 + \frac{d}{b_0 + b_1 \cdot d}$	(3)	Petterson (1955)
$h = e^{\left[b_0 + b_1 \cdot \ln(d) + b_2 \cdot \ln^2(d^2)\right]}$	(4)	Korsun (1948)
$h = b_0 + b_1 \cdot \ln(d)$	(5)	Logarithmic
$h = e^{\left[b_0 + b_1 \cdot \ln(d) + b_2 \cdot d\right]}$	(6)	Freese (1964)
$h = 1.3 + (b_1 \cdot d + b_2 \cdot d^2)$	(7)	Van Laar and Akça, (1997) (3)
$h = e^{\left[b_0 + b_1 \cdot \ln(d)\right]}$	(8)	Van Laar and Akça, (1997) (6)
$h = e^{\left[b_0 + b_1 \cdot \frac{1}{d}\right]}$	(9)	Van Laar and Akça, (1997) (7)
$h = 1.37 + b_1 \cdot (1 - e^{-b_2 \cdot d})$	(10)	Van Laar and Akça, (1997) (8)
$h = b_1 \cdot (1 - e^{-b_2 \cdot d})$	(11)	Van Laar and Akça, (1997) (9)
$h = b_0 \cdot \left[\frac{d^{b_1}}{b_2 + d^{b_1}}\right]^{b_2}$	(12)	Van Laar and Akça, (1997) (10)

Notes: h = height, *d*= dbh, b_0, b_1, b_2 = constants of the equations

Height curve functions such as the parabola (equation (1)) or the logarithmic equation (equation (5)) were developed for even-aged stands of a single tree species, with little variation of diameters. These functions do not suit well for the description of uneven aged, multi-layered stands with high species diversity as found in this study.

The relationship between height and diameter is used to produce for the bulk of measured diameters and their estimated heights. Referring to Kramer and Akça (1995), a sample of 30 – 40 tree heights is sufficient for the drawing up of a height curve. These numbers, however, refer to stand inventories in the temperate zone, where maximum tree diameters are usually smaller than in the moist tropics. For this study, a sample of 80 – 110 tree heights, with the maximum dbh up to 100 cm was used.

3.4.3 Stand basal area

The stand density expresses to which extent a given area is covered with trees. It is an indicator for the productivity of a stand and can be used to estimate the potential yield (Sterba, 1981). Basal area and number of stems, two parameters that are easy to measure, are commonly used to describe stand density. Stand basal area (*G*) is defined as the sum of the cross section of all trees of a stand, measured at 1.3 m height. It can be expressed as:

$$G = \sum_{i=1}^{N} g_i \qquad \text{where} \qquad g_i = \frac{\pi}{4} \cdot d_i^2$$

where: g_i = basal area of the individual tree

d_i = diameter of the individual tree

3.4.4 Stand volume

Stand volume is the most important stand characteristic in stand inventories. It is a function of the number of trees, the basal area and height and the form of trees. The stand volume is usually estimated from the diameter and height of the mean tree (Van Laar and Akça, 1997). However a higher precision is achieved when the stand volume is estimated as a sum of the volumes of the individual trees:

$$V = \sum_{i=1}^{N} v_i$$

where: V = stand volume

v_i = volume of individual tree

N = number of trees

The volume of individual trees is normally estimated from a function with dbh and height as predictor variables:

$$v = g \cdot h \cdot f$$

where: v = volume

$g = \frac{\pi}{4} \cdot d^2$ (Basal area)

h = height

f = form factor

In this study, diameters of all trees dbh ≥10cm were measured and recorded. The corresponding tree height was deduced from height curves. The form factor is a reduction factor by which the volume of the reference cylinder (=basal area x tree height) has to be multiplied to obtain the tree volume (Loetsch et al., 1973). The form factor varies between different tree species with the tree age. For uneven-aged mixed stands in the tropics, a form factor of (0.5) is commonly used (Whitmore, 1984).

The stand volumes for the disturbed forest stands in Kota Kinabalu were estimated as:

$$V = \sum_{i=1}^{N} g_i \cdot h_i \cdot 0.5$$

Where V is volume of the above-ground wood and bark (minimum diameter 10 cm). The results of stand basal area and stand volume are shown in table 20 in chapter 4.

3.4.5 Accuracy and error of vegetation assessment

According to Zöhrer (1980), a sampling error results from the fact that only a part of the entire population is assessed. The most suitable measure for the sampling error is the standard error. When non-sampling errors can be eliminated to the greatest possible extent, the standard error (e.g. that the mean basal area) is a suitable measure for the accuracy of the vegetation assessment. The sample size is sufficient when the standard error does not exceed the desired value. For most vegetation assessments, a standard error of 10% is tolerable.

The standard error for the measurement of the mean basal area ($S_{\bar{g}}$) is calculated as:

$$S_{\bar{g}} = \frac{S_g}{\sqrt{n}}$$

where: S_g = standard deviation of basal area

n = sample size

The standard error of mean basal area as a percentage ($S_{\bar{g}}\%$) is then calculated as:

$$S_{\bar{g}}\% = \frac{S_{\bar{g}}}{\bar{g}} \cdot 100$$

where: $\bar{g}$ = mean basal area

The value for the mean basal area ($\bar{g}$), the standard deviation (SD) and the standard error as percentage ($S_{\bar{g}}\%$) for this research stands is shown in table 21 in chapter 4.

3.4.6 Floristic analysis

Species composition

The Importance Value Index (IVI), developed by Curtis and McIntosh (1951). It demonstrates the ecological importance of a certain species in a certain vegetation types and it combines three features of a species: Number of individuals, coverage and distribution in a single index by summing up the relative abundance, relative dominance and relative frequency values. According to Lamprecht (1989), abundance, dominance and frequency are defined as follows:

- Abundance: stem number of a given species per hectare.
- Dominance: degree of coverage of a species as an expression of the space it occupies usually calculated as the sum of all individuals of the given species, e.g. in m^2.
- Frequency: the occurrence of a given species in a set of plots, mentioned in percentage.

The species are often assigned to five classes according to their relative frequencies as shown in table 12. These classes expresses the occurrence or absence of a given species in set number of plots, to express as a percentage of all plots (Raunkiaer, 1934 and Lamprecht, 1989).

Table 12: Frequency classes according to Raunkiaer (1934)

Class	Relative frequency
I	1 – 20%
II	21 – 40%
III	41 – 60%
IV	61 – 80%
V	81 – 100%

Frequencies do depend on the size of the plots: the larger the plot, the larger the number of species in the higher frequency classes. Consequently, only frequency diagrams based on identical plot sizes can be compared (Lamprecht, 1989). The size of the plots in this study was 2048 m^2. The high frequency values of class IV and V, indicate a high degree of floristic homogeneity i.e. the respective species occure regularly in the respective vegetation types. Contrarily to this, the low values of class I and II indicate that the respective species only occure scarcely. However frequencies also depend on the total number of trees.

The IVI provides information about the importance of a species with respect to the vegetation structure or species compositition of a given stand. Its value represents a percentage fraction of the total species composition. The Important Value Index (IVI) is calculated for each species as:

IVI = relative abundance + relative dominance + relative frequency

where: abundance = number of individuals (n/ha)
dominance = basal area (m^2/ha)
frequency = number or percentage plots in which the species is represented

Species diversity

Species diversity is defined as the number of different species present in a particular area or vegetation type. Several common indices were used to demonstrate the species diversity of the stands as follows:

a) Whittaker (1960) distinguished α, β and γ diversity. The diversity within a biocoenosis or particular stand is also called α diversity. The most simple indicator for α diversity is *species density*, which is usually expressed as the number of species per hectare. The *ratio of individuals to species* is another measure for α diversity that is easy to determine. It produces the average number of individuals per species. However, it gives no information on the frequency of individual species (a given value may be achieved with many rare species and a few common species or with species having more or less the same proportion).

b) The *Simpson index* (Simpson, 1949) avoids that disadvantage. It gives the probability of any two individuals drawn at random from an infinitely large community to belong to different species as:

Simpson's Index:

$$D = \frac{\sum_{i=1}^{k} n_i.(n_i - 1)}{N.(N - 1)}$$

where: n_i = number of individuals in the i-th species

k = number of species

N = total number of individuals (all species)

The value of *D* is between 0 and 1: As *D* increases, diversity decreases. The Simpson index is therefore usually expressed as 1-*D*, i.e. the higher the value is, the higher is also the species diversity (Magurran, 1988).

c) Another index giving information about species diversity is the *Shannon index* (*H'*); (Shannon and Weaver, 1949) which is estimated by:

$$H' = -\sum_{i=1}^{k} p_i \cdot \log p_i$$

Where: p_i = proportional abundance of the *i*-th species

k = number of species

If the data are in the form counts, p_i is calculated as $\frac{n_i}{N}$ where n_i is the number of the individuals of the *i*-th species and *N* is the total number of the individuals (Greig-Smith, 1983). The base of the logarithm is arbitrary, however, logarithms to the base *e* are most commonly used. It can be calculated as:

$$H' = \sum_{i=1}^{k} \frac{n_i}{N} \cdot \ln \frac{n_i}{N}$$

The value of *H'* becomes more meaningful if it is compared to the maximum possible diversity H_{max}, which it is theoretically obtained when all species of the sample are represented with the same number of individuals. In that case, the above-mentioned equation can be written as:

$$H_{\max} = \ln k$$

where: $H_{\max}$ = maximum possible diversity

k = total number of species

The ratio of H' to H_{max} can be taken as a measure of 'Evenness', (Pielou, 1969), using the equation:

$$E[\%] = \frac{H'}{H_{\max}} \cdot 100$$

where: $E[\%]$ = Evenness

H' = observed diversity according to Shannon

$H_{\max}$ = maximum possible diversity

The number of trees, species density, the Simpson and Shannon indices and the Evenness of the stands of the observed vegetation types are compared in table 23 in Chapter 4.

Species similarity

Species similarity is defined as the degree of symmetry of two species in either analogy or resemblance. The similarity or dissimilarity of two biocoenoses or stands is also called β diversity. Species can be compared using a similarity indices. For the floristic comparison of stands, Sörensen (1948) proposed the coefficient of similarity that is calculated as *Sörensen Index*:

$$K_s = \frac{2c}{a+b} \cdot 100$$

where: a = number of species of stand A

b = number of species of stand B

c = number of species common to both stand

Sörensen's coefficient of similarity is calculated with the numbers of species, giving the same weighting to dominant and sporadic species. Because this fact reduces the meaningfulness of this coefficient, Lamprecht (1969) proposed a modified indicator, which also pays attention to the corresponding dominances (basal area) of the species calculated as:

$$K_d = \frac{\sum^{k} d_c}{\sum d_a + \sum d_b} .100 \ (\%)$$

where: d_a = dominance of one species of stand A

d_b = dominance of one species of stand B

d_c = dominance of one species common to both stands

k = number of species

However, according to Brodbeck (2004), to describe the similarity of two stands, it is not sufficient to look at how many species these stands have in common, but it is necessary to examine which importance these common species do have in the two stands. The ecological importance of a species is best described by its IVI (see above), which apart from the basal area, also takes other factors into consideration. Therefore a coefficient of similarity has been calculated that is weight with the IVI of the stands.

$$K_{IVI} = \frac{\sum^{k} IVI_c}{\sum IVI_a + \sum IVI_b} .100 \ (\%) \qquad \text{or} \qquad K_{IVI} = \frac{\sum^{k} IVI_c}{6}$$

where: IVI_a = important value index of one species of stand A

IVI_b = important value index of one species of stand B

IVI_c = important value index of one species common to both stands

k = number of species

3.5 Bird Survey/ Observation and Analysis

The presence of birds in the urban landscapes is the final testimony to the quality of the urban environment. Birds can be an important ecological indicator to be achieved in balancing between the natural and the built environment. The aim of this study was to analyse the possibility of the green areas as a site to conserve bird species by;

- *Exploring the number of bird species and bird habitat areas in the green areas.*
- *Analysing the population density and abundance of bird species using distance sampling software.*

3.5.1 Bird Survey

In order to conduct the study, there are some mechanisms for obtaining the data which include, firstly: review from literature, books and scientific reports available from World Wide Fund (WWF-Kota Kinabalu), Sabah Wildlife Department and others. Secondly: field surveys and observations as a complement and confirmation. For this purpose, the point transect sampling method was used.

Point transect are often termed variable circular plots in the ornithological literature, where points are often placed at intervals along straight transects (Buckland et al., 1993). It is a simple method that provides a uniform way of counting birds over time or across locations. In large areas, randomly allocated point counts can be used as representative samples for the area. Point transect sampling are visited over a period of several days or longer to assess how many and what types of birds are present in that area.

For this field survey and observation, a total of 32 sampling points were established at the same locations that had been used for the tree inventory. At each sampling point, every bird species observed or heared within distances up to 100 metres from the centre points was recorded, using 10-meter intervals.

To facilitate the procedure a grid was drawn on the map to illustrate the distance between the observation points and the sampling point to the bird detected. Sometimes, it was necessary to move a little bit from the point because some bird species respond to movements or are difficult to be seen in a closed canopy like the Woodpeckers, Eagles and Owls. The characterization of habitat types surrounding the sampling point were also recorded and located in the map by the help of a Global Position System (GPS). The detailed point transect sampling design for bird survey is illustrated in Figure 11.

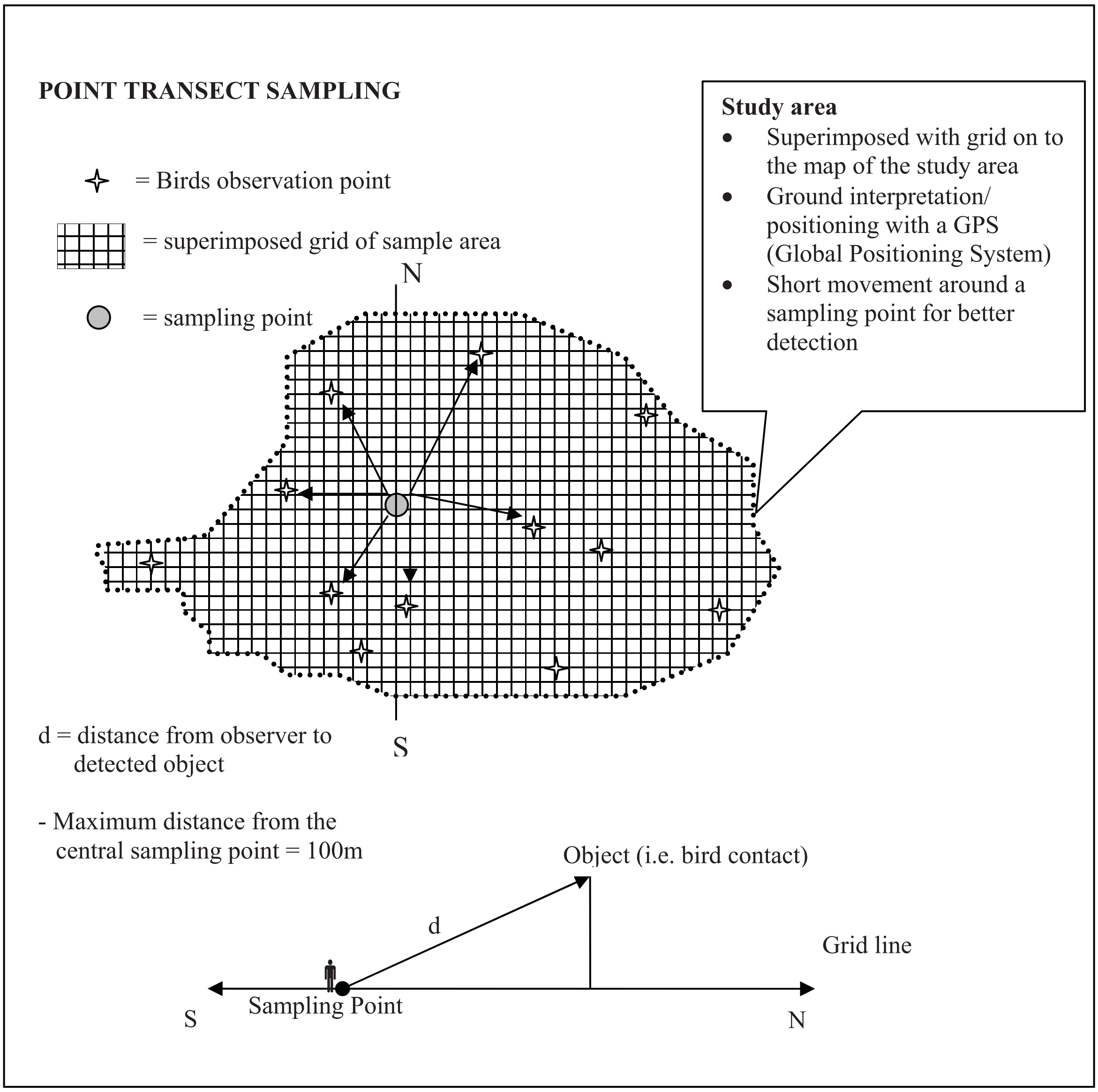


Figure 11: Detailed point transect sampling plot for bird survey
(Source: Own presentation)

The collected information about bird habitats within the 100-meter radius around each sampling point included: elevation, slope, aspect, distance to water, type of agriculture areas, type of disturbance (landslide, fire, etc), major tree species, shrub species, major herb species and seeds or wild fruit that potentially serve as birds' food. Birds were then identified down to species level with the support of a checklist:

a) Field Guide Bird of Borneo by MacKinnon and Phillipps (1993).
b) A photographic guide to birds of Borneo Sabah, Sarawak, and Kalimantan" by Davison and Chew (2001).
c) On-spot identification with the help of local bird expert.

3.5.2 The Detection Function and Assumptions

The central concept of distance sampling is the detection function $g(y)$:

$g(y)$ = the probability of detecting an object, given that it is at distance y from the random point or line
= Pr {detection | distance y}

The distance y refers to the sighting (radial) distance r for point transect. By which the detection probability (Pr) is derived based on distance in meter from the investigator. Generally the detection function decreases with increasing distance, but $0 \leq g(y) \leq 1$ always. In the development to follow, usually assume that $g(0) = 1$, that is, object on the point are detected with certainty (Buckland et al., 2001).

According to Bibby et al., (2000), the detection probability is essential to calculate the bird population with respect to its density and heterogeneity. To extrapolate the bird density of each individual bird species, the minimum counts should be approximately 60–80 but, for less precise estimates it can also be calculated with fewer observations. However if birds are clustered, the sample sizes has to be even larger (Buckland et al., 1993).

Bibby et al., (1993) stated that point transect methods also can be used to compare differences in bird population between sites and to monitor changes in bird populations when an area changes. With respect to its habitat conditions point transect sampling often are utilized in areas where line transects are impractical. Potential bird habitat area and other important bird area characterization were mapped using GIS software.

Statistical inference in distance sampling rests on the validity of several assumptions. First, the survey must be competently design and conducted. No analysis or inference theory can make up for fundamental flaws in survey procedure. Second, the physical setting is idealized namely: Objects are spatially distributed in the area to be sampled according to some stochastic process with rate parameter D (= number per unit area). Randomly placed points are surveyed and a sample of n objects is detected, measured and recorded.

Three assumptions are essential for reliable estimation of density from point transect sampling. These assumptions are given in order from most to least critical:

1. Objects directly on the point are always detected (i.e. they are detected with probability 1, or $g(0) = 1$).
2. Objects are detected at their initial location, prior to any movement in responsive to the observer.
3. Distances are measured accurately or objects are correctly counted in the proper distance interval.

3.5.3 Bird Data Analysis

DISTANCE sampling software was used to estimate the bird population density. It's is a Windows-based computer package that can be used to design and analyze distance sampling surveys of wildlife populations. For the standard distance sampling method, the fundamental parameter of interest is density (D = number per unit area) and population size ($N = D \cdot A$), where A is the size of the study area (Buckland et al., 2001).

From Figure 11 above, we consider a series of k points positioned randomly, or a grid of k equally spaced points randomly superimposed on the study area. An observer measures the sighting (radial) distance r_i from the random point to each of the objects detected. Upon completion of the survey of the k points, there are n detected object with a distances measurements. In circular plot, an area of πw^2 around each point is censused. Conceptually, we can use the distances r_i, i = 1, ….., n, to estimate the effective radius P_a within the expected proportion of object detected within a radius w. Density D is then estimated by:

$$D = \frac{n}{k\pi w^2 P_a}$$

where:

n = number of bird detected from point

k = number of points surveyed

w = the radius searched around a point transect

P_a = proportion of objects detected within a radius w

3.6 Sociology Survey and analysis

3.6.1 Sociology Survey

The sociology survey was conducted as an *in-situ survey*, by distributing questionnaires (refer to appendices no. 6 - 7) and conducting interviews in the town area and in village communities settled close to the forest or to urban green areas. The purpose of this study was to determine the public perception and opinion concerning urban (forest and green areas) through a series of attitudinal and knowledge questions. It can be divided into two main objectives namely:

- *To obtain information demographic characteristics the people living near the green areas*
- *To analyse the local people's opinion on the functional uses and roles of the green area surrounding them*

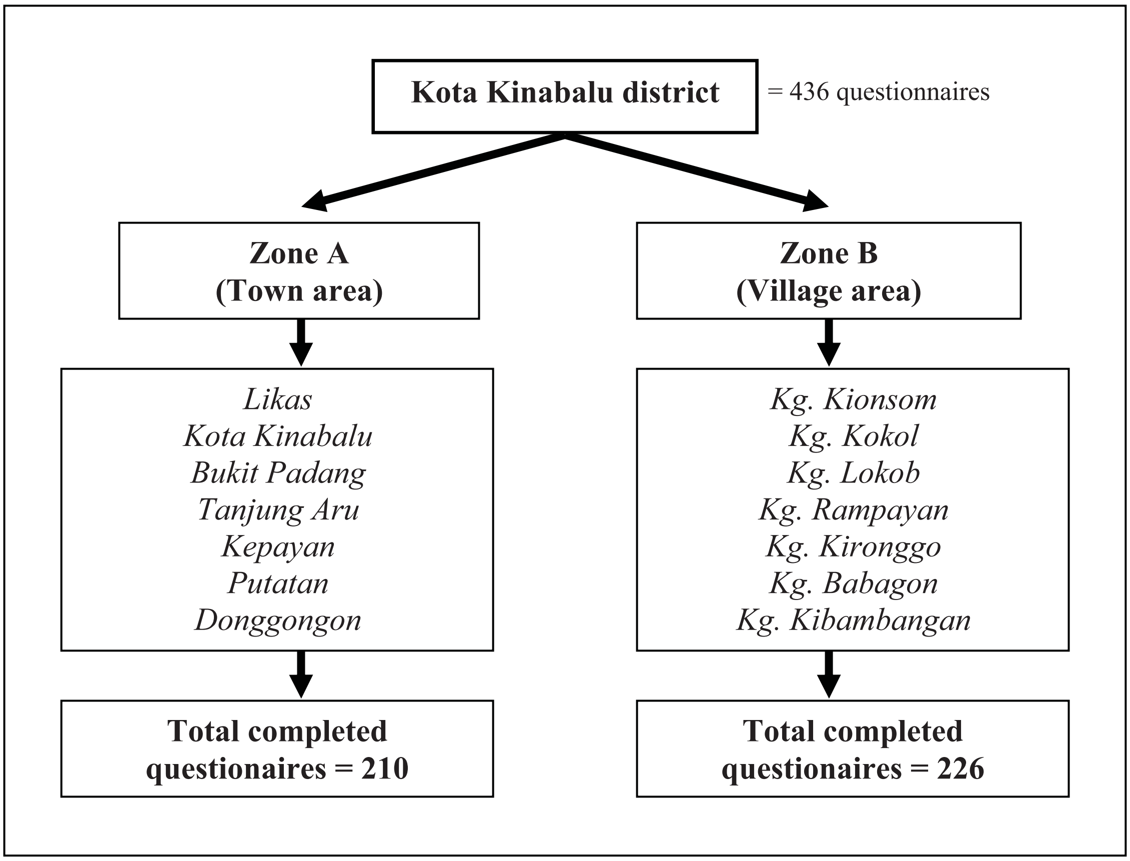
The distribution of the questionnaires was divided into two main zones e.g. town zone and village zone (Figure 12), a total of 450 questionnaires having been distributed to the public. The distribution of questionnaire was chosen randomly. In each of the village, the distribution of the questionnaire was based on households.

After filtering process, the number of returned completed-questionnaire was 436, which consists of 210 in town areas and 226 in village areas. The other 14 residual could not be further processed due to error and incomplete filling. A number of important issues were evaluated including; (1) demographic characteristics, (2) public perception concerning green areas, and (3) the most obvious differences between town and village people perceptions toward forest function uses.

Concerning issues number (2), eight major criteria were considered in the questionnaire: (a) the importance and benefits of urban green areas to the people, (b) motivations for visiting urban green areas, (c) the significance of conserving urban green areas, (d) the perception of tree management in Kota Kinabalu, (e) the dependence of villages communities on forest resources, (f) the opinion upon wildlife species found in the forest, (g) the perception of interesting nature resources in the own village and, (h) the problems given by the forest in the own village.

The differentiation between these two zones is more likely to be seen with respect to the population density, economic activities and socio-demography characteristics. FAO (1999), noted that community living in the village (suburban) or near the forest area will result in different opinions concerning the multi uses of forests, compared to people's living in the city.

In general, the questionnaires were distributed formally and distribution of the questionnaire was done with a team of 2 – 3 people in a group to the selected towns and village areas. The questionnaires structure is a closed-ended question with a combination of multiple scales. The statements show the amount of agreement and disagreement with dichotomous choices.



Note: 'Kg' or 'Kampong' is a Malaysian word and means 'Village'

Figure 12: The flow of questionnaires distribution in Kota Kinabalu district

For the interview method, semi-structured individual interviews (mix structured questions) with open-ended questions that ask *why* and *how* were used. Semi-structured interviews are conducted with a fairly open framework which allows focused conversational and two-way communication. Open-ended questions are used to follow up and probe for more detailed and explanatory answers. These semi-structured informal interviews were used to drop the bias of "making up the answer for my best performance" which some-times occur in a *formal interview*. The interviews were done with the help of a tape recorder.

To prevent the bias caused by a mistake in interpreting the results of the interviews, the interview process applied a confirmation process. The confirmation process was performed at the end of each interview process by confirming the key words of various informations which have been given by the respondents.

The scoring method used in both interviews and questionnaires is based on Likert's scales (Likert, 1932), which generally means that scale 1 is to express the qualitative value of something, which is considered as "strongly agree" interviewee. It respectively moves to "partly agree", "ambivalent", "partly disagree", and "strongly disagree" for scale 5. However, these scales can also mean an expression of "low" value to a "high" one, according to the criteria of the parameters used in the evaluation.

3.6.2 Sociology Data Analysis

The Statistical Package of Social Sciences (SPSS) and Microsoft Office Excel were used to analyse the questionnaires in a descriptive analysis, in frequency table, and percentage. In general, the quantitative analysis includes at least the total number, percentages, and averages (frequency distributions) for all important variable categories and cross-tabulations of important dependent and independent variables.

The findings serve to help identifying an emerging public concern and allow the government to better address the most contentious or misunderstood issues concerning urban forest management and uses. It is assumed that community living in the sub-urban area will lead to different opinions, perceptions or awarenesses compared from community living in the urban and town areas.

3.7 Classification of Land Cover and Urban Forest Functions

Anderson et al. (1976) noted that the knowledge about land use and land cover has become increasingly important to monitor the problems of uncontrolled development and deteriorating environmental quality. Land-use data are needed in the analysis of environmental processes and problems that must be understood if living conditions and standards shall be improved or maintained at current levels.

Knowledge of the present land use pattern concerning agricultural, recreational, forest and urban lands, as well as information about their changing proportions, is needed by legislators, planners, and local governmental officials to manage a better land use and to identify future development pressure points. This also includes prevention of inappropriate development.

The study tries to develop a comprehensive management concept in which identifying the essential ecological functions of urban green spaces shall contribute to safeguard the forest. To follow this objective two basic task/ missions need to be achieved, namely:

- *To update the state of land cover based land use/biotope mapping*
- *To analyse the significant role of urban and suburban trees and forests and classify it based on their important functions according to specific site conditions such as topography, soil, vegetations, bird habitats, utilities and recreations*

3.7.1 Land cover classification

Remote sensing images and spatial analysis were used to give an overview of different characteristics of land cover. For the purpose of the classification processes, two types of data were used for interpretation: Satellite data and aerial photographs. However, other sources of data as digital data and hard copy map were also needed to support the study as followed:

a) Soil class 1974, obtained from the Agricultural Department Sabah
b) Topographic map, Scale 1:50,000 (modified and geo-rectified), obtained from the Mapping Department Malaysia
c) Basic GIS map of Sabah, obtained from WWF-Kota Kinabalu
d) Road maps (in shape file), obtained from Kota Kinabalu City Hall
e) Agriculture land use legend, from the Agriculture Department Sabah

a) Satellite data interpretation

Satellite data is most frequently used to classify and map various forest and land-use types. Pixels image are classified according to their ground reflectance values as measured by the satellites. The desired map is created by displaying the classified pixels in their appropriate geographic context. Computer algorithms are used to examine the spectral data of the entire scene and to clump pixels with like spectral properties into common classes according to the specific clustering algorithm used. (Iverson et al., 1989). After classes are generated, the operator assigns meaning to the classes (i.e., converts the classes to landcover types) on the basis of ground-based data and the spectral properties of the class (e.g., water, green, bare land and etc. has unique reflectance characteristics) (Runkel, 1991).

For the purpose of this study, satellite image SPOT (System Pour I´Observation de la Terre) of Kota Kinabalu (band 4:3:2), taken on 19/01/2002 has been chosen for spectral characteristics regarding vegetation mapping. To be fully usable for resource management, the vegetation data have been transformed from a satellite image format into vector format of Geographic Information System (GIS) (Woodcock et al., 1994). The differentiation in band color was used to interpret the type of land cover as well as the homogeneity of vegetation types. The confirmation process was done in a field visit to obtain the real situation on the ground in representative sample areas.

b) Aerial photograph interpretation

Aerial photographs as further orientation aid, have invaluable use for resource classification and mapping. Such images serve as basis for inventory data on vegetation cover and land-use, systematic observation of land cover changes, such as deforestation and stratification in the context of sampling design (Reichert and Kalensky, 1992). Aerial photographs of Kota Kinabalu, in Colour Infra Red pictures (C.I.R) and taken in the year 2000 were obtained from the Mapping Department Malaysia. They have been used to further interpret the land cover and to stratify the forest types in order to select the suitable and representative sampling plots for more detailed terrestrial inventories.

After images classification from the satellite images, the colour infrared aerial photograph was used as a proof-check for the interpretation of the exact types of land uses and their changes using visual interpretation.

A basic mapping key had to be produced for the purpose of classification and mapping. Such key is usually defined as levels and classes in consideration of the purpose of use (national, regional or local) (Kiemstedt, 1994).

Actually, there is already some agriculture land use classification scheme which has been developed by the Agriculture Department Sabah in 1991. However, no proper system has been elaborated how to categorize the different landuse types in terms of keys and codes. The land-use classification is also too old to rely on. Thus for the purpose of this study it has only be used as a basis data, and a new classification was proposed on the basis of new settelite images.

The developed mapping key uses consecutive code numbers from (1000 until 9000), and the description of each identified type of land-use was adopted from the Agriculture Department Sabah (2003). Nine (9) different landuse/biotope types were recognized and distinguished, namely: 1) urban areas, settlements and associated non-agricultural areas, 2) horticultural lands, 3) trees, palm trees and other permanent crops, 4) cropland, 5) improved permanent pastures, 6) grasslands, 7) forest lands, 8) swamps, mangroves and wetland forests, and 9) unused lands. Within this classification, each type then was subdivided into classes named as *land use types* which were specified as symbol/legend that show where it belongs to. The detailed landuse/biotope classification is shown in table 51.

3.7.2 Suburban Forest Function Classification

The second task of this part of the study was to produce a functional zonation based on potential important area functions. The classification was done in the experimental plots with the aid of Aerial Photograph, Satellite image and Global Position System (GPS).

For this purpose, a total of 18 sampling areas were selected for field survey and classification of the forest and green area functions. The sreas are stratified based on nearest localities of towns and villages administration. Five sets of potentially important functions as listed in Table 13 were taken into consideration. In order to evaluate each function, the Poly-functional Assessment Method (PFAM) (URGE, 2001) was used to analyse and judge the state of an individual green space or forest area.

Table 13: The functions and subfunctions applied for classifying urban forest functions in Kota Kinabalu *(Source: Adapted from Volk & Schirmer (2004): Leitfaden zur Kartierung der Schutz- und Erholungsfunktionen des Waldes)*

No	Function	Subfunction
1	Conservation function	• Watershed management • Regulation of climate (cooling, shadowing) • Protection from soil erosion • Protection from noise • Protection from immission control
2	Recreation function	• Recreation activity • Outdoor sport
3	Bird habitat function	• For bird corridor area • For bird food
4	Nature protection function	• Species conservation • Biotope conservation • Process conservation
5	Utility function	• Fuel-wood • Timber

The actual conditions in these example individual areas were compared with the important functions that potentially could be derived from the green area. Specific criteria and indicators for each function are given in Chapter 7.3.4. Since this method takes all categories of land characteristics i.e. topographic characteristics, water, soil types, types of land cover and land use into account, this method could be used for zoning the urban green area in general.

The list of indicators then was improved to produce “goal assessment matrices” based on scale and rating of the areas in terms of their priorities e.g. *“very important area, fair but important and, not so important”* as shown in table 14. This evaluation was done based on the estimation of: (1) ecological site conditions; (2) human influence; (3) conservation requirements, and (4) the potential impact of the landscape elements that possibly affect the surrounding areas. This matrix was then scored relating the spatial analysis of functions with the observed areas (Table 14).

Table 14: Examples for scoring criteria of conservation function
(Source: Adapted from IUCN (1986): Managing protected areas in the Tropics)

Functions / Observed areas	Watershed management	Regulation of climate	Protection from soil erosion	Protection from noise	Protection from immission control
Area 1	X=(3)	X=(1)	-	X=(3)	-
Area 2	-	X=(1)	-	X=(2)	X=(1)
Area 3	X=(2)	-	X=(2)	X=(1)	-

Indicator/ Definition	Goal Assessment Matrices	Colour in Map
	(3) = Very important area	Red
As given in Chapter 7.5	(2) = Fairly important area	Yellow
	(1) = Not important for the respective function	Green

Note: X = *Present, and important area for the respective function*
(-) = *not represented*

The informations gathered from the field was then analysed and cross-checked with the satellite images. The information collected included terrain, slope, soil erosion risk, rivers, creeks and streams, land use conflicts, and nature conservation area. The judgment of each area was done according to the informations collected above and resulted in the functional zoning. The functions then were mapped using Geographic Information System (GIS) software e.g. ArcView 3.1, Erdas Imagine 8.6 and Arc-Info.

4.0 Tree Survey and Stand Analysis in Kota Kinabalu

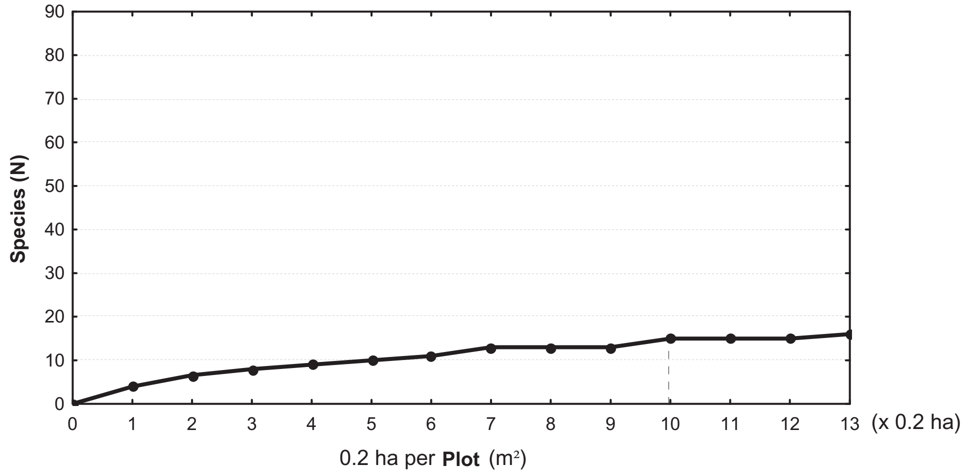
4.1 Species area curve

The assessment of the tree flora in a large area based on a full enumeration is not feasible due to restricted time and labour. Usually a representative area provides reliable data, but the minimum representative area has to be determined. It has been observed that if the study area increases, the number of species encountered in these areas will likewise increase, however, the increase in species numbers occurs in a decreasing rate.

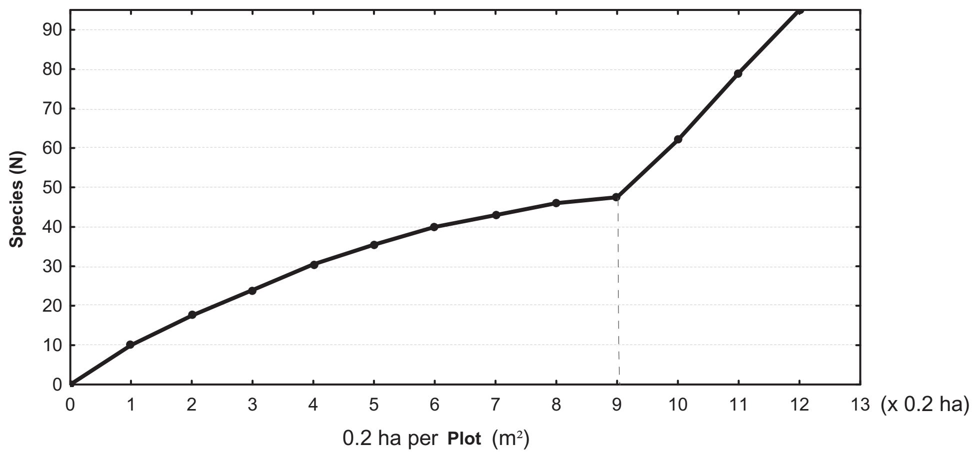
According to Cain and Oliveira (1956), the representative area is reached when the increase in number of species per unit area remain below 10% of the species area curve with a 10% expansion of the sample plot size. The study by Brodbeck (2004) in Sulawesi, Indonesia; Polinar, (2004) in the Philippines and Tran (2005) in Vietnam concluded that a sample plot of one-hectare size do fulfill the requirement for the minimum area for studying floristic characteristic in the Tropics.

In this study, a cumulative sample plot of 0.2 ha each was chosen to give estimates of the number of tree species found in each forest stand type. As shown in figure 13 (a), the species area curve for secondary re-growth shows that by plot 10 (2 ha) a sufficient plot area size is reached to describe the vegetation community in that area whereas more of the gradient has a relative small incline in the upper part.

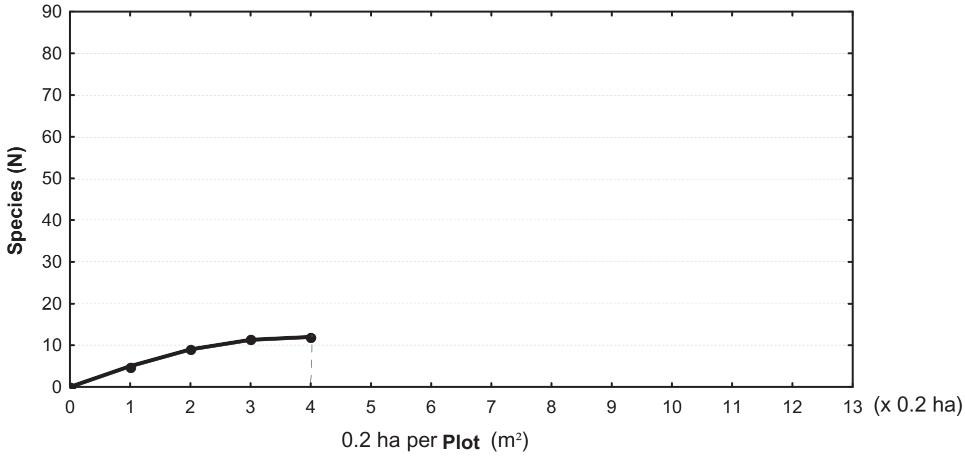
In figure 13 (b) the species area curve for mixed-horticulture stands indicates that by plot 9 (1.8 ha) the plot size could be accepted to describe the vegetation community because the number of species still remain below 10% for a 10% expansion of plot area within plot 8 - 9 (46 species/16000m^2 vs. 48 species/18000m^2, i.e. an increase of 5%). The suddenly increasing gradient due to changing site conditions by plot 9 – 12 indicates that new species occure. These are mainly caused by human impact.



a) Species area curve for secondary re-growth area



b) Species area curve for mixed-horticulture area



c) Species area curve for mangrove area

** Note: Missing species area curve for town stand because of complete enumeration*

Figure 13: Species-area curve in three different vegetation types in Kota Kinabalu

Figure 13 (c) shows the species area curve for a mangrove stand. It demonstrates that a sufficient plot size is reached (0.8 ha) to describe the vegetation community in this forest type. However, it is expected that an expansion of the number of sample plot by 50% further is even more effective/adequate to describe the vegetation community (the researcher encounted obstacles in gathering the data due to accessibility problems, i.e. tidal tides and plot establishment in a muddy area deprived the study).

The species area curve for Kota Kinabalu town areas was not drawn because there were no sampling plots establish. Instead the study investigated trees planted in the town of Kota Kinabalu. The town area consisted of an area approximately 70 ha of the total of Kota Kinabalu district.

4.2 Mean diameter

According to Van Laar and Akça (1997) a forest stand is defined as a group of trees occupying a specific area, sufficiently uniform as to be distinguishable from the forest adjoining areas. The same definition was applied to the forest stands investigated in this study. A stand can be characterised by mean diameter, diameter distribution, stand height, stand density, standing volume and other quantitative information collected in stand inventories.

The mean diameters and standard deviation for the four distinguished vegetation types are given in table 15. For data analysis, the mean diameter based on basal area (d_g) proved to be more meaningful because it calculates the basal area together. Mean diameters in Secondary Re-growth (SG), Mixed-Horticulture (MH) and Town Area (T) are much higher than in the Mangrove Area (M). In most of these stands (especially in Secondary Re-growth, Mixed-Horticulture and Town Area), a few very big trees are preserved to form shelter, while most of the small tree in the understorey were felled and replaced by cultivated plants. Many of these cultivated plants, which form the understorey, do not appear in the calculation of the mean diameter, because the dbh is often less than 10 cm (coffee, cocoa) or herbaceous plants (banana) are concerned.

Whilst, in the town area, many of the bigger trees were used as an ornamental shade tree mostly found on parking lots, closed to highways and near buildings (e.g *Pterocarpus indicus & Samanea saman).* Small trees, woody vines or herbs with dbh less than 10 cm were commonly used as hedges or line fences between the street and buildings and were not counted in this study.

Table 15: Mean diameter ($\bar{d}$) and mean diameter based on basal area (d_g) of four distinguished vegetation types in Kota Kinabalu, with tree dbh≥10cm.

	$\bar{d} \pm \sigma_x$ [cm]	d_g [cm]	Number of stems [N]
Secondary re-growth (SG)	29,1 ± 15,7	32,8	336
Mixed-horticulture (MH)	28,5 ± 14,5	31,9	434
Mangrove (M)	20,5 ± 11,2	23,4	118
Town area (T)	28,4 ± 16,2	32,8	1266

However, in the Mangrove area the mean diameter is small. Many of the small trees cannot reach the canopy, because of the great shading by the bigger *Rhizophoraceae* trees (This is most probably a distinctive feature of mangroves: they do not grow to the size of other trees, and natural regeneration under the canopy is of small diameter). The smaller trees formed a shade tolerant (*Avicennia* and *Bruguiera)* standing under the shade of the light demanders and opportunist. When gaps are formed after large trees died and fell the re-growth of other opportunist trees will speed up. The bigger trees perform an umbrella to the small trees by blocking and shading them. The inclusion of small diameter trees in the calculation leads to a decrease in the mean diameter of the Mangrove stands. Another factors is, most of the mangrove area in Kota Kinabalu has been disturbed and harvest by local villagers (for firewood and local consumption). Villages that reside nearby the Mangrove are: Kg.Rampayan, Kg.Lokob, Putatan and Kg.Kebagu which cut and use the small *Rhizophora* trees for firewood.

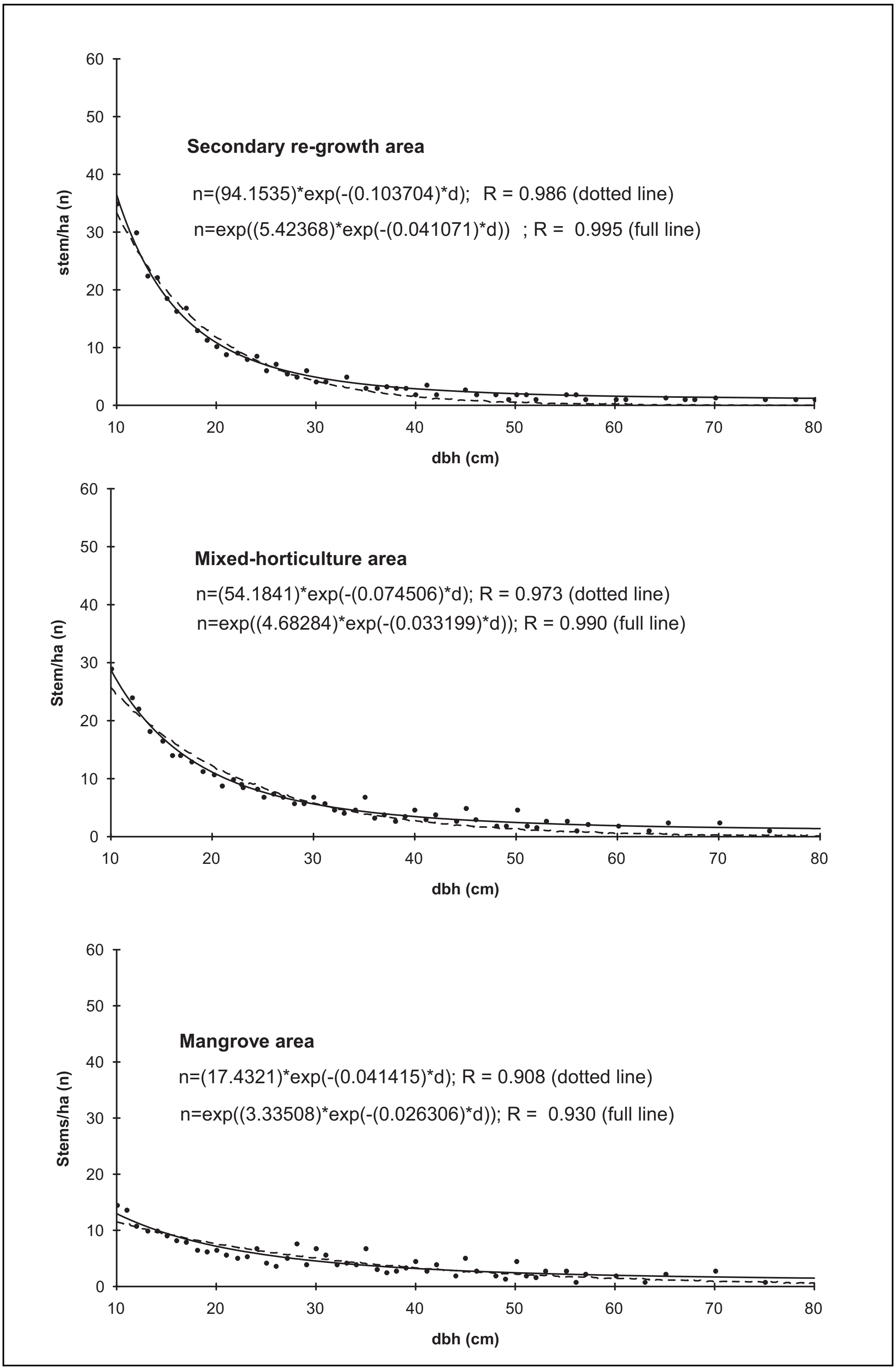
The correlation between low numbers of small and very big trees does not differ in all of these stands. The variation coefficient in the study ranges from (±50% to ±57%). Mixed-Horticulture area has the smallest variation coefficient of (±50%), followed by mangrove area (±54%). These values are also similar to those found in the tropical forest garden plots according to a study by Brodbeck (2004) in Tropical Sulawesi (±53% to ±72%). This indicates a high variability of diameters, which can be considered as normal in uneven-aged stands. The highest variation coefficient (±57%) was found in town area, where the spectrum of diameters ranges from 10 cm to 100 cm dbh.

4.3 Diameter distributions

The distribution of stem-numbers per diameter class gives a closer insight into the stand structure (Apel, 1996). These values, which can be easily calculated from the compiled basic data, are usually depicted in graphical form (Lamprecht, 1989). Several models are used to describe the approximate diameter distribution in a mathematical function, e.g. the Weibull distribution, the Beta distribution or the Normal distribution. In uneven aged natural forests however, an increasing number of stems with a decreasing diameter distribution can often be observed (Brodbeck, 2004).

The inverse J-Shape diameter distribution (in disturbed forests in Kota Kinabalu) can be expressed as a negative exponential function and logarithmic J-shaped function. In all study plots natural regeneration establishes itself over time and the stem numbers decrease from small to high diameters. The decrease in stem numbers is very fast in the smaller diameter classes and constantly slows down in the higher diameter classes. The diameter distribution models (refer to chapter 3, materials and methods) with the mentioned functions fit well with the correlation coefficients varying between 0.908 and 0.995 as shown in figure 14.

The logarithmic J-shape function is steeper in the small diameter range and flattens in the higher diameter range. The logarithmic J-shape function is therefore better suited to represent the trees in higher dbh ranges. In the Mangrove area, however, the low number of small trees leads to a very small gradient of the diameter distribution curve (figure 14).


Secondary re-growth area
n=(94.1535)*exp(-(0.103704)*d); R = 0.986 (dotted line)
n=exp((5.42368)*exp(-(0.041071)*d)) ; R = 0.995 (full line)
stem/ha (n)
dbh (cm)
Mixed-horticulture area
n=(54.1841)*exp(-(0.074506)*d); R = 0.973 (dotted line)
n=exp((4.68284)*exp(-(0.033199)*d)); R = 0.990 (full line)
Stem/ha (n)
dbh (cm)
Mangrove area
n=(17.4321)*exp(-(0.041415)*d); R = 0.908 (dotted line)
n=exp((3.33508)*exp(-(0.026306)*d)); R = 0.930 (full line)
Stems/ha (n)
dbh (cm)

(Contd.)

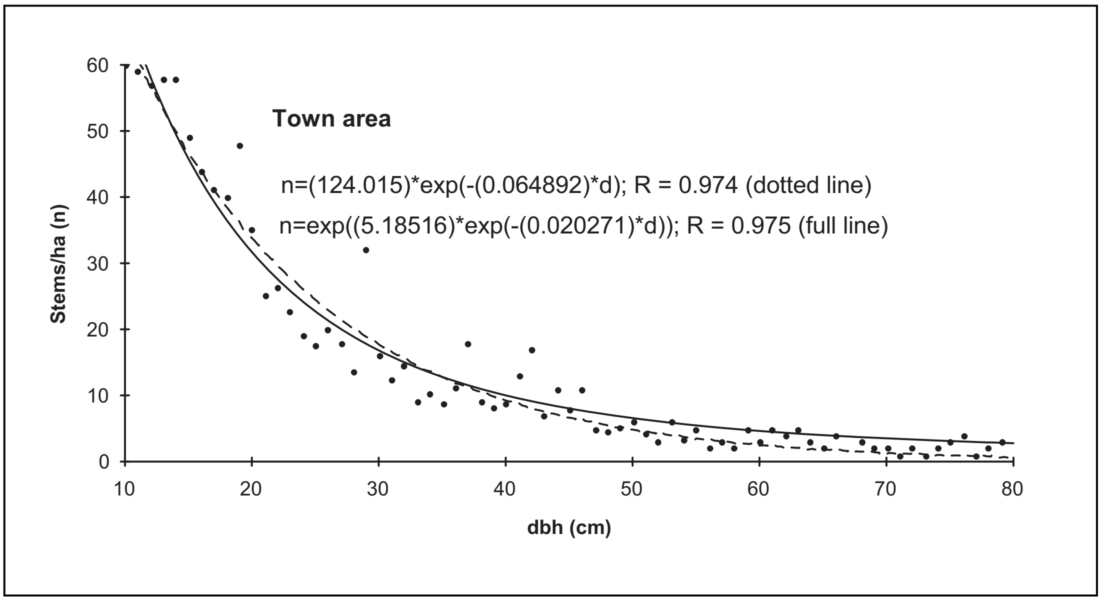


Figure 14: Diameter distribution in four vegetation types of the study area. Observed values (points) and curves fitted with negative exponential function $n = k \cdot e^{-a.d}$ (dotted line) and logarithmic J-shape function $n = e^{(k.e^{-a.d})}$ (full line).

Even though all stands have a similar basic pattern of diameter distribution, they differ in many details. The town area has a very high number of small trees, but the highest observed dbh is 100 cm. In the mangrove area, the numbers of small trees are lower, and the maximum observed dbh only reaches 75 cm.

Table 16: Stem number distribution according to 10 cm diameter classes

dbh class (cm)	Secondary re-growth	Mixed-horticulture	Mangrove area	Town area
10.0 – 19.9	108	140	40	430
20.0 – 29.9	84	122	35	394
30.0 – 39.9	71	93	23	229
40.0 – 49.9	36	50	16	115
50.0 – 59.9	21	13	1	40
60.0 – 69.9	11	10	2	13
70.0 – 79.9	4	4	1	8
80.0 – 89.9	1	0	0	20
90.0 – 99.9	0	1	0	16
≥ 100	0	1	0	1
Total	**336**	**434**	**118**	**1266**

While in secondary re-growth and mixed horticulture areas number of small trees is lower, but the maximum observed dbh reach 85 cm and 104 cm respectively. The stem number of diameter distribution according to 10 cm diameter classes is shown in table 16.

According to Brodbeck (2004), the ideal balance of diameter distribution in a managed natural forest is achieved “when the individual diameter classes are continuously replenished from the class below, and when the number of stems which grows into the next diameter class is equivalent to the number of stems which is recruited from one diameter class below in the same period of time. In terms of silvicultural operation, the recruitment in the highest diameter class can then be sustainably harvested in the same period of time. Because the diameter increment in the lower classes is lower than in the high diameter classes, the stem number in the lower diameter classes has to be higher to comply with that situation.

4.4 Stand height

According to Kramer and Akça (1995), a sample of 30-40 measured heights within one stand is sufficient for the drawing up of a height curve. These numbers, however, refer to stand inventories in the temperate zone, where maximum tree diameters are usually smaller than in the moist tropics. Brodbeck (2004) and Tran (2005), claim that in natural tropical forests with maximum diameters of up to 260 cm a sample of 30-40 tree heights is not sufficient to represent all diameter classes.

For this study with the maximum dbh of 100 cm sample size of 110 trees heights is regarded to be sufficient to represent all diameter classes. In the stand, the relationship of height to diameter is of stochastic nature. By plotting measured heights over diameters, a point cloud is obtained whose scatter is a measure of the homogeneity of the stand. If means of measured heights over diameters are calculated, this will in most cases produce a nearly linear curve (Loetsch et al., 1973).

Height curves derived form the tested equation functions (refer to Chapter 3, materials and methods) to well fit to the observed data had to satisfy the following requirements: the function should be monotone, increasing with increasing dbh; the standard deviation should be as low as possible and the correlation coefficient should be as high as possible (Van Laar and Akça, 1997). Here functions were used to developed height curves in this stands are describes by Pordan (1944) (eq.2), Petterson (1955) (eq.3) and Korsun (1948) (eq.4), produce a better fit. Fitted height curves for secondary re-growth, mixed horticulture, mangrove area and town area of this study are shown in figure 15.

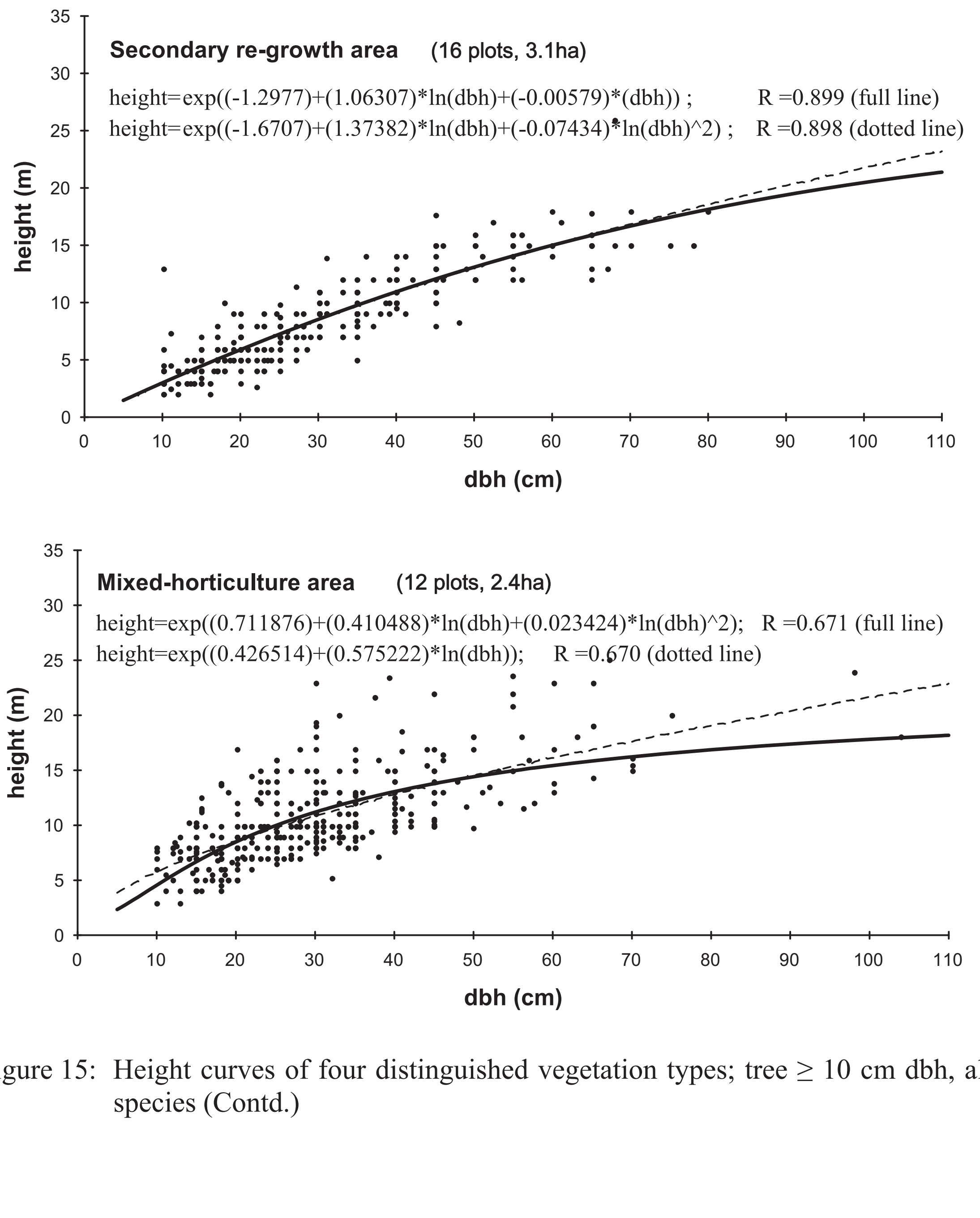
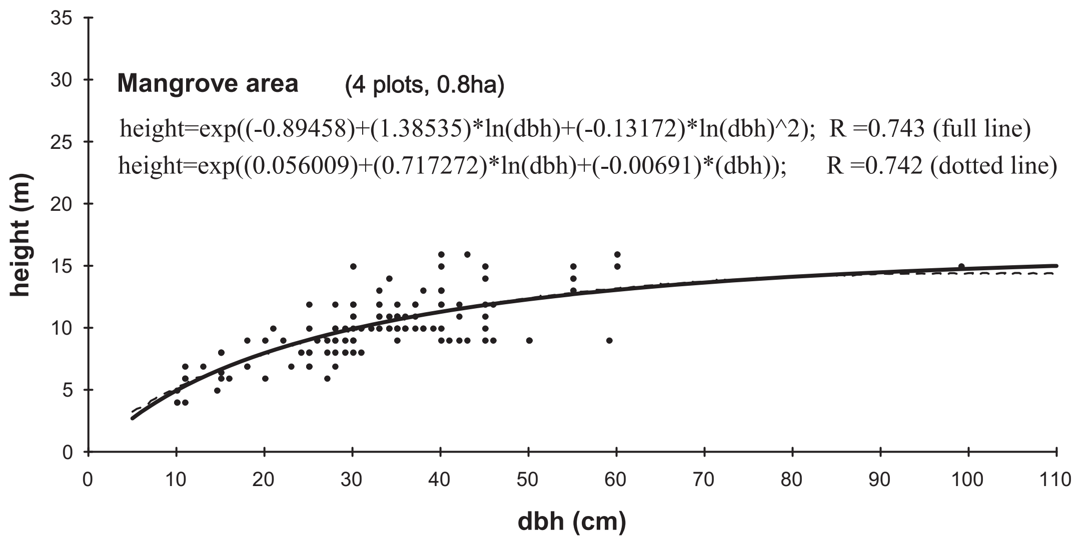


Figure 15: Height curves of four distinguished vegetation types; tree $\geq$ 10 cm dbh, all species (Contd.)



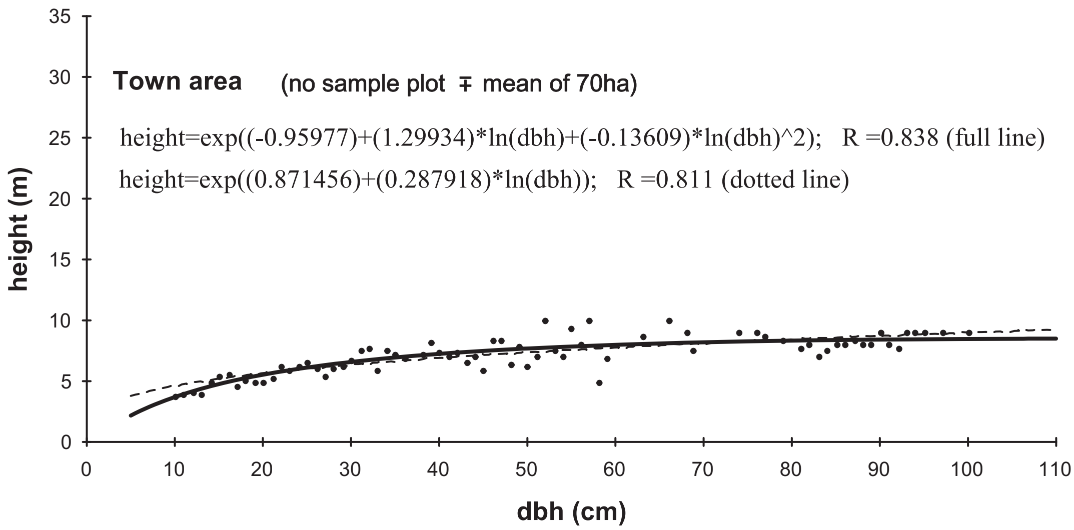


Figure 15: Height curves of four distinguished vegetation types; tree ≥ 10 cm dbh, all species

The dbh is a function of age and silvicultural treatment, whereas height is an indicator for the quality of the site (climate, soil, exposition) and can scarcely be influenced by silvicultural treatment. On good sites, increased growth energy favours the differentiation of sociological tree classes, leading to a relatively steep height curve and higher maximum heights, while curves of poorer sites rise much more slowly and maximum heights are lower (Loetsch et al., 1973).

The height growth is greatest in young stands, resulting in steep height curves. With increasing age, it slows down and eventually ceases, while diameter growth culminates much later. Furthermore, the shape of the height curve also depends on the characteristics of the tree species: fast growing pioneer species have a steeper height curve than climax species with slow growth. These correlations, observed on even aged stands of single tree species, can also partly be applied to the research plots of this study, which are uneven aged stands consisting of wide variety of species. The variation of the observed heights is lower in the secondary re-growth forests than in mixed-horticulture, a fact that is also reflected in the high values of covariance of 0.899 between height and dbh in all plots of secondary re-growth as compared to mixed-horticulture, mangrove and town area. The variation is also lower in the mixed-horticulture (0.671) than in the mangrove area (0.743). It can be explained by fact that human impact is higher in the mixed-horticulture area due to the favourable tree growth and soil conditions for agriculture. It appears that human interventions in mixed horticulture areas disturb the “natural” course of height curves (figure 15). While for the town area, most of the trees were periodically managed by the Kota Kinabalu city hall, and thinning of unwanted trees occurred annually.

4.4.1 Mean height and Top height

In this study, stems were grouped in nine 10 cm diameter classes (from class1: 10.0-19.9 cm to class 9: ≥ 90 cm dbh) for calculation of mean heights and top heights. Results from the different sample types are shown in table 17.

Table 17: Mean height ($h_{\bar{d}}$, h_g, h_L) and top height (h_H, h_{100}) of disturb forest stands in Kota Kinabalu, with tree dbh≥10cm.

	Mean height (m)			Top height (m)	
	$h_{\bar{d}}$	h_g	h_L	h_H	h_{100}
SG	9.0	9.9	12.6	12.7	13.0
MH	10.3	11.2	14.6	13.5	14.2
M	9.9	10.3	10.4	10.6	10.8
T	6.0	6.5	7.6	8.1	8.3

Notes: SG = Secondary re-growth, MH = Mixed horticulture, M = Mangrove and, T = Town stand

According to Brodbeck (2004), comparison of these different mean heights and top heights, will result in the following order:

$$h_{\bar{d}} < h_g < h_L < \; h_H \lesseqgtr h_{100}$$

This order holds true in secondary re-growth, mangrove and town area stands. In mixed horticulture stand, however h_L produced the highest value, because the few very big trees of that stand (dbh up to 100 cm) get a high weighting in the calculation of h_L. The top heights, h_H and h_{100}, which use the absolute numbers of the tallest or thickest trees, are smaller in the town area as compared to any others forest area type (see table 17 above). This is due to the fact that the overall number of stems in the town area is lower, which in turn means that the absolute number of tall trees is also smaller. However, it has to be considered that the maintenance activities and cutting of some big trees, which is part of the management program in the town area, can strongly influence mean height and top height.

4.5 Stand density

4.5.1 Stand basal area

According to Weidelt (1999), with the pantropical average basal area of the most virgin lowland rain forests closed canopy is about 30 m²/ha (trees dbh ≥10cm). Veillon et al., (1976) measured 30 and 32 m²/ha respectively (dbh ≥10cm) for evergreen lowland forests in Venezuela.

After Whitten et al. (2002), the basal area of lowland forest in Sulawesi varies between 25 and 50 m²/ha (dbh ≥10cm). In primary forests of Central Kalimantan, Arifin (1995) measured 28 m²/ha, while Kammesheidt et al. (2004) found 36 m²/ha in natural forest of Imbak Canyon, Sabah (both dbh ≥10cm). Kammesheidt et al. (2004) further described that comparable to similar studies in Sabah the basal area was found to be in the range of (26-43 m²/ha). For East Kalimantan, Goldammer (1993) reports a basal area of 33.7

m^2/ha in primary forests and of 21.9 m^2/ha in a 35 year old secondary forest (both dbh ≥10cm). Mitlöhner (1990) reports a basal area of up 31.7 m^2/ha from dry deciduous forests of Paraguay.

In this study the stand basal area of secondary re-growth stands (28.4 m^2/ha) is almost as good as in the natural forest as mentioned above, which indicates a forest-like character of the stands. It almost achieves the basal area of closed stands as given in literature. While in mixed horticulture, mangrove and town stands the basal area was measured with 14.5 m^2/ha, 11.6 m^2/ha and 1.5 m^2/ha respectively, a value that underlines the optical impression of a sparsely stocked stand. In fact, local communities felled most of the trees in mixed horticulture and mangrove stands for local consumption e.g. firewood, and housing uses (table 18).

4.5.2 Stand volume

The results of stand basal area and stand volume in Kota Kinabalu are shown in table 18. The overall value for stand basal area and stand volume in mixed horticulture and mangrove stands are lower than those in secondary re-growth stand which indicates a high heterogeneity of the investigated stands.

Table 18: Stand basal area and stand volume of forest stands in Kota Kinabalu, with tree dbh≥10cm.

	Number of trees (N)	**Stand basal area (m^2/ha)**	**Stand volume (m^3/ha)**
SG	336	28.4	164.9
MH	434	14.5	92.5
M	118	11.6	65.1
T*	1266	1.5	5.6

Notes: SG = Secondary re-growth, MH = Mixed horticulture, M = Mangrove and, T = Town stand
**count per ha in term of an area with approximately 70 ha.*

The secondary re-growth stand, with the highest basal area has also the highest value for stand volume of (164.9 m³/ha). Standing volume in mangrove stands (65 m³/ha) is much lower than in mixed horticulture stands (92.5 m³/ha). While for town stands, the stand basal area is the lowest with also smaller stand volume of 5.6 m³/ha are due to sparsely stocked of trees and periodically managed by the Kota Kinabalu City Hall.

4.6 Accuracy and error of the vegetation assessment

The value for the mean basal area ($\bar{g}$), the standard deviation (SD) and the standard error as percentage ($S_{\bar{g}}$%) is shown in table 19.

Table 19: Standard error of plot basal area ($S_{\bar{g}}$%) of different vegetation types in Kota Kinabalu

	$\bar{g} \pm$ SD	n	$S_{\bar{g}}$%
Secondary re-growth area	0,09 ± 0,03	12	7,9
Mixed-horticulture	0,08 ± 0,02	12	7,0
Mangrove area	0,04 ± 0,02	4	29,7

Note: No accuracy assessment for town area, due to complete enumeration

In the vegetation assessment, the standard error of the measurement of the basal area per plot was below 10% in secondary re-growth and mixed horticulture areas. In spite of the high variance of single values, the estimation of the mean basal area is sufficiently accurate, due to the high number of plots. While in mangrove areas, with the lowest number of plots, the standard error was more than 10%. The stands seem to be quite homogeneous, and perhaps in the past, they might have been influenced by human activities e.g. cutting trees for firewood. Other error might be due to the small sample in the mangroves. However an increase of the samples size (e.g. by adding additional plots), which could possibly reduce the standard error, was not feasible.

4.7 Floristic analysis

4.7.1 Species composition

The most common species in the investigated forest stands of Kota Kinabalu, ranked after their IVI are presented in table 20. In secondary re-growth stands, *Hevea brasiliensis* is the most dominant species with the highest IVI of 20.9. This species is favored in the market at recent time for softwood and furniture production.

In the past it was planted for latex production by locals and the planting was subsidized by the government. The rubber production scheme was introduced by the Sabah government as early as 1950 to upgrade the socio economic livelihood of the people in Kota Kinabalu. The latex from the *Hevea brasiliensis* tree still can produce rubber for local consumption but the rubber production has become unfavorable to the people living in the area.

The second important species in secondary re-growth stands is *Acacia mangium* with IVI value of 17.2 (rank 2nd). This species is widely planted in Sabah as a hardwood for particle board, especially in Kota Belud, Kudat, Sook and Kinarut. It tends to be an invasive woody pioneer species. Others important species which are believed to occur by natural regeneration and which are categorised as a local pioneer are *Macaranga tanarius*, *Artocarpus anisophyllus*, *Alstonia angustiloba*, *Vitex pubescens* and *Eugenia sp* as shown in table 20. These species are believed to be a good indicator for secondary forests (Keßler, 2000).

In the mixed-horticulture area, *Acacia mangium* reaches the highest IVI value of 33.8 (rank 1st) and *Acacia auriculiformis* 20.1 (rank 2nd) is the most dominant species. *Hevea brasiliensis* was ranked as the 3rd (14.3). Although *Hevea brasiliensis* is still a dominant species of mixed horticulture stands, it is believed that most individuals have been cut down in most stands and changed by other crop plants (e.g. cassava, peanuts and vegetables) for local uses and local consumption.

Table 20: The most common tree species in the four distinguished forest types ranked by their Importance Value Index (IVI)

Rank	Species	Dominance (m^2/ha)	Abundance (n/ha)	Frequency	IVI
Secondary re-growth area					
1	*Hevea brasiliensis**	2.2	30	0.56	20.9
2	*Acacia mangium**	1.9	24	0.44	17.2
3	*Macaranga tanarius*	0.6	23	0.56	13.2
4	*Artocarpus anisophyllus*	1.6	11	0.56	13.2
5	*Alstonia angustilobia*	1.1	13	0.63	12.5
6	*Vitex pubescens*	0.6	11	0.56	9.6
7	*Eugenia sp*	0.3	10	0.13	5.0
8 – 88	Other species	20.1	214	9.75	208.4
1 – 88	Total	28.4	336		300
Mixed horticulture area					
1	*Acacia mangium**	1.9	29	0.67	33.8
2	*Acacia auriculiformis**	1.2	15	0.50	20.1
3	*Hevea brasiliensis**	1.1	8	0.33	14.3
4	*Mangifera indica*	0.7	5	0.58	11.6
5	*Cocos nucifera*	0.4	6	0.67	10.7
6	*Callophylum innophylum*	0.7	8	0.17	10.4
7	*Terminalia catappa*	0.5	8	0.25	9.6
8 - 95	Other species	8.0	102	11.16	189.4
1 - 95	Total	14.5	181		300
Mangrove area					
1	*Rhizophora apiculata*	2.9	31	1.0	63.8
2	*Rhizophora mucronata*	2.2	20	0.75	45.3
3	*Acacia mangium**	1.3	23	0.75	40.1
4	*Nypa fruticans*	1.7	10	0.25	26.3
5	*Bruguiera parviflora*	0.6	5	0.50	15.7
6	*Casuarina equisetifolia*	1.0	4	0.25	15.1
7	*Thespesia populnea*	0.2	4	0.25	8.2
8 - 23	Other species	1.7	21	4.25	85.6
1 - 23	Total	11.6	118		300

*Note: The exotic[1] tree species are marked with **

[1] An **exotic species** (also known as an **introduced species**) is an organism that is not indigenous to a given place or area and instead has been accidentally or deliberately transported to this new location by human activity.

Table 20: The most common tree species in the four distinguished forest types ranked by their Importance value Index (IVI) (contd).

Rank	Species	Dominance (m^2)	Total Individual (n)	IVI
Town area				
1	*Pterocarpus indicus*	60.0	392	87.2
2	*Veitchia merillii*	4.4	140	15.2
3	*Delonix regia**	7.5	94	14.5
4	*Roystonea regia**	6.4	50	9.9
5	*Tabebuia rosea**	2.0	87	8.7
6	*Andira surinamensis**	2.0	71	7.5
7	*Mimusops elengi*	0.7	40	3.8
8	*Cassia fistula*	1.6	28	3.7
9	*Cocos nucifera*	0.9	26	2.9
10	*Bauhinia blakeana*	0.4	13	1.4
11 – 40	Other species	20.8	325	45.2
1 - 40	Total	106.7	1266	200

Note: No frequency data for town area because of no sample plot

The respective practice of shifting cultivation of the land lead to unfertile soils and was then left behind for a certain period of time until it become fertile again. As a result the land became prone to invasive weed species like wild *Acacia spp.* The fast colonization of wild *Acacia spp* in the area is due to the easy spreading of seeds by wind and birds. Others most common species are either planted fruit trees (*Mangifera indica*, *Cocos nucifera*) or ornamental crops (*Callophylum innophylum*, *Terminalia catappa*). Thus, these stands offer a large variety of uses for their owners and are highly productive.

In the mangrove area, *Rhizophora apiculata* is the dominant species with the highest IVI value of 63.8, ranked first of 23 species. This species is a highly valued timber species and a favorite in the market for charcoal production as well as for piling and construction purposes. The Malaysian government has recently formulated a new strategy not to cut mangrove trees in order to safeguard the coastal shore from being eroded by tides. Other most common species are *Rhizophora mucronata*, *Acacia mangium*, *Nypa fruticans*, *Bruguiera parviflora*, *Casuarina equisetifolia* and *Thespesia populnea.*

In the town area most of the trees are planted, especially for ornamental, aesthetic and greening purposes. The dominant species with the highest IVI values are *Pterocarpus indicus* (87.2) followed by *Veitchia merillii* (15.2), *Delonix regia* (14.5), *Roystonea regia* (9.9), *Tabebuia rosea* (8.7), *Andira surinamensis* (7.5), *Mimusops elengi* (3.8). All these trees are managed and maintained periodically by the Kota Kinabalu City Hall. The most frequently planted tree species are *Pterocarpus inducus, Samanea saman* and *Delonix regia* which serve as ornamental or wayside trees with an average age of 50 - 60 years old. The choice for the planted tree species is focussed on fast growing species, flowering characteristics, minimum shedding leaves and functional uses e.g. pollution and dust control.

4.7.2 Species diversity

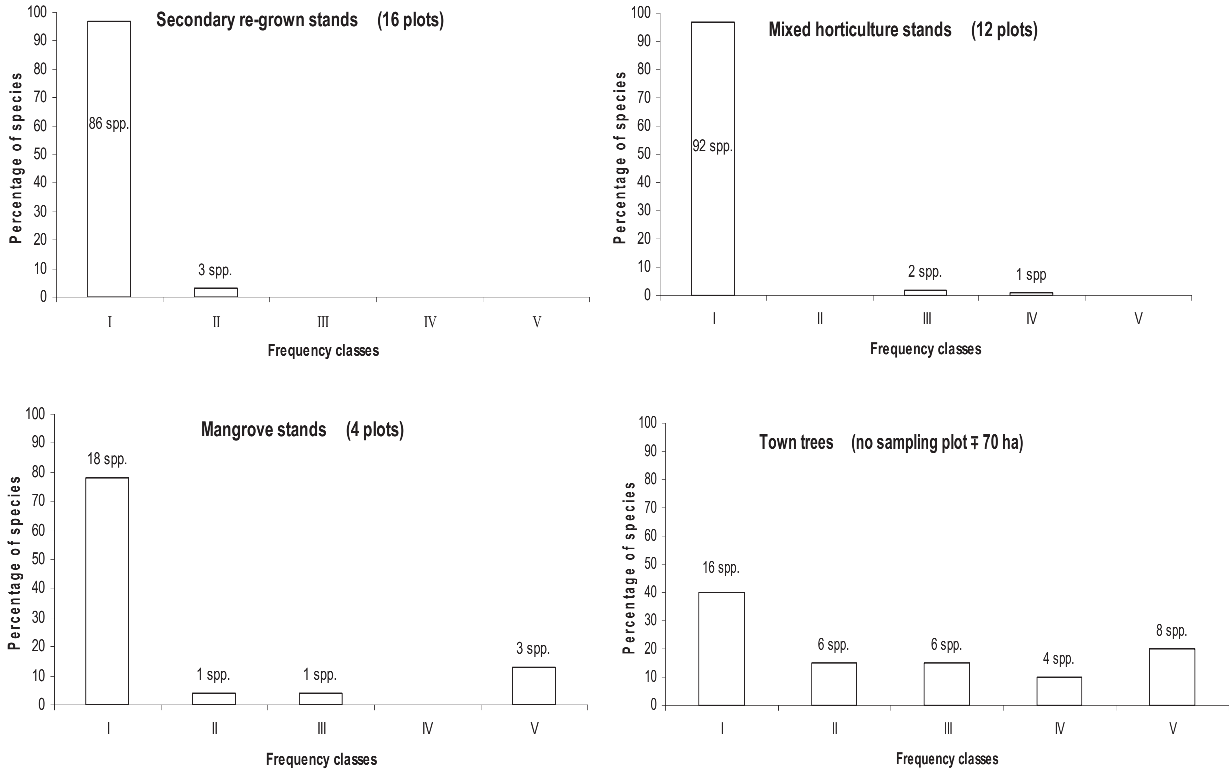


Figure 16: Frequency diagrams and number of tree species (dbh ≥ 10 cm) per frequency class in the four investigated forest stand types of Kota Kinabalu. (Plot size: 2048 m²)

Figure 16 shows the frequency diagrams for the four distinguished vegetation types, i.e. the occurrence of species in the subplots. The frequencies give an indication of the diversity of a stand. The high values class IV and V indicate a high degree of floristic homogeneity. However, frequencies also depend on the total number of tree individuals. The highest diversity, with 97% of the species in class I (frequency 1-20%) seem to be realized in secondary re-growth and mixed-horticulture stands

In comparison to this, the town inventory has only 40% in class I and 15% in class II but encompasses all other high frequency. The result indicates a comparatively low diversity with a high total number of trees and also the highest ratio of individuals per species but only few different species included (table 21). Consequently, chances are higher that a species occurs in many plots. A similar connection could be observed in the mangrove stands with only 118 trees per hectare, distributed over 23 species. The number of individual trees, species and diversity according to Simpson and Shannon indices and the Evenness of the investigated forest stands are compared in table 21.

Table 21: Tree species diversity calculated in some different index (dbh ≥10cm)

	Number of trees (N/ha)	Total Species (n)	Simpson index (1-D)	Shannon Index (H’)	H_{max}	Evenness E[%]
Secondary re-growth	336	88	0.03	1.7	1.9	87.4
Mixed horticulture	434	95	0.04	1.6	1.9	83.0
Mangrove	118	23	0.14	1.0	1.4	74.1
Town	1266*	40	0.13	1.2	1.6	73.9

**number of trees under the management of Kota Kinabalu City Hall with an area approximately 70 ha*

The results of Simpson and Evennes show that the tree flora in secondary re-growth stands (H’=1.7 & E%=87.4) and mixed horticulture stands (H’=1.6 & E%=83.0) is characterized by a high degree of diversity compared to the mangroves (H’=1.0 & E%=74.1) and town inventory (H’=1.2 & E%=73.9). The total species number also indicates high species number in secondary re-growth (88) and 95 in mixed-horticulture, which suggest the stands is vibrant with natural succession occurs in high rate than in the azonal habitat (mangrove) and town inventory. In the Mangrove stands there are 23 species and over 80% of the individuals belong to the same family, Rhizophoraceae. This is most probably a distinctive feature of mangroves stands: the xerophytic characteristics i.e. soils, water, salt and tidal influences other zonal species succession. Also in the in Town inventory about 50% of the tree population belonge to the same species, namely *Pterocarpus indicus.*

4.7.3 Species similarity

The highest degree of similarity (45.9) was observed between secondary re-growth (SG) and mixed horticulture (MH) stands. This indicates that several tree species can be found in both areas that the floristic composition in these area is similar to each other to a remarkable extend (table 22).

Table 22: Coefficient of similarity *(K)* in pair comparisons of different stands, based on the species composition (K_s), the dominance of species *(K_d)*, and the important value of species *(K_{IVI})* of Kota Kinabalu (dbh ≥ 10 cm)

K_s	SG	MH	M	T
SG	-	45.9	14.4	12.5
MH	45.9	-	22.0	31.1
M	14.4	22.0	-	22.2
T	12.5	31.1	22.2	-
K_d	**SG**	**MH**	**M**	**T**
SG	-	9.6	12.8	46.0
MH	9.6	-	18.4	51.1
M	12.8	18.4	-	53.2
T	46.0	51.1	53.2	-
K_{IVI}	**SG**	**MH**	**M**	**T**
SG	-	9.1	14.1	18.0
MH	9.1	-	16.3	20.2
M	14.1	16.3	-	25.2
T	18.0	20.2	25.2	-

Notes: ***In respect with the resuts in Table 24: Value > 25 is declared as “very high value of similarity” and Value < 20 as “low value of similarity”***
SG = Secondary re-growth, MH = Mixed horticulture, M = Mangrove and, T = Town stand

On the other hand, the floristic composition differs greatly (K_s only 14.4 and 12.5 respectively) with secondary re-growth – mangroves; and secondary re-growth and town inventory are compared. Most of the tree species in the mangrove stands and in the town inventory could not be found in the secondary re-growth and mixed-horticulture areas. However, in mixed horticulture – mangroves; mixed horticulture – town inventory (K_s only 22 and 31.1 respectively). This can be indicates that there possibly some species can be found on both of these areas.

A comparison between coefficients of similarity based on dominances (K_d) or on Important Values (K_{IVI}) respectively shows some interesting results: the high similarity between secondary re-growth and mixed horticulture with respect to their species composition, turns low when the dominating of species are compared K_d (9.6) and even lower when their ecological important value K_{IVI} (9.1) is used.

For the comparison of similarity in K_d and K_{IVI} could not be relies on the basis of these study are due to the calculation formula took only the dominating species. Additionally, K_d and K_{IVI} only took the most dominance as basis of the calculation and further, only the important value or common important species in the IVI ranking is been considered. On the other hand, the K_s do taken all the number of species in both stands for the purpose of the comparison/ calculation is more reliable.

4.7.4 Species richness

Species richness is defined as a simple measure of biodiversity and is simply a count of the number of different species in a given area. Table 23 shows that, of the four study stands, the mixed horticulture stand has the highest number of species and families, with a total of 95 species, belonging to 33 families. Secondary re-growth shows the second highest species number among the four stands, with a total of 88 species, belonging to 28 families. In general, after the forest canopy is opened, it may give a favorable condition for natural regeneration of more light demanding species, therefore species richness would be higher in secondary re-growth and mixed horticulture areas.

Table 23: Number of species and family in four forests stands (dbh $\geq$ 10 cm) in investigated area Kota Kinabalu

Group of species	Secondary re-growth		Mixed horticulture		Mangrove Stand		Town Stand	
	Sp	*Fa*	*Sp*	*Fa*	*Sp*	*Fa*	*Sp*	*Fa*
Total (N)	88	28	95	33	23	12	40	17

Note: Sp = Species; Fa = Family

The number of species and families of the other stands (mangrove and town stands) is much lower ranging between 23 – 38 species and 12 - 17 families. This can be explained that the town stands have been recently planted and periodically managed by the respectives department (i.e. pruning and trimming of long branches for the purpose of safety) that why the species richness was low.

On the other hand, the distinguished characteristics of edaphic factors (soil factors, structure, composition, aeration, the mineral contents of surface and soil water and water movement, including changes in water levels, probably the most important and most widely distributed are caused by an extreme water regime) in mangroves forest in Kota Kinabalu only limited to a few common species that can really tolerate to the anaerobic condition in the investigation areas. In addition, Lamprecht (1989) also stated that mangrove might be rather poor in terms of species in comparison to natural forest with a total only 51 species can be found in South-East Asia.

The most common families of trees in the four different vegetation types are listed in table 24. Families which occur in all the four stands are: *Leguminosae, Moraceae and Palmae*, while *Euphorbiaceae* occur in three stands types and *Anacardiaceae and Bombacaceae* families only in 2 stands. The species with the same families in the stands are more or less similar.

Table 24: The most common families of trees in four different vegetation stands according to theirs number of species and cover, (dbh ≥ 10 cm)

	Secondary re-growth			Mixed horticulture		
No	**Family**	**Sp**	**%**	**Family**	**Sp**	**%**
1	*Lauraceae*	9	10,1	*Leguminosae*	16	16,8
2	*Leguminosae*	9	10,1	*Euphorbiaceae*	9	9,5
3	*Moraceae*	8	9,0	*Moraceae*	9	9,5
4	*Anacardiaceae*	7	7,9	*Myrtaceae*	7	7,4
5	*Dipterocarpaceae*	7	7,9	*Palmae*	5	5,3
6	*Palmae*	6	6,7	*Anacardiaceae*	4	4,2
7	*Bombacaceae*	5	5,6	*Apocynaceae*	3	3,2
8	*Euphorbiaceae*	5	5,6	*Bombacaceae*	3	3,2
9	*Meliaceae*	5	5,6	*Combretaceae*	3	3,2
10	*Myrtaceae*	4	4,5	*Guttiferae*	3	3,2
	Others	24	27,0	Others	33	34,7
Total		88	100		95	100
	Mangrove			**Town**		
No	**Family**	**Sp**	**%**	**Family**	**Sp**	**%**
1	*Leguminosae*	4	17,4	*Leguminosae*	14	36,8
2	*Rhizophoraceae*	4	17,4	*Palmae*	5	13,2
3	*Euphorbiaceae*	2	8,7	*Apocynaceae*	2	5,3
4	*Malvaceae*	2	8,7	*Bignoniaceae*	2	5,3
5	*Meliaceae*	2	8,7	*Fabaceae*	2	5,3
6	*Palmae*	2	8,7	*Moraceae*	2	5,3
7	*Verbenaceae*	2	8,7	*Annonaceae*	1	2,6
8	*Burseraceae*	1	4,3	*Casuarinaceae*	1	2,6
9	*Casuarinaceae*	1	4,3	*Combretaceae*	1	2,6
10	*Moraceae*	1	4,3	*Dilleniaceae*	1	2,6
	Others	2	8,7	Others	10	18,4
Total		23	100		40	100

4.8 Regeneration potential

The natural regeneration potential indicates how plants can re-establish themselves in an area by way of natural regeneration. In this study tree regeneration has been recorded in secondary re-growth, mixed horticulture and mangrove stands encompassing all trees with the height ≥1 m and dbh ≤ 10 cm in were considered as promising trees, since they had overcome the dense ground vegetation layer. In all plots, species numbers and family numbers of tree seedlings were collected and are presented in figures and tables. Promising natural regeneration in secondary re-growth stands encompasses 32 species which are listed in figure 17 according to their rank. Individuals of *Dillenia suffroticosa* are not only the most numerous but also the most dominant regeneration trees (with IVI = 31.8%). The second dominant species in secondary re-growth stands is *Macaranga tanarius* with IVI value of 24.6 (rank 2nd). This species is widely distributed in Sabah especially occurring naturally in secondary forests. Consequently it was categorized as a local pioneer. Other regeneration species which are believed to occur naturally are *Acacia mangium, Alstonia angustiloba, Hevea brasiliensis* and *Artocarpus anisophyllus.* By looking at the overall regeneration species in figure 17, it can be concluded that most of them are similar with the dominating mature trees in the stands. The closed canopy of the emergent does not supply enough light to promote the seed of the shade tolerant trees to regenerate.

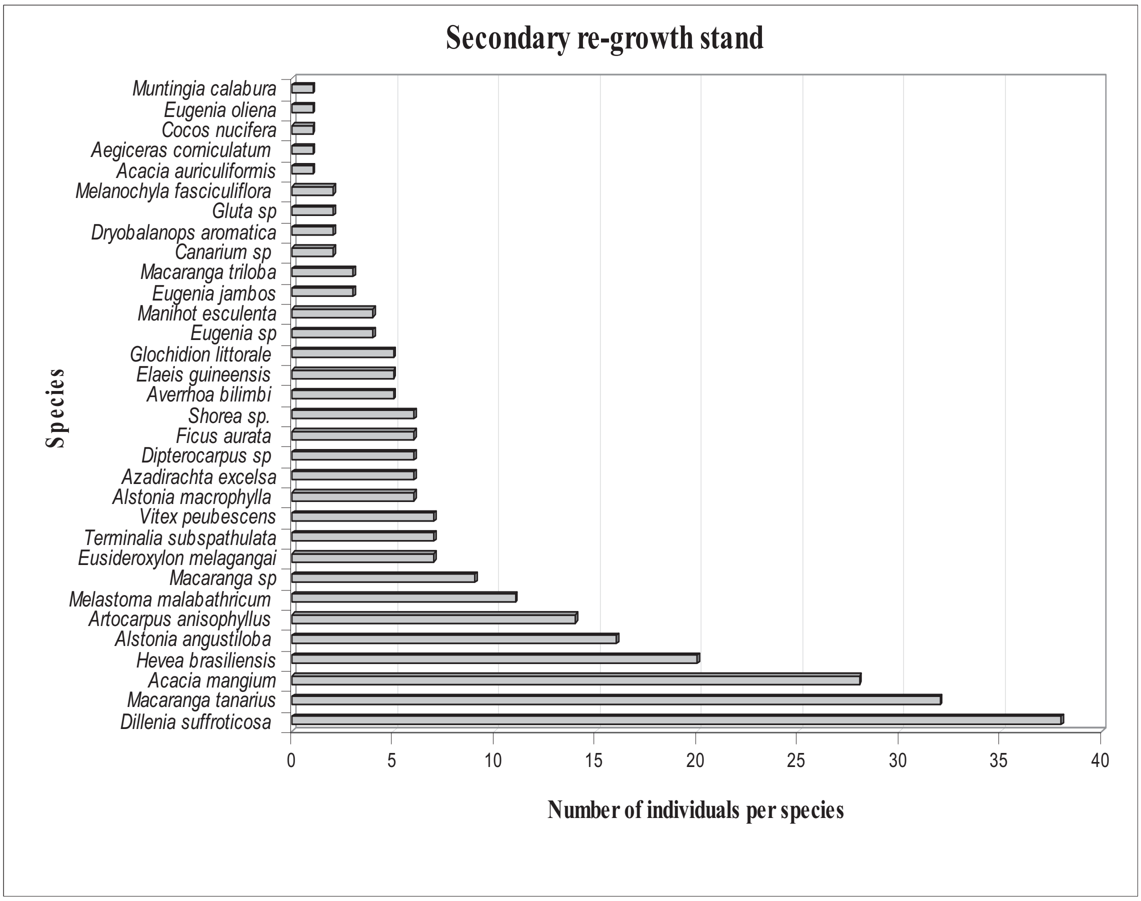


Figure 17: Number of individuals per species of natural regeneration in secondary re-growth stands of Kota Kinabalu (40m² x 16 plots = 640m²)

Table 25: The most common regeneration species in secondary re-growth stands ranked according to their IVI

Secondary re-growth stand			Abundance		Frequency		IVI
Rank	**Scientific name**	**Family**	**N**	**%**	**Freq.**	**%**	
1	*Dillenia suffroticosa*	Dilleniaceae	38	14,56	35	17,24	31,80
2	*Macaranga tanarius*	Euphorbiaceae	32	12,26	25	12,32	24,58
3	*Acacia mangium**	Leguminosae	28	10,73	16	7,88	18,61
4	*Alstonia angustiloba*	Apocynaceae	16	6,13	18	8,87	15,00
5	*Hevea brasiliensis**	Euphorbiaceae	20	7,66	14	6,90	14,56
6	*Artocarpus anisophyllus*	Moraceae	14	5,36	12	5,91	11,28
7	*Melastoma malabathricum*	Melastomataceae	11	4,21	4	1,97	6,19
8	*Eusideroxylon melagangai*	Lauraceae	7	2,68	7	3,45	6,13
9	*Macaranga sp*	Euphorbiaceae	9	3,45	5	2,46	5,91
10	*Vitex peubescens*	Verbenaceae	7	2,68	6	2,96	5,64
11	*Alstonia macrophylla*	Apocynaceae	6	2,30	6	2,96	5,25
12	*Azadirachta excelsa*	Meliaceae	6	2,30	5	2,46	4,76
13	*Dipterocarpus sp*	Dipterocarpaceae	6	2,30	5	2,46	4,76
14	*Shorea sp.*	Dipterocarpaceae	6	2,30	5	2,46	4,76
15	*Glochidion littorale*	Euphorbiaceae	5	1,92	5	2,46	4,38
16	*Ficus aurata*	Moraceae	6	2,30	4	1,97	4,27
17	*Terminalia subspathulata*	Combretaceae	7	2,68	3	1,48	4,16
18	*Averrhoa bilimbi*	Oxalidaceae	5	1,92	4	1,97	3,89
19	*Elaeis guineensis**	Palmae	5	1,92	3	1,48	3,39
20	*Eugenia sp*	Myrtaceae	4	1,53	3	1,48	3,01
21	*Eugenia jambos*	Myrtaceae	3	1,15	3	1,48	2,63
22	*Macaranga triloba*	Euphorbiaceae	3	1,15	3	1,48	2,63
23	*Manihot esculenta*	Euphorbiaceae	4	1,53	2	0,99	2,52
24	*Melanochyla fasciculiflora*	Anacardiaceae	2	0,77	2	0,99	1,75
25	*Canarium sp*	Burseraceae	2	0,77	1	0,49	1,26
26	*Dryobalanops aromatica*	Dipterocarpaceae	2	0,77	1	0,49	1,26
27	*Gluta sp*	Anacardiaceae	2	0,77	1	0,49	1,26
28	*Acacia auriculiformis**	Leguminosae	1	0,38	1	0,49	0,88
29	*Aegiceras corniculatum*	Myrsinaceae	1	0,38	1	0,49	0,88
30	*Cocos nucifera*	Palmae	1	0,38	1	0,49	0,88
31	*Eugenia oliena*	Myrtaceae	1	0,38	1	0,49	0,88
32	*Muntingia calabura*	Elaeocarpaceae	1	0,38	1	0,49	0,88
1-32	Total		261	100	203	100	200

*Note: The exotic tree species are marked with **

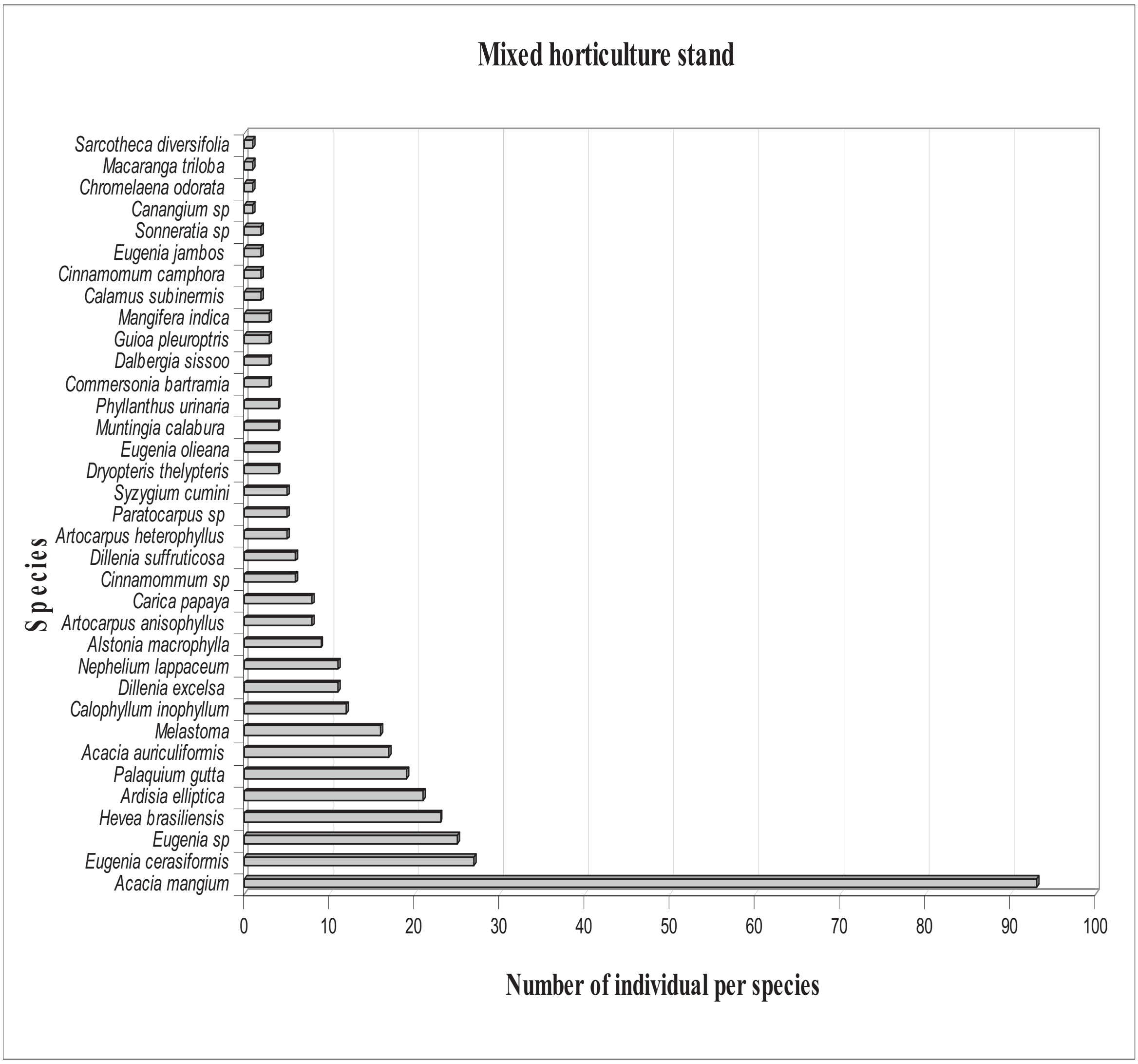


Figure 18: Number of individuals per species of natural regeneration in mixed horticulture stands of Kota Kinabalu (40m² x 12 plots = 480m²)

In mixed horticulture stands (table 26), there are 35 species of naturally regenerated trees. The five most dominant species are *Acacia mangium* (IVI = 50.3%) followed by *Eugenia sp* (IVI = 15.2%), *Hevea brasiliensis* (IVI = 12.9%), *Eugenia cerasiformis* (12.8%) and *Melastoma malabathricum* (10.7%) respectively. The number of trees regeneration in mixed horticulture is higher (367) than in any other stand type. This might be is due to periodically interference of human activities in these areas, which also introduced new species (e.g. fruit trees and perennial crops).

Table 26: The most common regeneration species of mixed horticulture stands ranked according to their IVI

Mixed horticulture			Abundance		Frequency		IVI
Rank	Scientific name	Family	N	%	Freq.	%	
1	*Acacia mangium**	Leguminosae	93	25,34	60	25,00	50,34
2	*Eugenia sp*	Myrtaceae	25	6,81	20	8,33	15,15
3	*Hevea brasiliensis**	Euphorbiaceae	23	6,27	16	6,67	12,93
4	*Eugenia cerasiformis*	Myrtaceae	27	7,36	13	5,42	12,77
5	*Ardisia elliptica*	Myrsinaceae	21	5,72	12	5,00	10,72
6	*Melastoma malabathricum*	Melastomataceae	16	4,36	10	4,17	8,53
7	*Acacia auriculiformis**	Leguminosae	17	4,63	9	3,75	8,38
8	*Palaquium gutta*	Sapotaceae	19	5,18	6	2,50	7,68
9	*Nephelium lappaceum*	Sapindaceae	11	3,00	9	3,75	6,75
10	*Alstonia macrophylla*	Apocynaceae	9	2,45	9	3,75	6,20
11	*Dillenia excelsa*	Dilleniaceae	11	3,00	6	2,50	5,50
12	*Carica papaya**	Caricaceae	8	2,18	7	2,92	5,10
13	*Calophyllum inophyllum*	Guttiferae	12	3,27	4	1,67	4,94
14	*Dillenia suffruticosa*	Dilleniaceae	6	1,63	6	2,50	4,13
15	*Paratocarpus sp*	Moraceae	5	1,36	5	2,08	3,45
16	*Artocarpus anisophyllus*	Moraceae	8	2,18	3	1,25	3,43
17	*Cinnamommum sp*	Lauraceae	6	1,63	4	1,67	3,30
18	*Dryopteris thelypteris*	Dryopteridaceae	4	1,09	4	1,67	2,76
19	*Eugenia olieana*	Myrtaceae	4	1,09	4	1,67	2,76
20	*Phyllanthus urinaria*	Phyllanthaceae	4	1,09	4	1,67	2,76
21	*Syzygium cumini*	Myrtaceae	5	1,36	3	1,25	2,61
22	*Artocarpus heterophyllus*	Moraceae	5	1,36	2	0,83	2,20
23	*Commersonia bartramia*	Sterculiaceae	3	0,82	3	1,25	2,07
24	*Dalbergia sissoo*	Fabaceae	3	0,82	3	1,25	2,07
25	*Guioa pleuroptris*	Sapindaceae	3	0,82	3	1,25	2,07
26	*Muntingia calabura*	Elaeocarpaceae	4	1,09	2	0,83	1,92
27	*Mangifera indica*	Anacardiaceae	3	0,82	2	0,83	1,65
28	*Calamus subinermis*	Palmae	2	0,54	2	0,83	1,38
29	*Cinnamomum camphora*	Lauraceae	2	0,54	2	0,83	1,38
30	*Sonneratia sp*	Sonneratiaceae	2	0,54	2	0,83	1,38
31	*Eugenia jambos*	Myrtaceae	2	0,54	1	0,42	0,96
32	*Canangium sp*	Annonaceae	1	0,27	1	0,42	0,69
33	*Chromolaena odorata*	Asteraceae	1	0,27	1	0,42	0,69
34	*Macaranga triloba*	Euphorbiaceae	1	0,27	1	0,42	0,69
35	*Sarcotheca diversifolia*	Oxalidaceae	1	0,27	1	0,42	0,69
1-35	Total		367	100	240	100	200

*Note: The exotic tree species are marked with **

The fast colonization of wild *Acacia spp* is promoted by burning and clearing, since burning activities help to break the seed dormancy in legumes of most *Acacia* species to regenerate naturally. From the overall regeneration species list in figure 18, it can be concluded that most of them also dominate as matured trees in the respective plots like i.e. *Acacia mangium* and *Hevea brasiliensis*.

Figure 19 show that, the highest abundance of regeneration species in the Mangrove stand is *Rhizophora apiculata* with 42 individuals followed by *Rhizophora mucronata* with 37 individuals. This species form as the typical species that can be found in most of the mangroves plots in the study area.

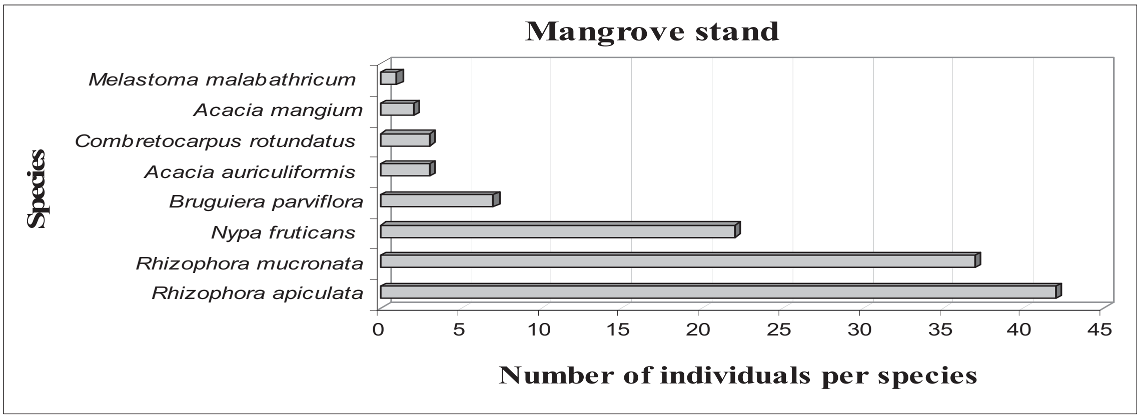


Figure 19: Number of individuals per species of natural regeneration in mangrove stands of Kota Kinabalu (40m² x 4 plots = 160m²)

Table 27: The most common regeneration species of mangrove stands ranked by their IVI

Mangrove			Abundance		Frequency		IVI
Rank	Scientific name	Family	N	%	Freq.	%	
1	*Rhizophora apiculata*	Rhizophoraceae	42	35,90	32	39,51	75,43
2	*Rhizophora mucronata*	Rhizophoraceae	37	31,62	24	29,63	61,25
3	*Nypa fruticans*	Palmae	22	18,80	13	16,05	34,85
4	*Bruguiera parviflora*	Rhizophoraceae	7	5,98	6	7,41	13,39
5	*Combretocarpus rotundatus*	Anisophylleaceae	3	2,56	2	2,47	5,03
6	*Acacia mangium**	Leguminosae	2	1,71	2	2,47	4,18
7	*Acacia auriculiformis**	Leguminosae	3	2,56	1	1,23	3,80
8	*Melastoma malabathricum*	Melastomataceae	1	0,85	1	1,23	2,09
1-8	Total		117	100	81	100	200

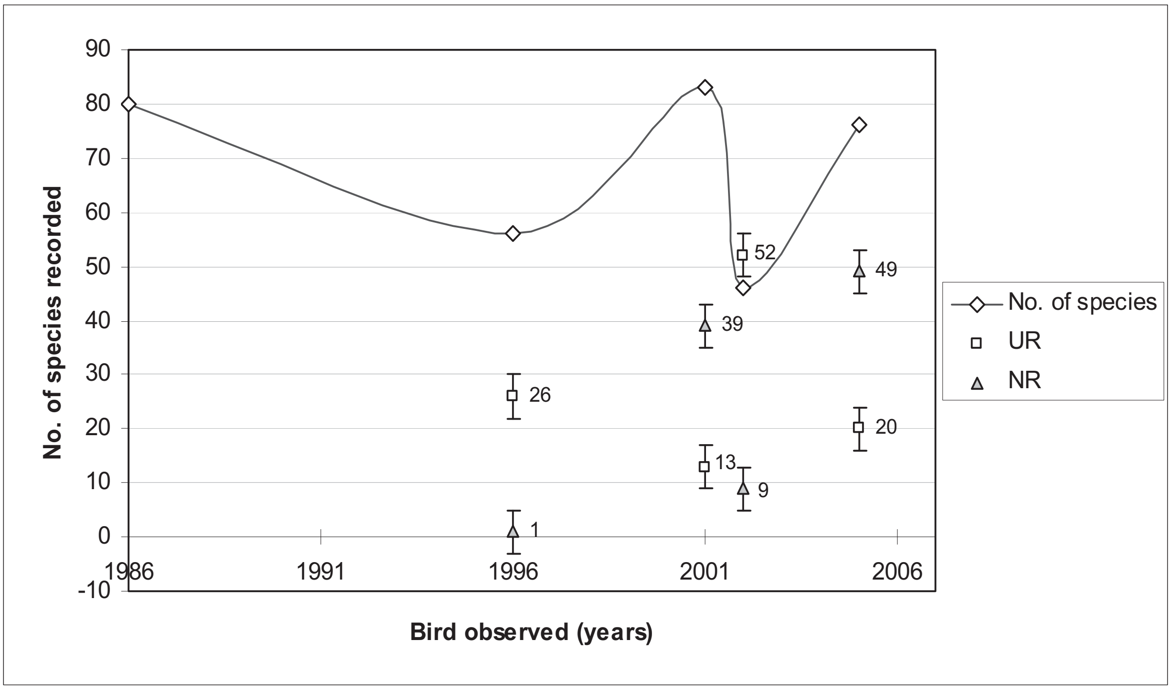
*Note: The exotic tree species are marked with **

There are 8 species of trees which regenerate in the mangrove stands (table 27). The five most dominant species are from *Rhizophora apiculata* (IVI = 75.43%) followed by *Rhizophora mucronata* (IVI = 61.25%), *Nypa fruticans* (IVI = 34.9%), *Bruguiera parviflora* (13.4%) and *Combretocarpus rotundatus* (5.0%) respectively. Figure 19, also proof that most of the regeneration trees are quite similar with the matured trees which dominate in the respective plots.

5.0 Bird Survey and Analysis

5.1 Development of birdlife in Kota Kinabalu

Data from previous studies as well as data which were collected by the author in 2005 illustrate what kind of birds can be found in Kota Kinabalu. It is interesting to compare the data observed from different years to see just how they differ, or to see if certain areas are sufficiently similar to be developed or managed in the same way. Very often data from different years are compared to see what changes may be taking place over time, or to identify patterns or events that may repeat themselves at certain intervals. The data for each year then needs to be reorganized to facilitate the comparison; it is also a good basis for monitoring and managing activities in the future. The detailed systematic list of the recorded birds in Kota Kinabalu is given in the appendices 13 – 18 whereas a summaried version of birdlife development or change in the past 20 years is illustrated by the following figures. In figure 20, the number of recorded bird species is shown.



Note: UR = spesies unrecorded; NR = new recorded species in that specific year

Figure 20: Pattern of bird species recorded from the years 1986 – 2005 in Kota Kinabalu *(Source: Systematic bird's species lists recorded by Rick Addision (2002), WWF Kota Kinabalu (2001) and Andy, Siew & Renie (2005))*

The underlying data however is rather heterogenous and conclusions are difficult to draw. Nevertheless, it can be stated that one third of the 80 bird species that had been reported in 1986, were not recorded again in 1996. While one fourth of the 83 bird species that had been reported in 2001, were not recorded again in 2005. Nevertheless 49 other species were reported in that year for the first time.

According to BirdLife International (2006), many factors might be associated with these changes of birdlife. The declination of bird species however is believed to be mostly generated by human influence. Corresponding habitat destruction, degradation and fragmentation are by far regarded as the biggest problem impacting 86% of the *Globally Threatened Birds*.

In particular, unsustainable forestry and expanding and intensifying agriculture are the paramount threats. The most devastating human impact on biodiversity is the alteration and destruction of habitats, caused by changes in land use: draining of wetlands, clearing of land for agriculture, felling of forests for timber, and pollution of the environment. Other impacts on biodiversity include the modified or direct exploitation (e.g., over-harvesting of plants or animals), and introduction of alien (non-native) species. Many other factors are also significant, including an ever-spreading infrastructure. When poorly planned and managed, this destroys natural habitats and brings with it damaging human activities, including logging, agriculture and fire. The pollution of air, land and water also has a direct impact on birds.

5.2 Present birdlife observed in Kota Kinabalu

5.2.1 Bird categories

As shown in figure 21, the bird species recorded during the survey in 2005 belong to 28 category classes. The detailed inventory list of birds observed is given in Appendix 16. A total of 135 species were identified and further categorised based on taxonomic list by *James Clements´ Birds of the world;* a checklist which takes into consideration bird distribution, horizon, behaviours and family (Wikipedia, 2006). The category class which encompasses the biggest number of species is Waders (14.07%); Herons, Storks and Bitterns follow on second position (12.59%); Raptors (8.15%) and Bulbuls (7.41%) on the third and fourth place respectively.

The presence of most Waders and Herons is due to the intact of coastal area with swamps, mudflats and associated mangroves. This area is probably also an important habitat for Raptors which eat small fishes (Mudskipper *Boleophthalmus boddarti*), crustaceans (Mud Lobster *Thalassina anomala*) and small mammals (Plantain Squirrel *Callosciurus notatus*), like the *Lesser Fish Eagle (Ichthyophaga humilis), Osprey (Patidion haliaetus)* or *Brahimy Kite (Halistur Indus)* they can usually be observed near the sea side or river mouth areas (refer to appendices 22 – 21).

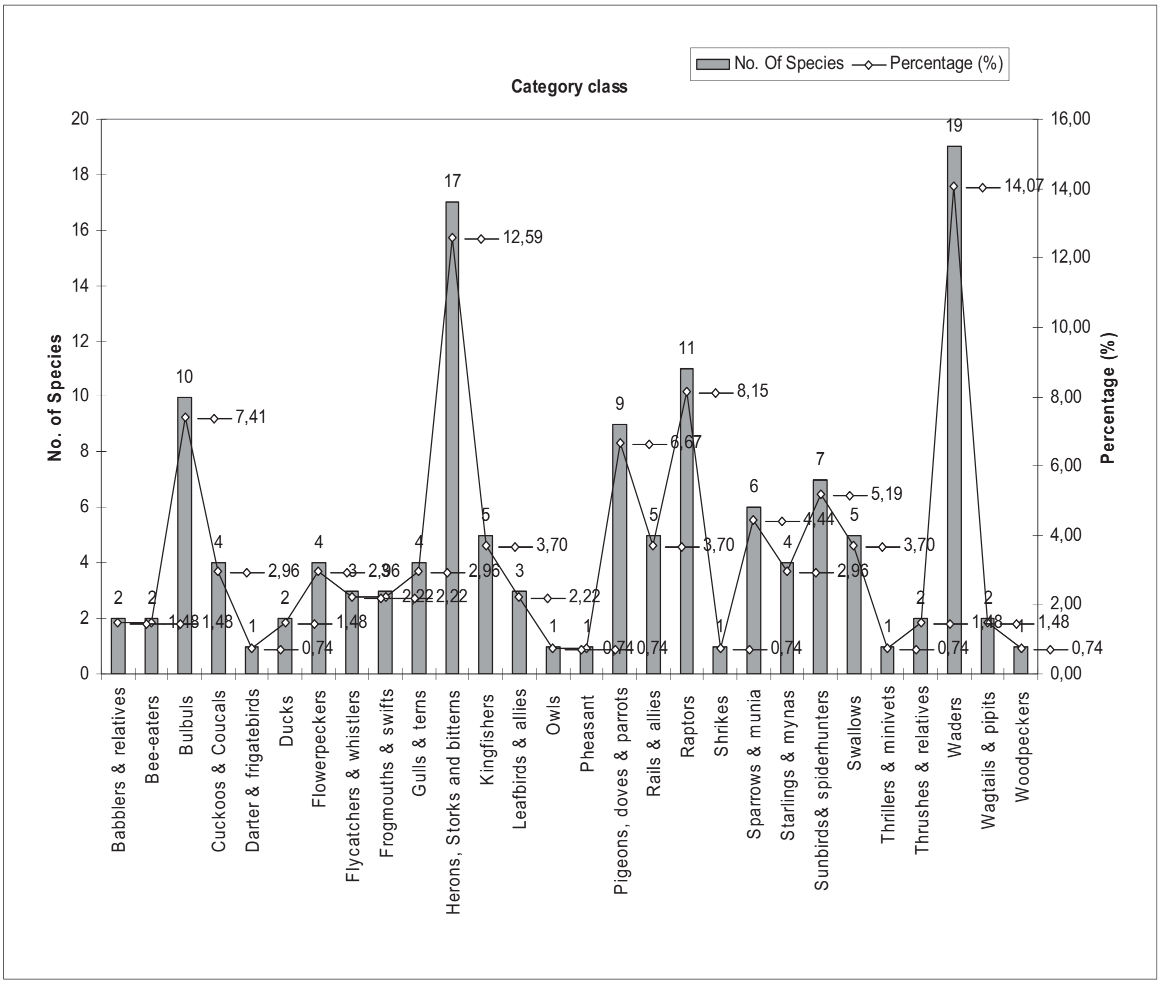


Figure 21: Categories of bird species recorded in Kota Kinabalu in 2005
(Database: own inventory; Categories: Wikipedia 2006)

5.2.2 Bird families

Figure 22 presents the represented bird species families. Most of the recorded species belong to the family *Ardeidae* (16 species), *Nectariniidae* (11 species), *Pycnonotidae* (10 species), *Accipitridae* (9 species) and *Scolopacidae* (9 species) respectively. *Herons, Bittern and Storks* belong to the *Ardeidae* family and were found as 'waterbirds' associated with water, usually at the coastal and mangrove areas. On the other hand, *Flowerpeckers*, *Sunbirds* and *Spiderhunters* belong to the *Nectariniidae* family which prefers the natural and lowland forest.

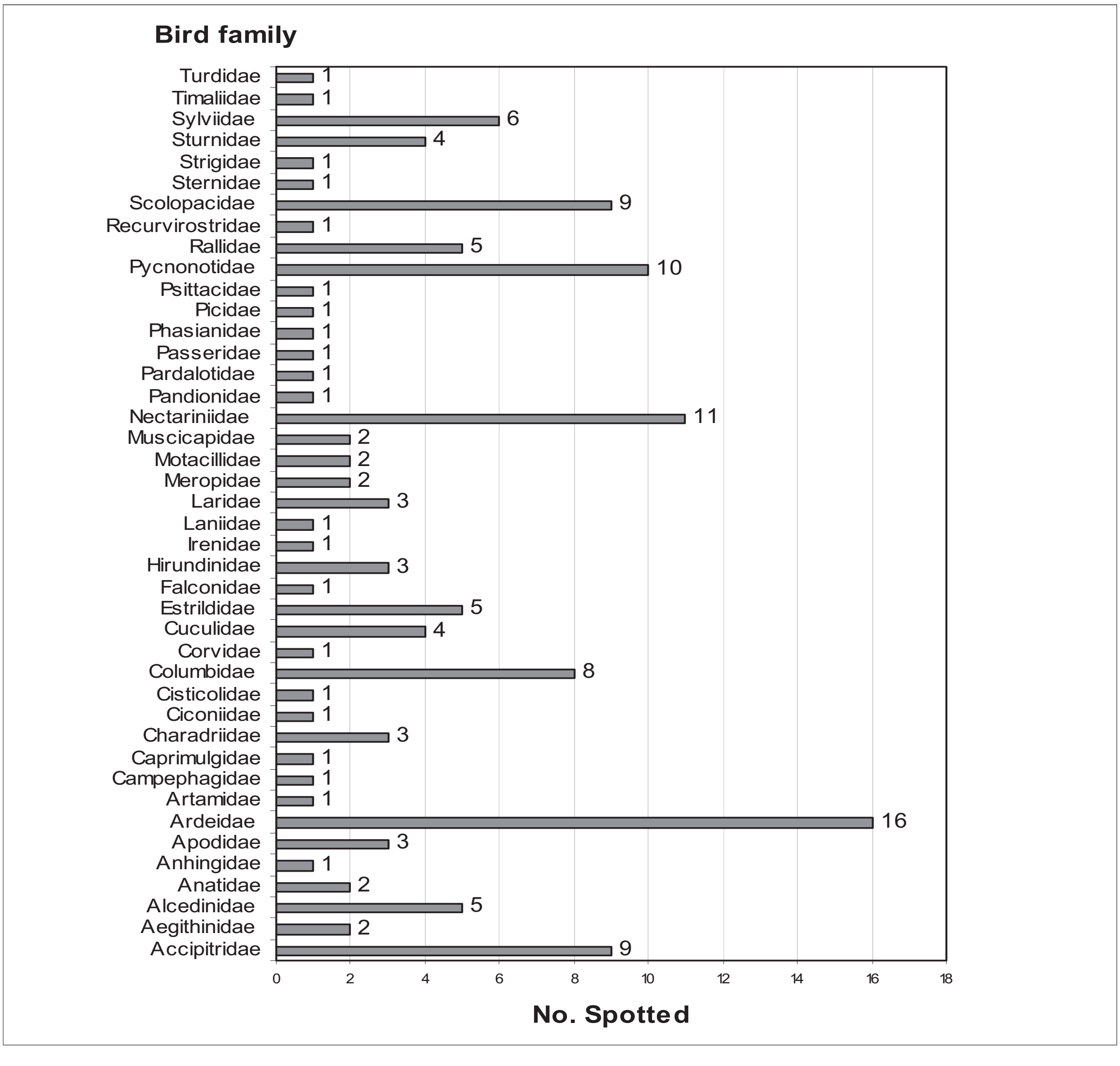
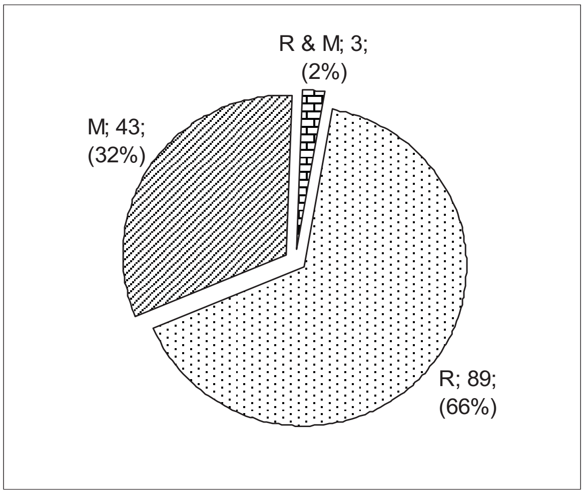


Figure 22: Families of birds species, recorded in Kota Kinabalu in 2005
(Source: Own presentation)

5.2.3 Bird presence/ persistence

Most of the birds observed in Kota Kinabalu are resident birds (66%). Migratory birds form of 32%, whereas 2% includes both resident and migratory birds as shown in figure 23. *"Resident birds"* means, that the bird species is breeding and stays in the same area or location throughout the year without migrating. Migration occurs with birds moving from one biome to another. In most cases birds migrate to avoid local shortages of food which is usually caused by winter seasons. The species that periodically migrate are called *"migratory birds"* (Wikipedia, 2004).



Note: M = Migratory bird, R = Resident bird

Figure 23: Number of resident and migrant birds recorded in Kota Kinabalu in 2005

5.2.4 Overall population density and abundance

The selected program of distance sampling delivered an estimated population density (D) of 14.11 birds/km² with a 95% confidence interval, between a range of 11.53 – 17.25 birds km². The result also shows a total population of 3526 individuals covering area of 280 km² (table 28). Compared to this, the bird population density in Kinabalu Park (approximately 60 km away from Kota Kinabalu), ranges between 11-19 birds km² covering an area of 750 km² (Mustafa et al., 1998).

Table 28: Population density and abundance of birds in Kota Kinabalu

	Estimate	%CV	df	95%	Confidence Interval
D (Density)	14.105	10.26	461	11.534	17.248
N (Abundance)	3526.0	10.26	461	2884.0	4312.0

Notes: CV = coefficient of variation, df = degree of freedom

Within the chosen distance of 100 m from the randomly chosen survey point, a sufficient detection probability was only given up to a distance of 75 m. Some birds' species are very difficult to detect, while other species are easy to find. As an example, a *woodpecker* bird is known to be shy and very difficult to be seen in closed canopy forest. However an experienced surveyer can identify the singing or burrowing sound of the *woodpecker*, and then estimate the distance in which the bird was heard.

Species that are easier to be spotted are *waders, herons, storks* and *bitterns*. They often occur in clusters and groups and do not hide away in bushes or trees. In this survey, rare species that were difficult to be spotted belong to *Woodpeckers, Wablers* (*Tailorbird and Snipe*), and *Sunbird & Spiderhunters*, while the remotes detected birds are Raptors (*Hawk, Eagle and Harrier*). Sometimes they were spotted flying far (≥ 75 m distance) in the sky and only could be identified using binoculars.

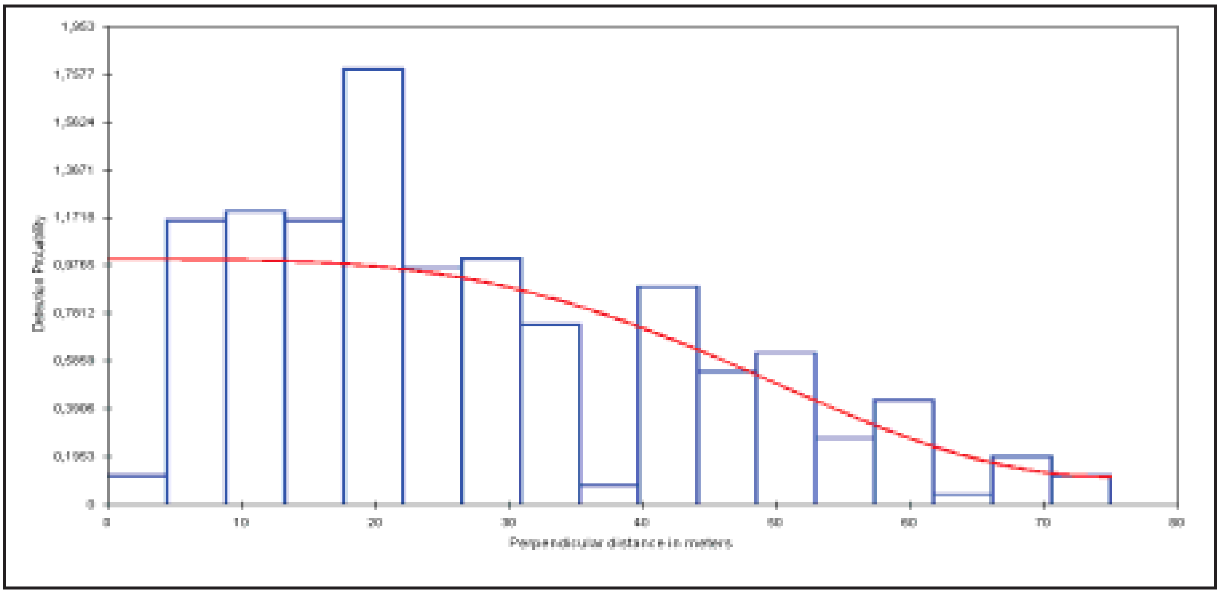


Figure 24: Detection probability of all birds recorded using point transect sampling method in Kota Kinabalu

Figure 24 further suggests that some birds were moving before they could get counted. This means that birds may take evasive movement prior to detection. In distance sampling assumption, however these objects must be taken at their original location. Bird's movement after detection is not a problem, as long as the original location can be identified accurately and the appropriate distance be measured. In contrast, if the observer records the same animal for several times due to unrecognised movements, bias can be large.

5.3 Bird Habitats in Kota Kinabalu

By looking at the SPOT images data (2002) of Kota Kinabalu with the scale of 1:50000 (figure 25), it becomes clearly perceptible that many of the widespread urbanized areas are still 'intact' to a certain degree incorporating many scattered green areas. These greens do still serve as an important area for bird life, connecting the green areas which surround the Kota Kinabalu district in the east and the coastal area which adjoins it in the west (could also be refer in chap 7/ figures 42 - 43). It can thus be of high importance for both coastal as well as forest bird life. The list of recorded birds proofs profusion of coastal birds (*waders, heron, storks* and *bittern*) and forest birds (*raptors, bulbuls, pigeons, doves* and *parrots*).

Table 29: Green corridor area for birds in Kota Kinabalu classified from SPOT setellite images

Important Classes of Area		Hectare (ha)	Percentage (%)
Urban and developed areas		8743.32	30.34
Mix horticulture and grassland	*Greens*	6552.52	22.74
Paddy and riverside		1588.04	5.51
Old rubber and scrub		7074.00	24.55
Forest and Mangrove		4855.76	16.85

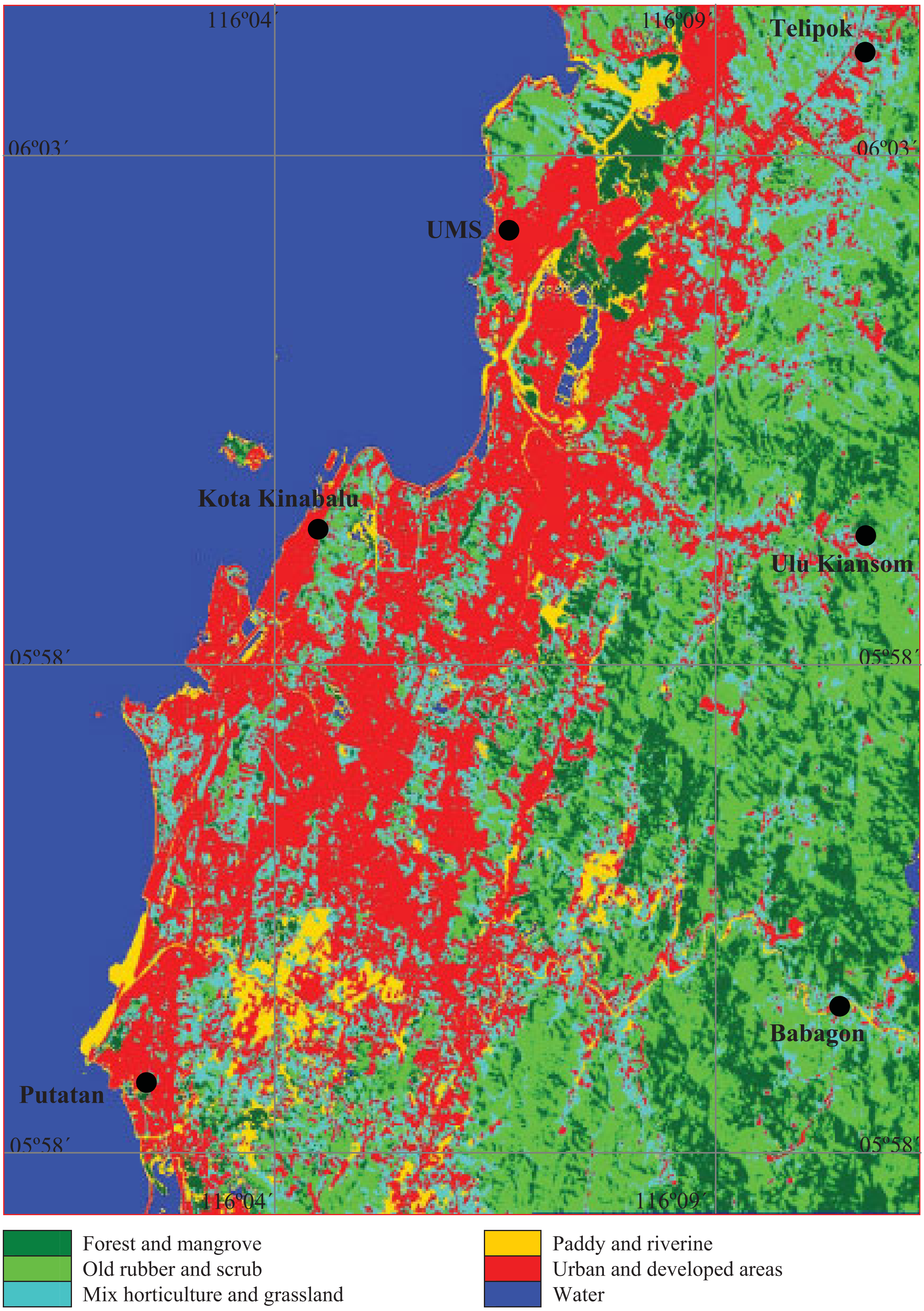


Figure 25: Kota Kinabalu spatial pattern derived from SPOT Image data with proportion of 64.14% green areas (Scale 1:50,000)
(Source: Own presentation)

Based on the table 29, the total "greens" in the study area of Kota Kinabalu still amount to **18,482.28ha (64.14%).** These green areas encompass mixed horticulture and grassland, paddy and riverside, old rubber and scrub as well as secondary forests and mangroves, and it can be assumed that these greens can still provide habitat areas for birds, if they are properly managed and confined by the government.

From the spatial pattern, the green areas have been further transformed into habitat categories for bird life namely: secondary growth areas; grasslands & scrubs; hill vegetation areas; plantation areas; rice paddy fields; coastal mangroves; swamp areas; riverside areas; pond, lakes & pools; coastal areas; town areas and residential areas. The descriptions of important bird life / habitat areas are given in table 30. They can also be characterised by their typical birdlife species as given in appendix 22.

Table 30: Important bird habitat categories in Kota Kinabalu district
(Source: Own presentation, and each description adapted from Dickinson et al. (1996): Key to ecological status)

Habitat categories	Description
Secondary growth areas	Secondary growth area is an area which was previously a forest that has been disturbed in some way, naturally or unnaturally. It can be created in a number of ways, from degraded forest recovering from selective logging, to areas cleared by slash-and-burn agriculture that have been reclaimed by forestry. Generally, it's consisting by a less developed canopy structure, smaller trees and less diversity.
Grasslands & scrubs	The general appearance of grassland is an area which included shrubs and trees (generally below 5 meters) cover less than 50% of the area. When the scrub component covers more than 50% of the area, it is designated as Scrub Forest and is put under category Forest land. Grassland are categorised with; **a) Lalang, Unimproved Course Pasture and / or Scrub-Grassland:** Grasslands may occur naturally or as the result of human activity like pasturing. Usually this area developed naturally and mostly dominated by *Imperata cylindrical* grass type vegetation. **b) Idle lands (Grasses and Scrub Forest):** the accumulating degradation of soil quality through the continuous harvesting of crops. It is simple: let the tract of land remain idle for a period of time in order to allow nutrient-rich eolian (wind deposited) and other silt to be deposited and rejuvenate the soils productivity. **c) Grass Covered Erosion Scars and Landslides:** Intensive agricultural practices have contributed to high rates of erosion scars on hillslopes. This bare soil often exposed to landslide, thus these areas also has been prepared for the development of grass covers.

(contd.)

Table 30: Important bird habitat categories in Kota Kinabalu district
(Source: Own presentation, and each description adapted from Dickinson et al. (1996): Key to ecological status) (Contd.)

Habitat categories	Description
Hill vegetation areas	Hill vegetation occurs in a landform that extends above high terrain in the area. The distinction between a hill and a mountain is that hill is generally somewhat lower and less steep than a mountain. Usually its ranges between 500 – 1000 feet asl. The type of vegetation usually includes old rubber trees, scrub forest and natural vegetation after lefit behind shifting cultivation areas.
Plantation areas	Areas which include mixed hoticulture and perennial tree crops. The mixed horticulture includes all mixed vegetable, yams, tapioca, chillies, pineapples, fruit trees, bananas, papayas, coconuts, etc. The most common location is along roads and riverbanks. Frequently this type forms buffer strips between estates and smallholding crops. The tree crop includes all stages of growth under various forms of management. The crops under this category are rubber tree, oil palm, cocoa, coconut, coffee, orchards, bananas, pineapple and sago palm.
Rice paddy fields	A paddy field is a flooded parcel of arable land used for growing rice. Mostly found on the river plains of the West Coasts of Sabah. Most paddy fields are smaller than 2 hectares and sometime formed as patches.
Coastal Mangroves	Mangrove area: This category includes all poorly drained land exhibiting seasonal or permanent waterlogging. Rhizophoraceae, Lumnitzera and Acrostichum dominated in this category, as well as mangrove areas which has been recently cut-over. Usually found near coastal or river mouth.
Swamp areas	A swamp is a wetland area that features permanent inundation of large areas of land by shallow bodies of water, generally with a substantial number of dry-land protrusions. Swamps usually include a large amount of woody vegetation and usually termed as marsh. Swamps are generally characterized by very slow-moving waters. They are usually associated with nipah palm and bebaru tree (*Thespesia populnea*) adjacent with rivers or lakes.
Riverine areas	A **riverine area** is located or inhabiting near a river banks or riparian. Consists of a large natural waterway. It is a specific term in the vernacular for large streams, stream being the umbrella term used in the scientific community for all flowing natural waterways. In the vernacular, stream may be used to refer to smaller streams, as may creek, run, fork, etc.
Pond, lakes & pools	A body of water smaller than lake usually fresh water, surrounded by land. Also include garden ponds, engineered treatment features (water & electric hydro), and field units in agriculture for example, "pondfields" for rice and aquaculture.

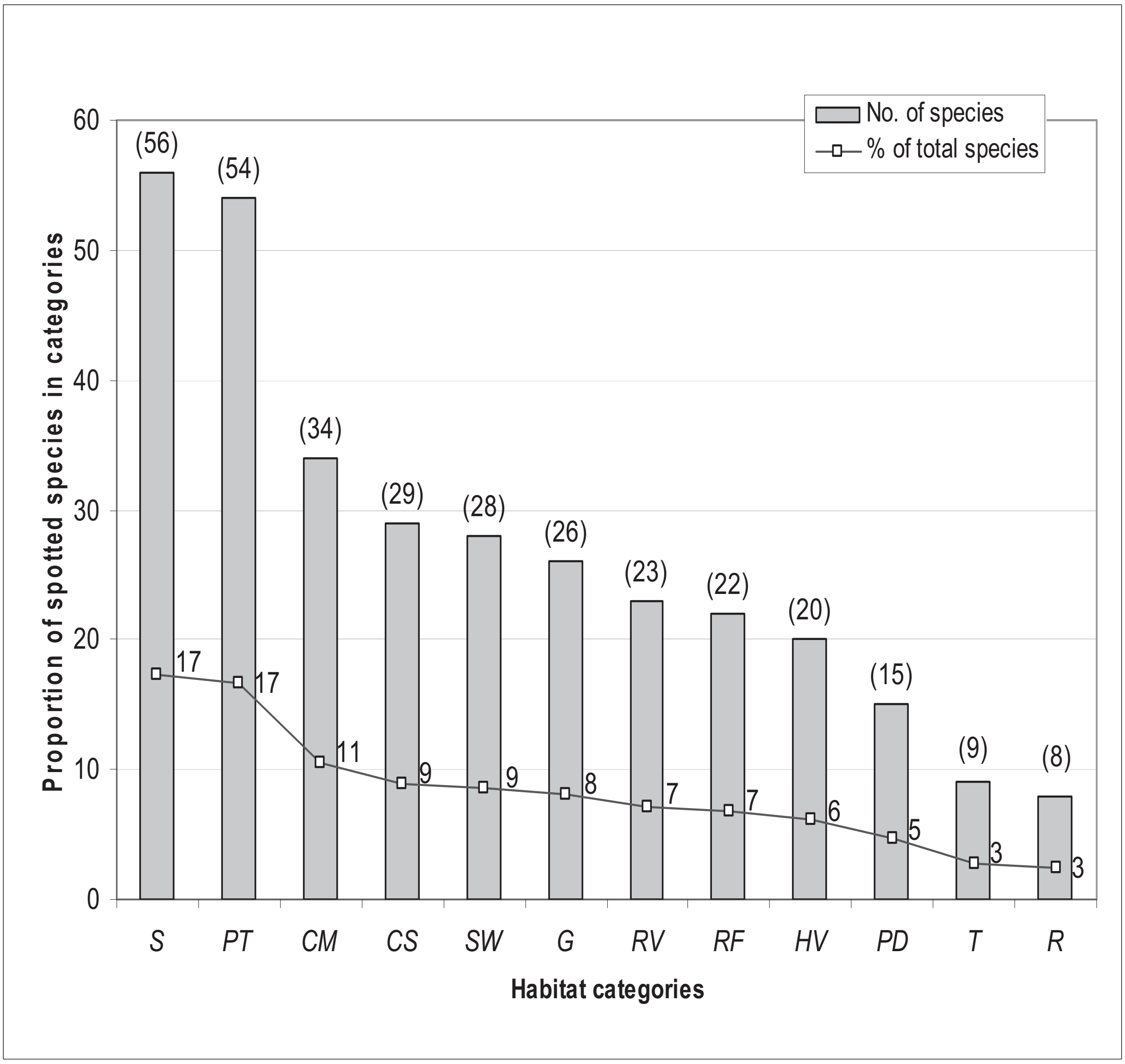
(contd.)

Table 30: Important bird habitat categories in Kota Kinabalu district
(Source: Own presentation, and each description adapted from Dickinson et al. (1996): Key to ecological status) (Contd.)

Habitat categories	**Description**
Coastal areas	The **coast** is defined as the part of the land adjoining or near the ocean. A **coastline** is properly, a line on a map indicating the disposition of a coast. A **coast** is an island or continent that borders an ocean, gulf, sea, large lake, or lagoon and usually found along Kota Kinabalu coast.
Town areas	*Town area* mapped as a growth centres such as city, urban and sub urban towns, which generally are distributed at the coastal fringes facing the harbours and settlement centres. Among the important criteria in distinguishing this major category include the existence of infrastructures, the existence of public buildings and the provision of utilities for the population. This term also used to define an area where there is an increased density of human-created structures in comparison to the areas surrounding it.
Residential areas	A residential area is a type of land use where the predominant use is housing. In areas that are zoned residential, buildings may include single family housing, multiple family housing such as (apartments, duplexes, townhomes (or similar configurations), condominiums) or mobile homes. Zoning for residential use may permit some services or work opportunities or may totally exclude business and industry.

Figure 26 shows the numbers of bird species spotted in these habitat categories. The most bird species were found in the secondary growth areas (17.3%), secondly the plantation areas (16.7%), thirdly the mangrove areas (10.5%), and then the coastal areas (9.0%) respectively.

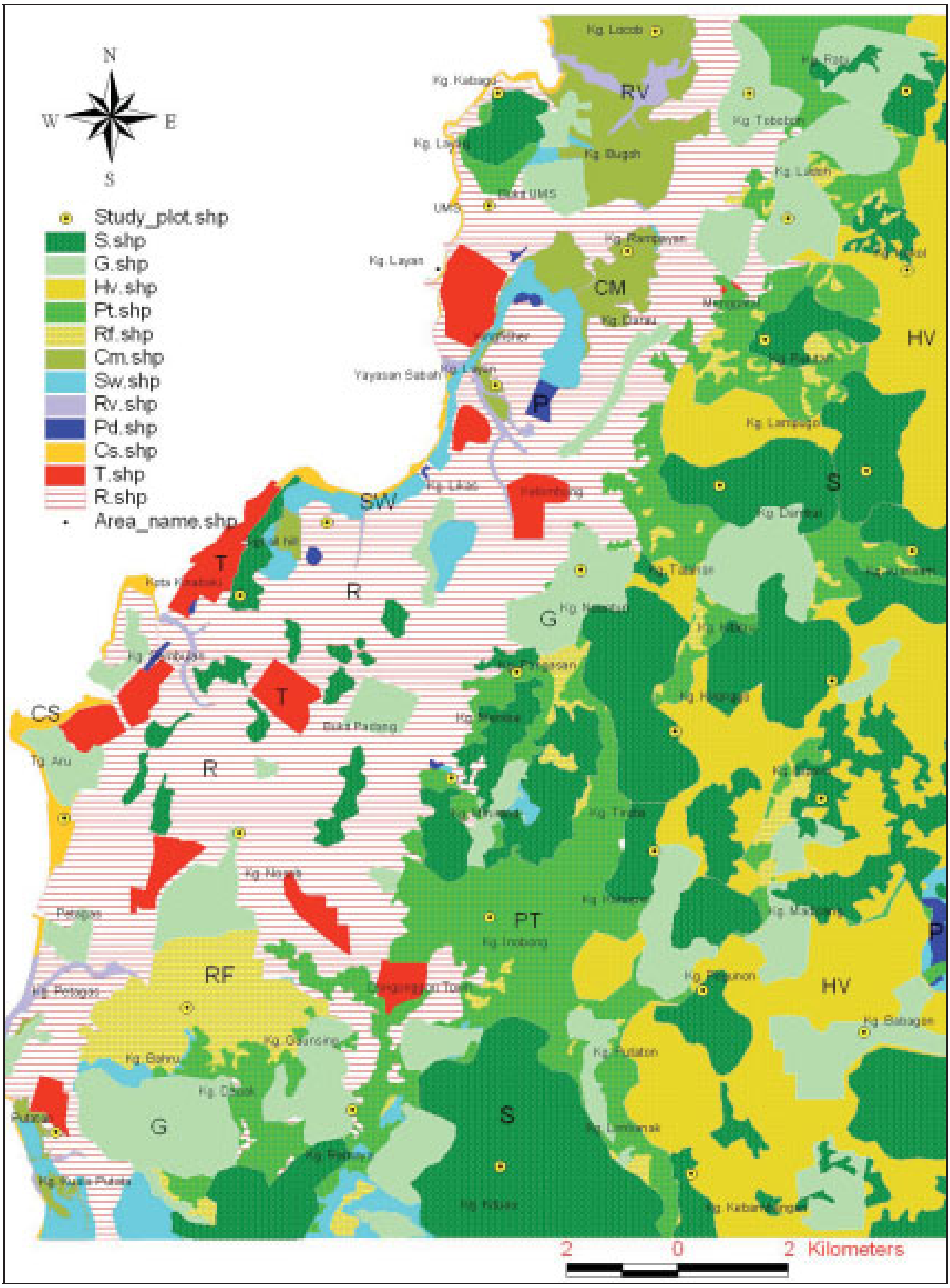
Secondary growth and plantations were analysed to be most important for birdlife, they host many different plant species which attract insects, both serving as bird foods. Mangroves and coastal areas appear as highly productive ecosystems, inhabited by a large variety of crabs, fish, worms and molluscs which form the basis of a food chain that also supports a large variety and abundance of bird species. The map of bird habitat categories is shown in figure 27.



Note: *S = Secondary growth area; CM = Coastal mangrove; Cs = Coastal area, RF = Rice field; Sw = Swamp; G = Grassland & scrub; RV = Riverine area; PT = Plantation area; T = Town; Hv = Hill vegetation area (approximately 500-1000ft); Pd = Pond, lakes & pools; R = Residential area*

Figure 26: Numbers of spotted bird species in different habitat categories in Kota Kinabalu.

Since the habitat is the place where a particular species lives and grows, each habitat type represent the physical environment a species population needs to survive which consists of all necessary components. Food is essential to perform life functions and cover provides protection, such as places to nest, hide, sleep and travel. The area required by an animal to survive is called space.



Notes: *S = Secondary growth area; G = Grassland & scrubs; Hv = Hill vegetation area (approximately 500-1000ft); Pt = Plantation area; Rf = Rice field; Cm = Coastal mangrove; Sw = Swamp; Rv = Riverine area; Pd = Pond, lakes & pools; Cs = Coastal area; T = Town; R = Residential area*

Figure 27: Bird habitat categories in Kota Kinabalu (further description see table 30) Scale 1:50,000 *(Source: Own presentation)*

Table 31: Important tree species that attract insects and provide food for birds *(Source: Own observation)*

Habitat categories	Plant/ Tree species
Secondary growth area	*Ficus sp, Careya arborea* (Putat), *Eugenia sp* (Kelat), *Macaranga sp* (Mahang), *Bulbophyllum macranathum* (Ephyphitic orchid), *Vitex pubescens* (Kulimpapa), *Sandoricum koetjape* (Sentul hutan), *Fagraea volubilis* (Todopon puok), *Ficus sp.* (Ara), *Melastoma malabathricum* (Senduduk), *Fagraea fragrans* (Tembusu), *Musa sp.* (Pisang hutan), *Artocarpus sp* (Terap hutan), *Parkia sp* (Petai)
Grassland & scrubs	*Melastoma malabathricum* (Senduduk), *Lantana cemara* (Bunga Tahi Ayam), *Ixora Javanica* (Shrub)
Hill vegetation	*Hevea brasiliensis* (Getah), *Ixora Javanica* (Shrub), *Cieba pentandra* (Kapok), *Cinnamomum iners* (Kayu manis), *Zingiber sp* (Ginger)
Plantation area	*Hevea brasiliensis* (Rubber), *Coffea sp.* (Kopi), *Elaeis guineensis* (Oil Palm), *Eugenia jambos* (Jambu mawar), *Nephelium lappaceum* (Rambutan), *Artocarpus sp* (Terap), *Durio zibethinus* (Durian), *Lansium domesticum* (Langsat)
Rice field	*Oryava sativa* (Paddy), *Areca catecu* (Pinang), *Zea mays* (Jagung), *Passiflora feotida* (Climber)
Coastal Mangrove	*Rhizophora sp* (Bakau), *Lumnitzera littorea* (Teruntum), *Scaevola frutescens* (Sea lettuce), *Acrostichum aureum* (Piai raya), *Sonneratia alba* (Perepat), *Hibiscus tiliaceus* (Bebaru)
Swamp area	*Nypa fruiticans* (Nipah), *Mimosa pudica* (Shrub), *Acacia sp.* (Akasia), *Leuceana leucocephala* (Petai belalang), *Thespesia populnea* (Bebaru)
Riverine area	*Ficus spp* (Ara), *Acacia sp* (Akasia), *Thespesia populnea* (Bebaru), *Leuceana leucocephala* (Petai belalang)
Pond, lakes & pools	*Duranta plumieri* (Shrub), *Lantana cemara* (Bunga Tahi Ayam), *Fagraea fragrans* (Tembusu), *Tamarindus indica* (Asam Jawa), *Thespesia populnea* (Bebaru)
Coastal area	*Thespesia populnea* (Bebaru), *Terminilia cattapa* (Ketapang), *Morinda elliptica* (Bengkudu), *Ficus bengalensis* (Ara), *Ficus religiosa* (Ara), *Cocos nucifera* (Kelapa)
Town area	*Pterocarpus indicus* (Angsana), *Samanea saman* (Hujan-hujan), *Ptychosperma macarthurii* (Palm), *Fagraea fragrans* (Tembusu), *Tecoma stans* (Yellow bells), *Delonix regia* (Semarak Api)
Residential area	*Delonix regia* (Semarak Api), *Canarium sp.* (Kedondong), *Cinnamomum iners* (Kayu Manis), *Tamarindus indica* (Asam Jawa), *Michelia champaca* (Cempaka), *Cocos nucifera* (Kelapa), *Leuceana leucocephala* (Petai belalang)

Many birds' species feed from the ground, in mud or long grass. Those which feed on fruit or nectar will be attracted by these food sources, but the majority of birds feed on insects. Table 31 shows the major tree species found in the study plots that are used by birds for food and at the same time attract small insects. These species also can be found in the respective tree species inventory plots (chapter 4). The list as mentioned above is not exhaustive, and more research is needed to add more species.

5.4 Potentially important bird areas in Kota Kinabalu (IBAK)

Birds are highly responsive to essential features in a landscape (e.g., freshwater, trees or types of grasses) as well as their patterns and processes. Different species respond to different types of landscape features on the macro as well as the micro scales. Macro-features are climate property, types of habitats and land-uses like wet or dry areas, freshwater or saltwater marshes, urban areas, agricultural areas or coastal areas. However, the occurrence of a species at a site is also dependent on micro-features, such as:

- the amount of trees and natural vegetation on the site
- the presence and types of birds' food
- the amount of human activities and over built areas (building and asphalt)
- the availability of water

Thus, landscape features (at the macro and micro level), influence birds presence at a given survey site. According to Hostetler (2002), a certain kind of species can be known to occur in a city, but whether they occur in a particular area depends on the landscape features located in that area. In urban areas, the number of birds (abundance) tends to be high, but the number of different species (species richness) tends to be low.

Based on the study plots in Kota Kinabalu, a potentially important birdlife area classification was realised by using Arcview GIS software. It differentiates between 1) rich birdlife area 2) medium rich birdlife area, and 3) poor birdlife area as shown in table 32. The collected data were analysed by overlapping the bird habitat areas as identified in figures 26 with spotted bird species number in that area (by plot survey) as shown in table 33

The identified bird habitat areas (figure 27 and table 30) were analysed again with respect to their potential species numbers (as given in figure 26 and appendix 22) and the calculated overall population density as defined in table 32.

Table 32: Bird density criterion for analyzing potentially Important Birdlife Areas in Kota Kinabalu (IBAK)

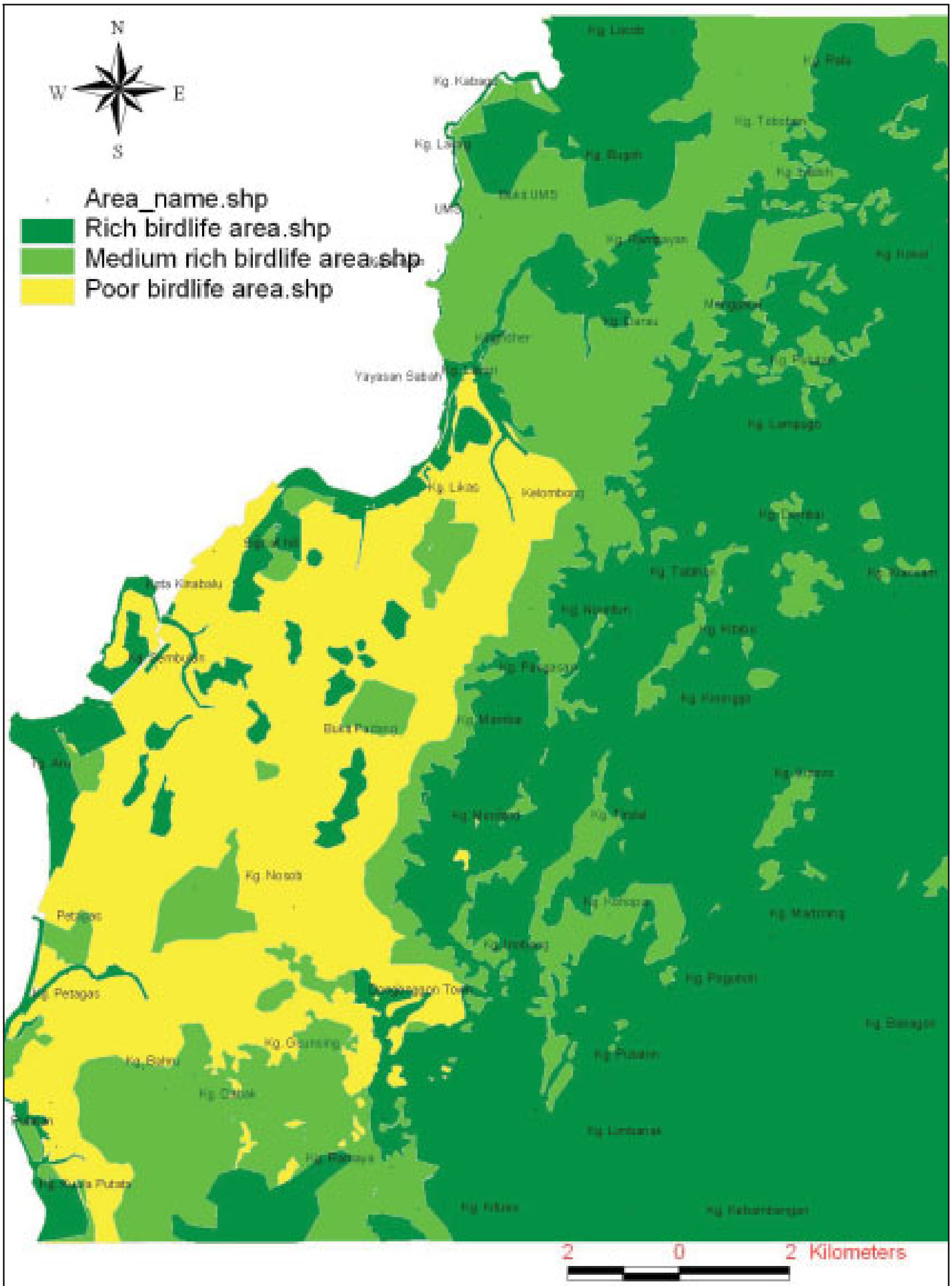
Criteria of IBAK	**Description/ indicator**
Rich birdlife area (***3***)	Significantly important habitat for the conservation of birds with bird density, D > 15 birds/ km².
Medium rich birdlife area (***2***)	Important habitat for the conservation of birds with density of, D < 15 birds/ km².
Poor birdlife area (***1***)	Unimportant bird habitat with the occurrence of birds less than 5 birds/ km².

Table 33: Important birdlife areas in Kota Kinabalu (IBAK) based on study plots *(Source: Own presentation)*

Plot	Study plot locations	S	CM	CS	RF	SW	G	RV	PT	T	HV	PD	R
1	Prince Philip Park			*3*			*2*	*1*		*2*			*1*
2	Kg. Bantayan	*2*							*2*				
3	Kg. Minintod								*2*				
4	Bukit Padang	*3*				*2*						*2*	*1*
5	Kg. Putatan		*2*	*2*		*1*	*1*	*2*		*1*			
6	Kg. Kepayan				*2*	*1*	*1*			*1*			
7	Kg. Tangihan				*2*		*1*		*1*				
8	Kg. Nambazan	*2*			*1*	*1*	*1*		*1*			*1*	
9	Kg. Limbanak	*3*					*1*		*2*		*2*		
10	Kg. Kebambangan	*3*						*2*	*2*		*2*	*1*	
11	Kg. Babagon	*3*						*2*	*1*		*2*	*1*	
12	Kg. Kironggo	*2*					*1*	*2*	*2*			*1*	
13	Kg. Pangasan	*2*			*2*	*1*	*1*		*1*		*2*	*1*	
14	Kg. Pogunon	*2*						*2*					
15	Kg. Tindai	*2*			*1*	*1*	*1*		*2*				
16	Kg. Kipouvo	*3*			*1*			*1*	*1*		*2*		
17	Kg. Keliangau	*2*					*1*						
18	Kg. Kitabu	*3*					*1*		*2*		*2*		
19	Kg. Pomotodon	*2*					*1*		*2*				
20	Kg. Pulutan	*2*							*2*		*2*		
21	Kg. Kiansam	*3*			*1*				*2*		*2*		
22	Kg. Kokol	*3*							*2*		*2*		
23	Kg. Poring Poring	*3*							*2*		*2*		
24	Kg. Tampulan	*2*					*1*						
25	Kg. Bendolan						*1*		*1*	*1*			
26	Likas Bird KKCBS		*3*			*3*		*3*					
27	Kg. Rampayan		*2*			*1*							
28	Kg. Bangka Bangka		*2*					*2*		*1*			*1*
29	Kg. Kibagu	*2*		*2*			*1*		*1*				
30	Kg. Lokob		*2*			*1*							
31	Signall Hill	*2*								*1*			
32	UMS		*2*	*2*			*1*			*1*		*1*	*1*
Recorded bird species numbers		***56***	***34***	***29***	***22***	***28***	***26***	***23***	***54***	***9***	***20***	***15***	***8***

Notes: S = Secondary growth area; G = Grassland & scrub; Hv = Hill vegetation area (approximately more 500ft asl); PT = Plantation area; CM = Coastal mangrove; Cs = Coastal area, RF = Rice field; Sw = Swamp; RV = Riverine area; Pd = Pond, lakes & pools; T = Town; R = Residential area

This consideration of potential bird species diversity and bird population density finally lead to the deliminition of "potentially rich birdlife areas in Kota Kinabalu" as illustrated in figure 28.



Criteria of IBAK		Present area in hectare (ha)
Rich birdlife area		18,860 ha
Medium rich birdlife area		5,576 ha
Poor birdlife area		4,980 ha

Figure 28: Potentially Important Birdlife Area in Kota Kinabalu (IBAK) based on dominating land-use and bird survey assessment

Based on figure 28, most of the rich birdlife areas in Kota Kinabalu are located outside the city area of Kota Kinabalu. These types of areas are includes secondary growth areas, hill vegetation areas and, grassland and scrub areas. It can be assumed that this area provides important micro-features of bird habitats. The presence of natural and left behind green areas give some corridors or 'laluan[2]' for birds to live and fly. Furthermore, figure 28 also provide an indication of guidelines map for bird study, monitoring and management for Kota Kinabalu. As final remarks of important birdlife areas in Kota Kinabalu (IBAK), the Kota Kinabalu City Bird Sanctuary (KKCBS) is obviously not the only IBAK and there are other areas which need to be integrated into a careful preventive/ precautionary management (even including "poor birdlife areas") which would need upgrading measures from time to time. Without any indication from the respective organisatations or agencies, and in the long run, these areas could be degrade qualitative and quantitatively.

5.5 Basis for birdlife protection in Kota Kinabalu

5.5.1 Conditions of legal wildlife protection in Sabah (appendix 23)

Malaysia is one of the countries in South East Asia which still has abundant wildlife both in number and in diversity of species. The country's wildlife is protected under legislation for some of the species according to their importance and status. In the past, due to low population, effective measures could be taken such as legal actions on illegal activities in the forest areas. But with the increasing population at presence, illegal activities a more prevalent and the habitats of animals became fragmented as the land pressures increased. As a result, the wildlife populations have dwindled and some animals a known as extinct.

Therefore, a modern concept was initiated to form a system of protected areas including the representative ecosystems for all animal species and elephant ranges. The wildlife conservation enactment was formulated in 1997. The Sabah Wildlife Department is responsible for the protection and management of diverse wildlife species and protected areas, namely *National Parks, Wildlife Sanctuaries, Nature Reserve and Hunting Areas*.

The Director of Sabah Wildlife Department is generally responsible for the conservation progamme in Sabah. The Wildlife Conservation Enactment defines a number of protection measures and enforcements inside the wildlife sanctuary area and it covers several types of protection and offences. The details list of protected animals and plants is given in Appendix 23. Listed below are the important sections of the enactment which tell about wildlife sanctuaries, management plans, protected animals and offences.

Part 3: Wildlife Sanctuaries. (§ 9)

(1) The Minister after consultation with the Director considers that it is necessary in an area to:

a) protect nature and maintain wildlife habitats and natural processes in an undisturbed state
b) ensure the maintenance of biodiversity values or
c) ensure the conditions necessary to protect significant species of animals or plants, biotic communities or genetic resources

The Minister may place a proposal before the Cabinet recommending to advise the head of the state (*Yang di-Pertua Negeri*) that the area should be declared a Wildlife Sanctuary.

(2) The proposal provided for under subsection (1) shall include:-

a) a description of the area as accurate as possible and the boundaries of the proposed Sanctuary
b) an assessment of the fauna and flora and other biodiversity values of the proposed Sanctuary

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[2] *'Laluan'* is a Malay word, which refers to a lane, path or corridors.

c) particulars of the native or traditional rights that will continue to be exercisable after the realisation of the declaration of the proposed Sanctuary and
d) a summary of the consultations held with relevant Government agencies and a summary of the representations made by persons and communities likely to be affected by the declaration of the proposed Sanctuary

Part 3: Management plans. (§ 13)

(1) Within three years after the declaration of a Wildlife Sanctuary the Director shall prepare and submit to the Minister a management plan which has to include:

a) an analysis of the major resources of the Sanctuary
b) a map clearly defining the boundaries of the Sanctuary and a written description of these boundaries
c) detailed of management objectives
d) details of the zones into which the Sanctuary is divided for wildlife conservation and management purposes which may include zones or parts of zones to which members of the public may be admitted
e) a detailed programme of management actions for conservation and protection of the wildlife and its habitats including details of requirements of staff, staff facilities and equipment and estimates of expenditure
f) details of research proposals and
g) such other matters as may be required

(2) The management plan referred to in subsection (1) shall cover a period of five years.
(3) Further management plans or revision of parts thereof shall be submitted to the Minister at such intervals and in such manner as may be determined by the Minister.
(4) The Minister shall cause the management plan and any revision thereof to be published in such manner as shall be appropriate and to be made available for consultation by members of the public.

Part 4: Animals that shall not be hunted. (§ 25)

(1) No person shall hunt any animal of a species listed in Part I of Schedule 1. (See in Appendix 23)

(2) No person shall hunt:

a) an animal of a species listed in Part I of Schedule 2 or Schedule 3 without a licence
b) more than the quota of that species of animal included in a licence

(3) Any person who contravenes subsection (1) or (2) commits an offence and shall be liable on conviction:

a) in respect of an offence relating to an animal of a species listed in Part I of Schedule 1 to a term of imprisonment for not less than six months but not exceeding five years or
b) in respect of an offence relating to an animal of a species listed in Part I of Schedule 2 or Schedule 3, to a fine of (RM) fifty thousand ringgit or to imprisonment for five years or to both

Part 4: Animals that may be hunted in limited numbers. (§ 26)

(1) A person may hunt an animal of a species listed in Part I of Schedule 2 under the authority of a licence issued by the Director

(2) The Director may at any time by notice published in the Gazette declare:

a) the total number of animals of each species listed in Part I of Schedule 2 that may be hunted
b) the number of animals of each species listed in Part I of Schedule 2 that may be hunted in each Wildlife Area
c) the maximum number of animals of each species listed in Part I of Schedule 2 that any individual may be licensed to hunt

5.5.2 Present condition of wildlife protection in Kota Kinabalu

The following table 34 shows the main species recorded in the presented survey and their status of protection based on national and international legislative protection status.

Table 34: Accounted bird species in 32 representative sampling plots and their legal protection status

Scientific name/ Vernacular name	M/R	Wildlife Enactment Sabah, 1997	Birdlife Int. Red Data Book, 2003	CITES, 2005 Appendix	IUCN Red List, 2006
BULBULS *Criniger phaeocephalus* (Yellow-bellied Bulbul)	R			I	
Hypsipetes criniger (Hairy-backed Bulbul)	R			I	
Hypsipetes flavalus (Ashy Bulbul)	R			I	
Pycnonotus plumosus (Olive-winged Bulbul)	R			I	
Pycnonotus brunneus (Red-eyed Brown Bulbul)	R			I	
Pycnonotus erythrophthalmos (Spectacled Bulbul)	R			I	
Pycnonotus eutilotus (Puff-backed Bulbul)	R		NT	I	NT
Pycnonotus flavescens (Flavescent Bulbul)	R			I	
Pycnonotus goiavier (Yellow-vented Bulbul)	R			I	
Pycnonotus zeylanicus (Straw Headed Bulbul)	R	P		II	VU
DARTER & FRIGATEBIRDS *Anhinga melanogaster* (Oriental Darter)	R	P	NT		NT
DUCKS *Aythya fuligula* (Tufted Duck)	M			I	
GULLS & TERNS *Chlidonias hybridus* (Whiskered Tern)	M			I	
Chlidonias leucopterus (White-winged Tern)	M			I	
Larus ridibundus (Black-headed Gull)	M			I	

(Contd.)

Table 34: Accounted bird species in 32 representative sampling plots and their legal protection status (Contd.)

Scientific name/ Vernacular name	**M/R**	**Wildlife Enactment Sabah, 1997**	**Birdlife Int. Red Data Book, 2003**	**CITES, 2005 Appendix**	**IUCN Red List, 2006**
FLYCATCHERS & WHISTLERS *Ficedula westermanni* (Little Pied Flycatcher)	R			I	
HERONS, STORKS & BITTERNS *Ardea cinerea* (Grey Heron)	M	P		I	
Ardea purpurea (Purple Heron)	R	P		I	
Bubulcus ibis (Cattle Egret)	M	P		I	
Butorides striatus (Little Heron)	R	P		I	
Dupetor flavicollis (Black Bittern)	M	P		I	
Egretta alba (Great Egret)	R, M	P		I	
Egretta eulophotes (Chinese Egret)	R, M	P	VU	I	VU
Egretta garzetta (Little Egret)	R, M	P		I	
Egretta intermedia (Intermediate Egret)	M	P		I	
Egretta sacra (Pacific Reef-egret)	R	P		I	
Gorsachius melanolophus (Tiger Bittern)	M	P			
Ixobrychus sinensis (Yellow Bittern)	R	P			
Ixobrychus cinnamomeus (Cinnamon Bittern)	R	P			
Ixobrychus eurhythmus (Schrenck's Bittern)	R	P			
Leptoptilos javanicus (Lesser Adjutant)	R	P	VU		VU
Nycticorax nycticorax (Black-crowned Night-heron)	R	P			
Nycticorax caledonicus (Rufous Night-heron)	R	P			

(Contd.)

Table 34: Accounted bird species in 32 representative sampling plots and their legal protection status (Contd.)

Scientific name/ Vernacular name	**M/R**	**Wildlife Enactment Sabah, 1997**	**Birdlife Int. Red Data Book, 2003**	**CITES, 2005 Appendix**	**IUCN Red List, 2006**
OWLS *Otus bakkamoena* (Collared Scops-owl)	R			I	
LEAFBIRDS & ALLIES *Aegithina viridissima* (Green lora)	R		NT		NT
Chloropsis sonnerati (Greater Green Leafbird)	R				
PIGEONS, DOVES & PARROTS *Chalcophaps indica* (Green-winged Pigeon)	R	P		I	
Columba livia (Feral Pigeon)	R			III	
Ducula aenea (Green Imperial Pigeon)	R			I	
Geopelia striata (Peaceful Dove)	R			I	
Loriculus galgulus (Blue-crowned Hanging Parrot)	R	P		I	
Streptopelia chinensis (Spotted-necked Dove)	R			I	
Treron curvirostra (Thick-billed Green Pigeon)	R			I	
Treron olax (Little Green Pigeon)	R			I	
Treron vernans (Pink-necked Green Pigeon)	R			I	
RAILS & ALLIES *Amaurornis phoenicurus* (White-breasted Water-hen)	R			I	
Gallinula chloropus (Common Moorhen)	R			I	
Porphyrio porphyrio (Purple Swamphen)	M			I	
Porzana cinerea (White-browed Crake)	M			I	
Rallus striatus (Slaty-breasted Rail)	R			I	

(Contd.)

Table 34: Accounted bird species in 32 representative sampling plots and their legal protection status (Contd.)

Scientific name/ Vernacular name	M/R	Wildlife Enactment Sabah, 1997	Birdlife Int. Red Data Book, 2003	CITES, 2005 Appendix	IUCN Red List, 2006
RAPTORS *Accipiter gularis* (Japanese Sparrowhawk)	M			II	
Butastur indicus (Grey-faced Buzzard)	M			I	
Circus aeruginosus (Marsh harrier)	M			II	
Falco peregrinus (Peregrine Falcon)	M	P		I	
Haliaeetus leucogaster (White-bellied Sea-eagle)	R			I	
Haliastur indus (Brahimny Kite)	R	P		I	
Ichthyophaga humilis (Lesser Fish-Eagle)	M	P	NT	I	NT
Pandion haliaetus (Osprey)	M	P		I	
Pernis ptilorhynchus (Crested Honey-buzzard)	M	P		I	
Spilornis cheela (Grested Serpent Eagle)	R	P		I	
Spizaetus cirrhatus (Changeable Hawk Eagle)	R			I	
PHEASANT *Coturnix chinensis* (Chinese Painted Quail)	R	P		I	
SPARROWS & MUNIA *Amandava amandava* (Red Avadavat)	R			III	
STARLING & MYNAS *Aplonis panayensis* (Philippine Glossy Starling)	R			I	
Sturnus sinensis (White-shouldered Starling)	M			I	
Acridotheres cristatellus (Chinese Crested Myna)	R			I	
Acridotheres javanicus (White-vented Myna)	R			I	
SWALLOWS *Hirundapus giganteus* (Brown-backed Needletail)	M	P			

(Contd.)

Table 34: Accounted bird species in 32 representative sampling plots and their legal protection status (Contd.)

Scientific name/ Vernacular name	M/R	Wildlife Enactment Sabah, 1997	Birdlife Int. Red Data Book, 2003	CITES, 2005 Appendix	IUCN Red List, 2006
THRUSHES & RELATIVES *Copsychus saularis* (Magpie Robin)	R	P		I	
WADERS *Tringa nebularia* (Common Greenshank)	M			I	
WOODPECKERS *Picoides moluccensis* (Sunda Woodpecker)	R			I	

Notes: *(P) – Protected under Schedule 2, Part 1, Section 25(2) protected animals under Wildlife Conservation Enactment 1997, Sabah: (NT) - Near Threatened; (VU) – Vulnerable; (M) – Migratory, (R) – Resident*

CITES = Convention on International Trade in Endangered Species of Wild Flora and Fauna

Appendix I - species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances

Appendix II - species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival

Appendix III - contains species that are protected in at least one country, which asked other CITES Parties for assistance in controlling the trade.

Although the Wildlife Conservation Enactment 1997 calls for protection of birdlife in Sabah, the nominated species are not entirely listed in the species priority list of the Sabah Wildlife Department (SWD). This is due to the inconsistency of funding, and a lack of expertise and personells who are involved in the research of birdlife. Thus, research priority is focused on the more core or legalised natural areas like the "protected and conservation areas", with the consequence that the animal species that are given priority are species such as *Asian Two Horned Rhino, Asian Elephant, Tembadau, Orang-utan, Proboscis Monkey, Eustarine Crocodile, False-Gharial, Clouded Leopard, Sun Bear, all sea turtles* and *Dugongs*. The only green area in Kota Kinabalu which acts as a bird sanctuary at the moment is providing protection for birds is the Kota Kinabalu City Bird Sanctuary (KKCBS). The sanctuary with an area of 24 ha is situated, in close proximity to the Kota Kinabalu town. Nevertheless it has become an important habitat for some water birds as well as for wetland fish (KKCBS, 2005).

6.0 Public Perception of Urban Green in Kota Kinabalu

6.1 Demographic profile of survey respondents

The presented demographic data comprise gender, age, religion, education, and occupation. The majority of the respondents in both suburban and urban areas were female. In the town area, the ratio between female and male respondents are 52% female and 48% male, while for the village area, 59% were female and 41% were male.

Table 35: Ethnic background of respondents

Ethnic	Town Frequency	Town %	Village Frequency	Village %
Kadazandusun	62	30	149	66
Malay	47	22	48	21
Chinese	59	28	1	0.4
Indian	4	2	-	-
Others	38	18	28	12
Total	210	100	226	100

Note: Kadazandusun is the indigenous people of Sabah, mainly found on the west coast of Sabah

The ethnicity background of the respondents is predominately Kadazandusun with (30%) in town and (66%) in the village area (table 35). According to the monthly statistic bulletin of Sabah (July 2005) the population density of Kota Kinabalu is 1.173 per km² and the Kadazandusun form the biggest etnic community among others with a total of 519,800 in 2005.

Table 36: Religion background of respondents

Religion	Town Frequency	Town %	Village Frequency	Village %
Islam	85	41	70	31
Christian	76	36	156	69
Buddhist	41	20	-	-
Hindu	1	0.5	-	-
Others	7	3	-	-
Total	210	100	226	100

Note: Islam is the national religion, but the Malaysian Constitution guarantees freedom of worship

The religion of the respondents is predominately Islam with 41% in town, while Christian form the majority in the village areas with 69% (see table 36). The age of the respondents ranges from under 20 (but over 15) to over than 60 years, and is fairly similar across both areas. However compared to the town area, the percentage of younger people with (age < 20) and veteran people with (age > 60) is considerably higher (18% and 12% respectively), whereas young adults (age 20 – 29) are much more numerously represented in the city (46%, compared to 25%).

Table 37: Age group of respondents

	Town		Village	
Age group	Frequency	%	Frequency	%
<20	25	12	40	18
20-29	96	46	57	25
30-39	51	24	52	23
40-49	14	7	43	19
50-59	15	7	8	4
>60	9	4	26	12
Total	210	100	226	100

Also the state of education shows notable differences between both areas. In the town area about half of the interviewees were well educated people with diploma and degree qualification (23.3% and 32.9% respectively), while in the villages the lower educated people prevailed with 68% including 17% without any formal education. The highest education was degree with only a small number of 4%.

Table 38: Educational attainment of the respondents

	Town		Village		
Education level	Frequency	%	Frequency	%	
No formal education	-	-	39	17	
Primary school education	27	13	51	23	68
SRP/PMR*	25	12	64	28	
SPM/SPMV**	40	19	63	28	
STPM/Diploma	49	23	-	-	
Degree (BSc, MSc, PhD)	69	33	9	4	
Total	210	100	226	100	

**Lower secondary certificate,* ***Malaysia educational certificate*

Although the official occupation as administration or management employee is considerably higher in the city (22%, compared to 12% in the villages), the overall propotion of occupation there seems to be lower (44%, compared to 53%).

Private company and sales workers as well as businessman were better represented in the villages while people working in the agricultural sector were completely missing in the town. Unemployed people, part-time workers, housewifes, retired people and students constituted 57% of the urban respondents compared to 48% in the villages.

Table 39: Occupations of the respondents

Occupation category	**Town** Frequency	%		**Village** Frequency	%	
Administrative and managerial (includes: government servants; police, army and teachers)	46	22		26	12	
			44			
Private sectors and company	22	11		40	18	53
Businessmen and sales worker	22	11		33	15	
Agricultural (includes fishermen, selfworker, otherwise all farmers)	-	-		19	8	
Unemployed and part-time workers	40	19		36	16	
Others (includes housewives; retired and students).	80	38		72	32	
Total	210	100		226	100	

In town, most of the respondents earn an income of RM601 – RM1000 per month and university or college students are supported by money from their parents or scholarship from the government. People from the ‘administrative and managerial sectors’ mostly have higher incomes between RM1500 to RM2500. In contrast to this, the villages mostly earn a lower income between RM301 – RM600 per month.

Table 40: Income level of the respondents (RM/Month)*

	Town		Village	
Level of income	Frequency	%	Frequency	%
RM300 and below	-	-	-	-
RM301 – RM600	-	-	136	60.2
RM601- RM1000	145	69.0	51	22.6
RM1001 – RM1500	15	7.1	16	7.1
RM1501 – RM2000	20	9.5	23	10.2
RM2001 – RM2500	17	8.1	-	-
RM2501 – RM3000	9	4.3	-	-
RM3001 – RM4000	3	1.4	-	-
RM4001 and more	1	0.5	-	-
Total	210	100	226	100

**RM = Malaysian Ringgit (mean exchange rate in 2006: 1 Malaysian Ringgit (RM) = 0.22482 € (EUR))*

Only few respondents in the villages expressed that the young people did not like to stay in the village. Many of them get a job in the city and are living near their working places. Respondents working in the administrative and private sector expressed their reasons why they do not stay in their villages, complaining about the conditions in the village with unpaved roads, transportation problems, long distance from their working places etc. (e.g. Kokol, Kibambangan, and Kionsom). Even they have to pay high costs for renting an apartment; many people from the village choose to live closed to the town area.

6.2 Perception of urban green areas in the town zone

6.2.1 Importance and benefits of urban green areas

In this section respondents in the town area were asked about their knowledge and opinion about the importances and benefits of trees and forests to them and to the urban environment. The result indicates that most respondents strongly believed that the presence of trees or green spaces in town is very important. About 41% of them affirmed that trees help to reduce warmth and heat from the sunlight. In addition many respondents also expressed that due to the hot climate in Kota Kinabalu town, they felt that trees play a major role in providing shade and decrease the air temperature (usually on peak time in the afternoon, people tend to get shelter under the trees to shield them from the glare of hot sun).

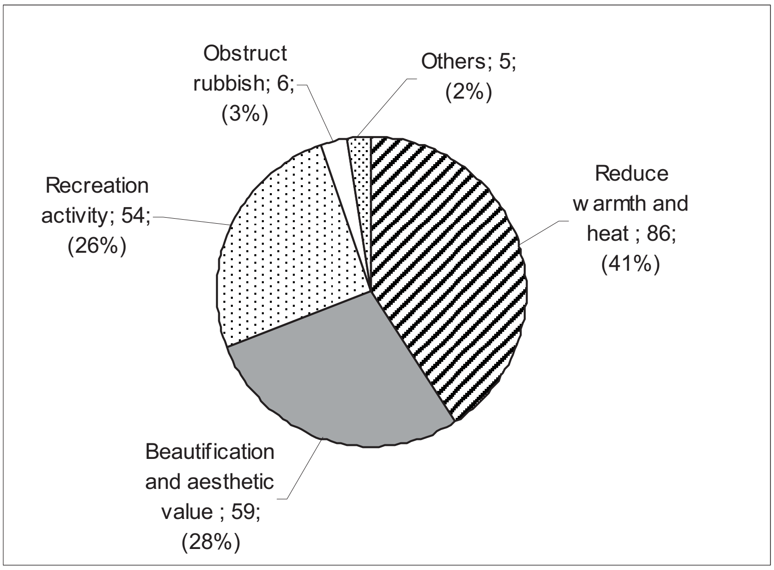


Figure 29: Major roles importances of trees and green spaces in town

Other important aspects of life which were named are beautification and aesthetic value (28%) and recreation (26%). Obstruction of rubbish (3%) and other environmental benefits like noise and dust reduction were only mentioned occationally (3% and 2%). Trees which form a good shape and flower yearly (like *Delonix regia, Cassia fistula,* *Tecoma stans* and *Pterocarpus indicus*) were preferred because they can add colour and natural beauty to the urban environment and soften the view of town architecture.

Table 41: Respondents perception on the benefits of trees in town

Tree benefits	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree
(i). The presence of trees in town is intensly valuable to me (directly or indirectly benefits)	25.2% (53)	66.7% (140)	2.9% (6)	4.3% (9)	1% (2)
(ii). When I feel bored or stressed, I will go to the parks or green areas to relese my mind	14.8% (31)	56.7% (119)	6.2% (13)	21% (44)	1.4% (3)
(iii). In my opinion, the presence of trees can provide habitat for wildlife to live such as birds, squarell and insects	24.8% (52)	62.9% (132)	11.9% (25)	0.5% (1)	-

The majority of the respondents stated that "the presence of trees in town is highly valuable to them" (66.7% agree and 25.2% strongly agree see table 41) and admits to visit the parks and green areas when feeling bored or stressed (56.7% agree and 14.8% strongly agree).

A very high number of respondents also acknowledged that trees or greens in the city can provide habitat for wildlifes e.g. birds, squarell and insects (62.9% agree and 24.8% strongly agree) see in table 41. These result show that the urban peoples of Kota Kinabalu are aware of and do appreciate the important benefit of trees to them.

6.2.2 Recreation activities for visiting urban green areas

The main activities practiced in green spaces or forests are shown in figure 30. Most visitors go there for *walking and sightseeing while admiring the scenery* (52%); *jogging, hiking and walking for sports* is the second common practices (36%); *picnicking and informal outdoor recreation activities* comes third (10%); *collecting plants and scientific purposes* were only rarely ever mentioned.

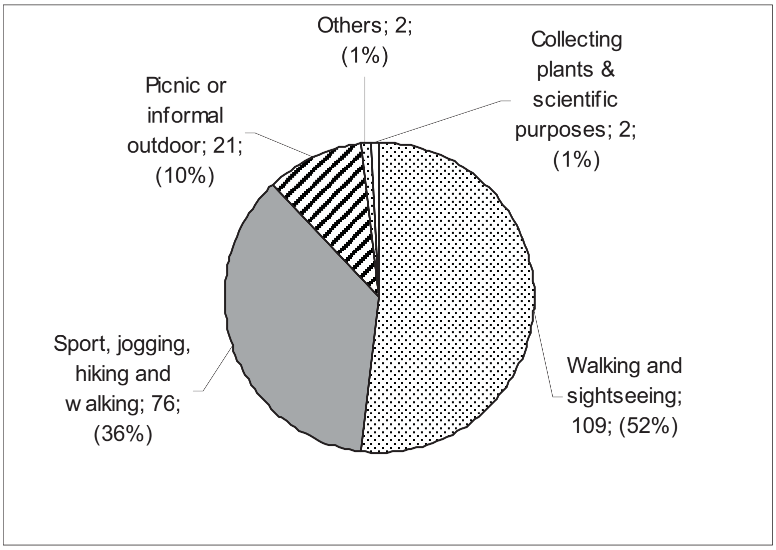


Figure 30: Town public reasons for visiting the green spaces or forests

When being asked what was the reason for walking, the interviewees answered that they were mainly "walking for fresh air, for peace and quietness for admiring the scenery and to forget the hustle bustle of the city". Some of them were also going with family, friends and lovers. Concerning sports, jogging, hiking and a sport walk, differences it was noticed that men and younger respondents tend to choose more active pursuits.

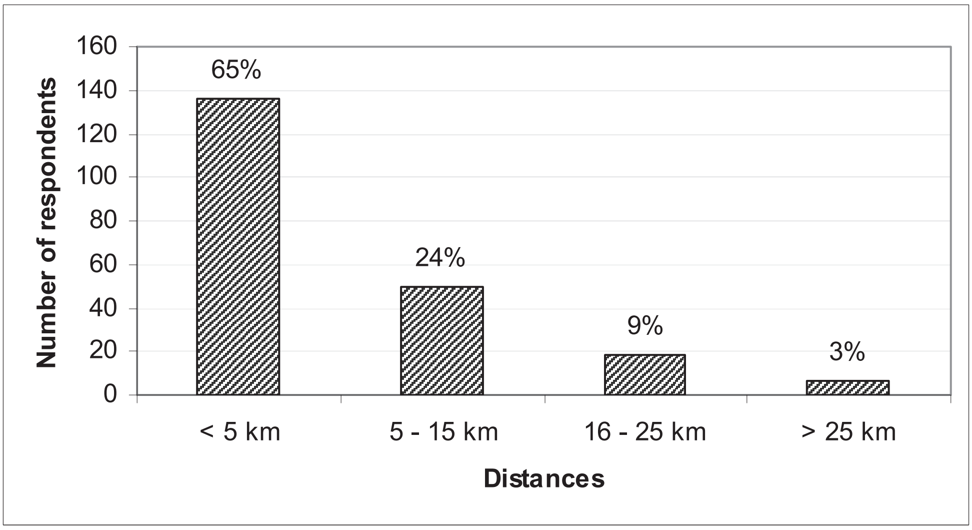


Figure 31: Distances (km) from homes to nearby green areas or parks in town

Most of the respondent's do not live very far from the green spaces or parks they visited, 65% lived less than 5 km away. These respondents also expressed that, they spend much time there during weekend and with their family members, friends and their loved one because of the short distances to their homes. 24% of the enquired visitors still had accepted a 5 – 15 km distance from their homes, whereas longer distance than that only rarely reported (12%).

6.2.3 The significance of conserving urban green areas

In this section, the urban interviewees were asked obout their perception and opinion concerning conservation issues (see table 42). An overall 90% of the respondents agreed or even strongly agreed that "*the townhall authorities should conserve all the green spaces in the area"*.Nobody did disagree, but 10% had no opinion. Nevertheless, only 16% of the enquired town people would be willing *to be involved in decision making in conservation of Kota Kinabalu*. More than half of respondents opposed to this (57%), while 11% had no opinion.

Table 42: Respondents perception and opinion towards conservation of green spaces

Conservation issues	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree
(i). In my opinion, the town hall planning authorities should conserve all the green spaces in my area	30% (62)	60% (126)	11% (22)	-	-
(ii). We are ready if we are given the oppurtinities to be involved in decision making of green conservation in Kota Kinabalu	1% (3)	15% (31)	21% (44)	57% (119)	6% (13)
(iii). In my opinion, an environmental awareness program and green campaign is necessary in my area	22% (47)	61% (129)	13% (28)	3% (6)	-
(iv). I think the people's of Kota Kinabalu have high awareness towards greenery and environment	8% (16)	36% (75)	35% (73)	21% (45)	1% (1)

About 84% agreed or strongly agreed that environmental awareness should be improved and a greening campaign would be necessary in their area, although the general awareness towards greenery and the environment was not really judged as bad. 43% agreed or strongly agreed that the peoples of Kota Kinabalu have a high awareness, but 35% had no opinion and 22% disagreed in this respect. This shows that the town community perception and awareness towards conservation issues is relevant but many of them do not want to be involved in decision making. They somehow agree with what ever the government will do as conservation effort.

6.2.4 The perception of tree management in Kota Kinabalu

Concerning tree management aspects, various questions were asked to know the respondents level of knowledge and satistification with the tree management in town. Historically, the tree management and maintenance activities organized and run by the Kota Kinabalu City Hall (DBKK) which in the mean time is known as Kota Kinabalu Municipal Council (MPKK).

The respondents were asked about different aspects of tree management, maintenance, safety, vandalisme, and satisfaction with the current tree management. The result shows that the respondents admitted that tree management in town is a necessity. With respect to tree species selection *choosing the right species for the right sites* (36%), *pruning from time to time to prevent hazards* (23%), *safeguard of old trees as heritage trees* (13%) *and control of insects, pests and diseases that might affect trees* (16%) as shown in figure 32.

The respondents were also asked to evaluate the trees maintainance program in town trees by judging whether are well maintained and if the workers who maintain them are experienced and skillful. An overall 60% the respondents evaluated the trees as well maintained and the workers as experienced and skilful, while 32% had no opinion and 3% disagreed.

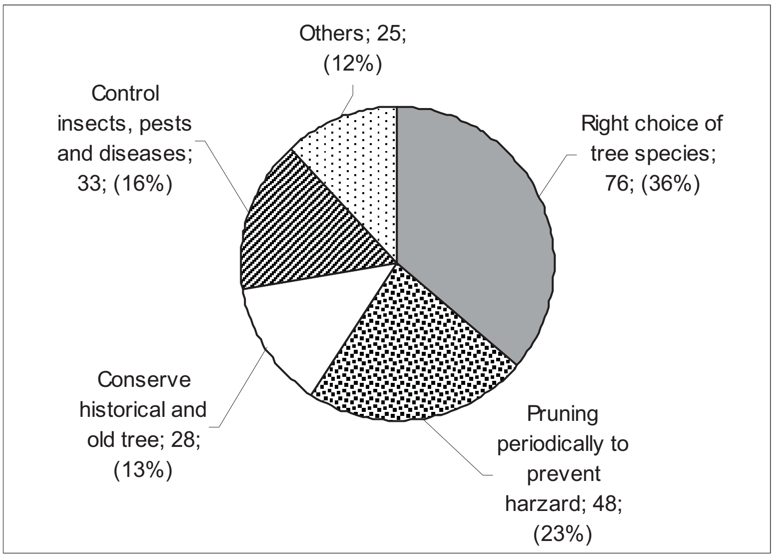


Figure 32: People's perceptions towards tree management in Kota Kinabalu

One of the official staff of DBKK, stated that most of his maintenance staff are long serving workers with 10 – 15 years of experience and that some of them had been sent to get training cources enhance their knowledge in tree maintenance (Jarapuddin Suin, 2004, pers.com).

The community members also agreed that *"tree hazard management or tree safety is necessary for the public safety*" with an overall quota of 89% agrees (table 43). The respondents also expressed that trees which might be danger on the public, e.g by hanging branches, cracks, low vitality tree, poisonous latex, or itchy aroma etc. should be marked by a signboard and description so that people would not touch approach them.

While most respondents did agrees that old trees town should be chopped and changed by new ones (56.7%), some people also stated that old trees could also be accepted as a heritage tree if they do not generate any danger (35%). Some of the respondents explicitly named old trees of Angsana *(Pterocarpus indicus)* and Rain Tree *(Samanea saman)* which were planted during the colonial times, to be safeguarded as heritage trees.

Table 43: Respondents perceptions and opinions on tree management in Kota Kinabalu

Tree management	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree
(i). In my opinion, trees are well maintained and people who maintain and mange the trees in town are experienced and skilfully	11% (24)	49% (102)	32% (67)	7% (14)	1% (3)
(ii). In my opinion, tree harzard management or tree safety is necessary for the public safety	24% (50)	65% (137)	4% (9)	7% (14)	-
(iii). In my opinion, old trees found in town should be cut and changed by new ones	16% (34)	41% (85)	8% (17)	33% (70)	2% (4)
(iv). In my opinion, most of the trees in town are not beautiful and effectuate dirtiness	-	35% (73)	12% (25)	48% (101)	5% (11)
(v). In my opinion, trees vandalism is caused by towns people (themselves)	7% (15)	43% (90)	25% (53)	24% (51)	1% (1)
(vi). Overall, I am satisfied with the current tree management activities in town	7% (14)	53% (111)	18% (37)	23% (48)	-

In contrast to this, more as a third of the respondents agreed that *"most of the trees in town are not beautiful and effectuate dirtiness"*. However, more than half opposed to this statement (53.3%) though on trees shed their leaves seasonably (e.g. *Pterocarpus indicus, Samanea saman and Pelthoporum pterocarpum*) and litter the roads. But most of these litters are cleaned by the Kota Kinabalu city hall.

Half of the respondents agreed that *"tree vandalisme is affected by town people in town themselves"*. Vandalisme is the activities of people trying to damage the tree by cutting, injurying or digging a hole inside the tree. The public also expressed that most vandalism occurs because of the people's bad attitude and a lack of appreciation of the benefits of trees. They also commented that vandalism on trees is usually done by younger people. As an overall result, people tend to be satisfied with the tree management and maintenance programme in town (60%) however, 23% are not and another 18% have no opinion in this respect.

6.3 Village zone: Perception of forest areas

6.3.1 Importance and benefits of the forests

Villagers do have other needs and views than town people concerning the importance and benefits of trees or forests to them. Asked about the important benefits of the forest, about 40% of the respondents stressed that the forest provides clean and fresh air, and another 39% says the forest provides clean water. Others rathers emphasized material benefits like food sources (14%), wooden forest products (5%), (figure 33).

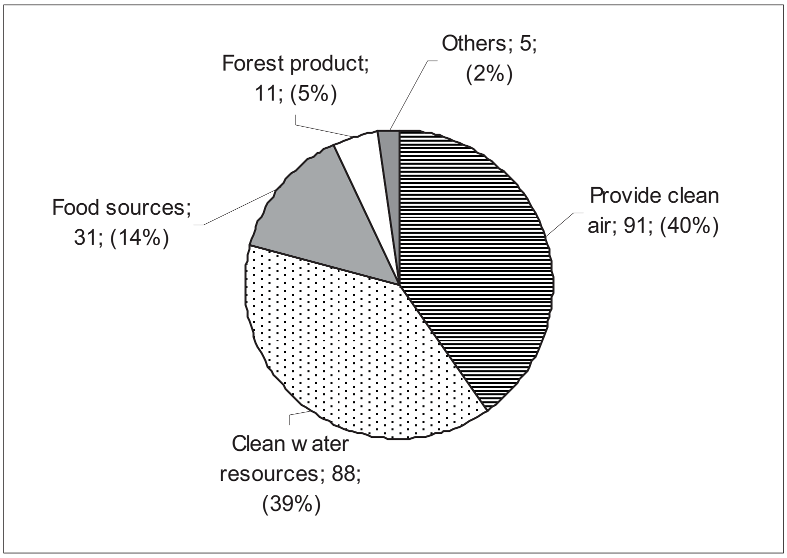


Figure 33: Village community opinion on the important forest resources in their area

Some of the respondents also expressed their transcendental appreciation like *"forests are where God exists"* or *"we love forests, it protects our health and well being of our children"* and others underlined that *"forests provide living soils* and are *"more than trees; namely a complex ecosystem, which is home to countless plants and animals'*.

6.3.2 Dependence upon forest resources

About 58.8% of the respondents stated they are dependent on the forest in their daily life, while 41.2% were not (table 44). Usually older people in the village had better knowledge about the uses of forest resources and many of them have been using these products for a long time, especially as medicinal goods.

According to one respondent who is a traditional medic man (*Dukun*) he uses the tree leaves, fruits, bark and roots for medicine and aromatherapy. The list of traditional medicine used by the village people is listed in the appendix 15. In contrast to this the younger members of the village community usually did not have any knowledge about traditional medicine. Some of them expressed that they are not interested in traditional medicine anymore because of the modern and sophisticated medicine available in the hospitals.

When asked about subsidies, support or help from the government to increase the socio-economic situation of the people in the village, 80% of the respondents stated they did not receive anything. Some of them expressed their dissatisfaction not to have received any aid from the government. Others respond that support only comes in the wake of a political campaigns.

Table 44: Village people dependent upon forest resources in their daily life

Forest resources	Yes	No opinion	No
(i). I depend on the forest resources in my daily life especially for food sources and medicines	59% (133)	-	41% (93)
(ii). I have ever received a kind of subsidy from the government to upgrade my socio-economic status in my area e.g. tree seedling, crop seed, paddy seed, vegetables stock, and etc.	20% (45)	-	80% (181)

Asked about the knowledge and use of non wood forest products (NWFP), most respondents stated that they did use some to upgrade their living (figure 34). About 50% of the respondents used products such as fruit trees, rubber, rattan and dammar, while 32% used plants for medicinal purpose. 12% took poles, tannins and charcoal, 4% sago, and 1% hunted wildlife.

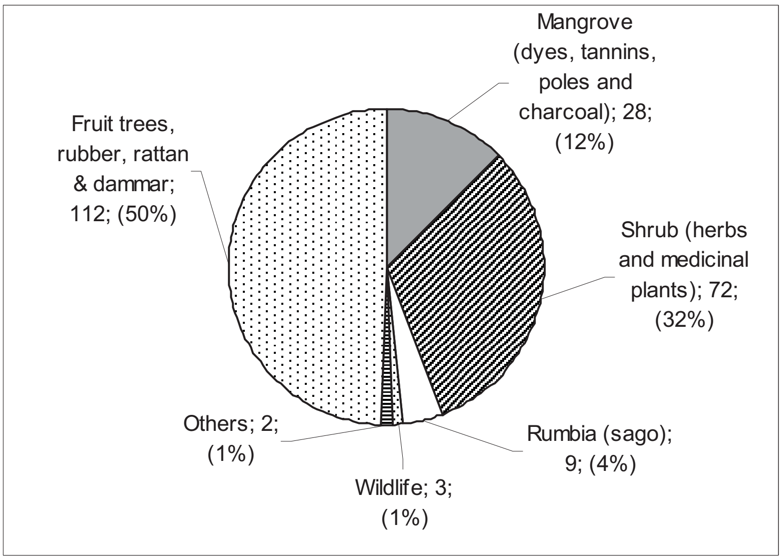


Figure 34: Type of forest resources and non wood forest products (NWFP) used by the villager

The respondents also expressed that they take wild fruit to sell them in the 'tamus'[3] and gain income. Other saleable products are such as *Garcinia hombroniana* (Akob-akob), *Bambusa sp*. (Bamboo tuber), *Parkia pinnata* (Petai-petai) etc. The important forest resources and their uses are listed in the appendix 15.

6.3.3 Perception and opinion towards conservation

In this section, respondents were asked obout their levels of interest in forests and their conservation awareness (table 45). Most of the respondents in the village have never participated in any seminar related to forestry or environment (85%). According to one of the respondents, seminars on forestry and environment are only given in towns but not in village areas. Due to this many people are not aware of forest related issues. Others said that if there was a seminar in their village, the Village Development and Security Committee (JKKK) or the Head of the village (Ketua Kampong) would not inform them in advance and only a selection of people would be chosen to attend the seminar.

[3] *"Tamus"* are a periodic local open trade fairs. These are spontaneous hustle of marketing activities as natives gather to buy and sell or barter their farm produce, handicrafts, traditional medicine, traditional ware, cultural instruments and food items.

Table 45: Village people's perceptions towards participation and decision making

Participation-decision making	Yes	No opinion	No
(i). I have ever participated in seminars or talks related to forestry, conservation or environmental awareness in any places before	14% (32)	0.4% (1)	85% (193)
(ii). If I had a chance I would be willing to participate in seminar related to forestry, conservation and environmental awareness (by the any agencies)	73% (164)	2% (5)	25% (57)
(iii). I agree if the forests or green spaces in my area will be protect or conserved by the government with our help	82% (185)	4% (9)	14% (32)

When asked about their interest and willingness to participate in any seminar related to forestry, 73% of the respondents expressed, their interest, while 25% were unwilling and not ready. Most of the unwilling respondents gave excuses for not participating because of many reasons: "*we are too old and it does not matter whether we participate or not", "I do not have any knowledge with that topic"* or *"we are poor people and we will need to dress well in such a seminar, so we are not prepared to participate"*. Most of the elder villagers with an age of more than 60 years were unwilling to join any seminar.

However, about 82% of the respondents agreed with protection and conservation of forest. Some of them even expressed their interest in helping the government, stating that "*if the government can provide us with some land to take care of and control, we surely would help"*. Overall, only few respondents indicated no opinion about forest issues, while the majorities were very interested. The analysis also revealed that female respondents showed substantially higher interest in forest issues than male.

6.3.4 Wildlife species found in the forest

Wildlife species that are usually spotted or observed in the forest, were snakes and monitor lizards named by (37%) of the respondents, mouse deer and barking deer (26%), birds and squirrels (15%), and monkey and wildboars (10%) shown in figure 35.

These wildlife species are usually not used for food sometimes because of religious purposes even though they could be eaten.

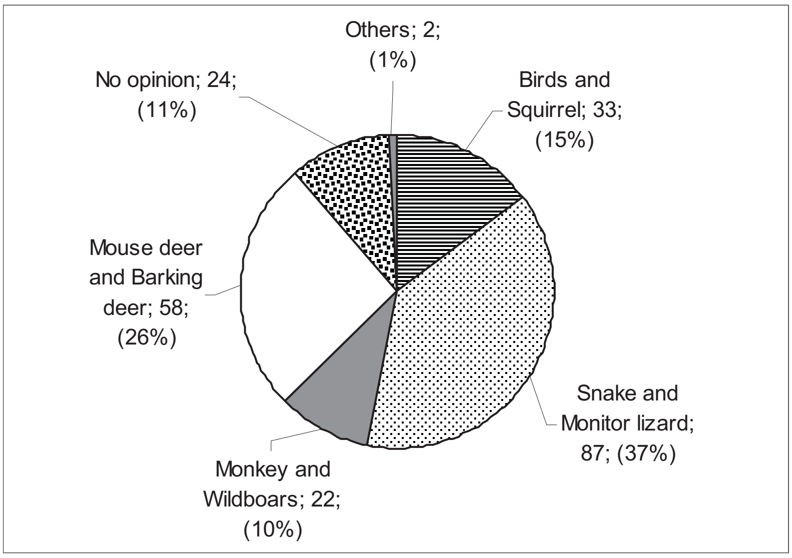


Figure 35: Village community opinion on the presence of wildlife species found in their area

6.3.5 Interesting nature resources in the villages

The interviewees further indicated six items which are interesting and could be promoted for tourism activities namely: scenic views (39%), waterfalls (31%), birds (23%), wildlife (2%), flowers (1%) and, big trees (1%) (figure 36). Table 46 shows a summary of attractions nature resources that can be found in the villages in Kota Kinabalu district.

The results indicate that village community members strongly feel that the forest near their places has a potential value for tourism in the future. Other respondents realized that in order to upgrade the socio-economic living of people in the village, they could form a committee and offer some tourism benefits like homestay programme, or exploring the forest area where many of them would know the forest trails. Others also expressed their willingness to join any course related to tourism to enhance their knowledge.

Table 46: Summary of interesting nature resources found in each village

Village name	Potential attractions
Kg. Kionsom *(GPS: 05º 58' 30.6" N and 116º 12' 01.8" E)*	a) Scenic View b) Waterfall & River c) Birds
Kg. Kokol *(GPS: 05º 59' 37.3" N and 116º 14' 02.4" E)*	a) Scenic View b) Waterfall & River c) Bird d) Big tree
Kg. Lokob *(GPS: 06º 04' 04.9" N and 116º 08' 32.3" E)*	a) Bird b) Wildlife c) Mangrove
Kg. Rampayan *(GPS: 06º 02' 02.9" N and 116º 08' 22.9" E)*	a) Wildlife b) Bird c) Mangrove
Kg. Kironggo *(GPS: 05º 58'10" N and 116º 08' 57.5" E)*	a) Big tree b) Birds c) Scenic View
Kg. Babagon *(GPS: 05º 54' 33.7" N and 116º 10' 24.2" E)*	a) Waterfall & River b) ScenicView c) Traditional Houses
Kg. Kibambangan *(GPS: 05º 59' 20.3" N and 116º 04' 49.6" E)*	a) Scenic View b) Big tree & Flower c) Waterfall & River d) Wildlife

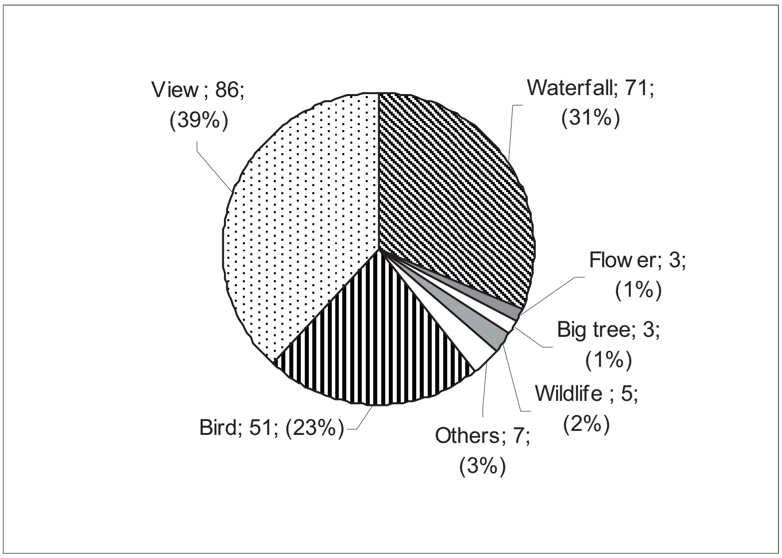


Figure 36: Interesting nature resources derived from the forest based on people's opinion in their places (recreation resources)

6.3.6 Problems given by the forest in the villages

When asked for problems given by the forest, many respondents indicated that the forest can be a place for mosquitos' breeding area with (43%). Forests are also often belived to be haunted, and a place where spirits live (38%). Furthermore they are considered as a place for crime and drug turnover (6%), a place where dangerous animals live (6%), including wasps (1%) as well as a waste area (3%) as shown in figure 37.

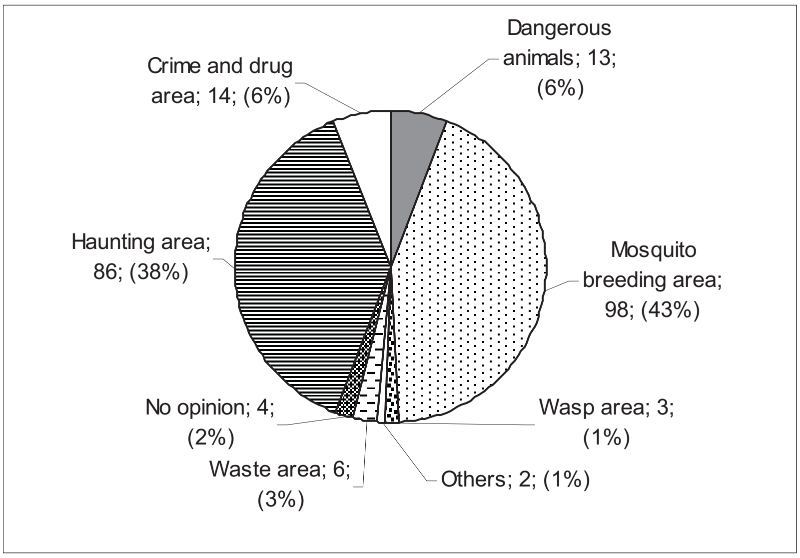


Figure 37: Village people perception of the problems stemming from the forest area

Contrariwise, the respondents were also asked what their opinion concerning the problems that threatens the forest today. 38% of the villagers stated that landuse practices and expansion are the main threat. Landuse expansion occurs, where people open a new area for farming, pasturing, settlement and shifting cultivation, even though they know that the area does not belong to them.

As the second problem, faced by the forest river pollution was mentioned, as it happens when forest land has been chopped and the rain washes the silt or clay from the uncovered soil into the rivers, thus directly polluting them. People in the village then need to filter their water to get clean and safe drinking water.

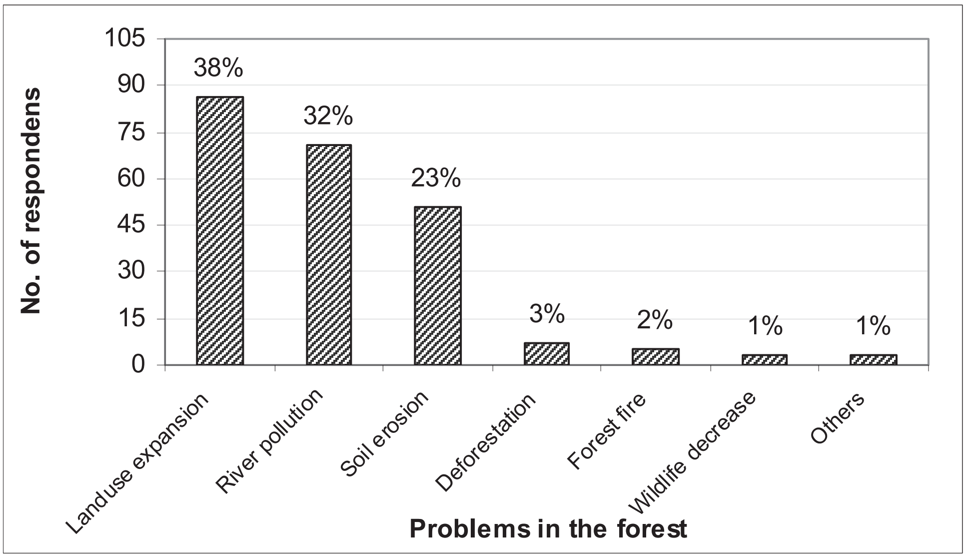


Figure 38: Village people perception of present threats faced by the forest

The third problem was soil erosion (23%). Many of the villages are located at the hilly area, where the cutting of trees easily affects the soil, especially during raining times. Land slides occur in many places. The good soil is washed away, leaving unfertile subsoils. Further hazards that were mentioned included deforestation (3%), forest fires (2%), decreasing wildlife (1%) and others (1%) as shown in figure 38.

6.4 Obvious differences between town and village people perceptions

The investigation showed some interesting difference between the town people and the village people. Two (2) different aspects can be mentioned namely, demographic characteristics and town-village peoples perceptions.

Regarding the demographic characteristics, most of the respondents in both towns and villages in Kota Kinabalu are Kadazandusun. The sub-urban population however also includes: Telipok, Manggatal, Penampang and Putatan which are mainly the 'shelter' or 'rest area' in the native Kadazandusun people. Although Kota Kinabalu is often mentioned as a stronghold of the Kadazandusun communities, the Chinese can be considered majority in town areas. In provisions of age groups, most of respondents in the town areas were categorized as young adults (age from 20-29) and were much more numerously represented in the cities than in the village areas. Most of the respondents in town also have a good education with higher qualification (diploma and degree) compared to the village areas, in which some are still without formal education. Administration or management employees are considerably more numerous in the town compared to the villages, while people working in agricultural sectors (includes fishermen, selfworker and farmers) are completely missing in the town. Most of the respondents in town areas also earn an income above RM600 per month, while in the villages the majority of the respondents get below RM600.

It can also be pronounce that the peoples in the town areas are mostly better in socio-economic conditions compared to the people living in villages (or sub-urban areas) where much of them are poor. Nevertheless, some people from the village areas do also migrate to the town because of the better opportunities for educations, occupations, and infrastructure benefits.

Concerning the people's perception of the importance and benefits of forest and green areas, most of the respondents in town affirm that trees helps to reduce warmth and heat from the sunlight. People living in villages, opined that forests provide fresh air and clean water resources for their daily use. Because of the sparsely dense vegetation and more intensive urbanization, the heat is obviously more perceived in town. The traffic there also leads to produce more unwanted environmental gases i.e. sulphur dioxide (SO_2) which is released from the vehicles and industrials and leads to climate changes. On the other hand, town peoples also agreed that the presence of trees in town provides beautification and aesthetic upgrade as well as recreation opportunities during leisure time.

Related to conservation and protection issues, the town peoples agreed that the government should conserve the green and forest areas. Moreover, they opined that environmental awareness programs and green campaigns should be stressed, especially to the youngest and in schools. Concerning decision-making processes, the town respondents mostly opined that they were not ready to be involved. They withdrew everything related to conservation and protection issues to the government decision. The village peoples, also agreed that the government or other environment bodies should have the responsibility to protect or conserve the forest areas. However, they also agreed and explained their interest if to be involved in helping the government to conserve or protect the forest close to their village.

With respect to management aspects, the town respondents seemed to be satisfied with the current tree management activities (beautifications, preserving old trees and enrichment plantings) and they also stated that the "right choice of tree species" in town is necessary, concerning the governmental effort to plant more trees in town.

The village communities opined that they depended on the forest resources in their daily life, by taking fruit trees, rubber, rattan and dammar from the forests nearby them. With the surplus, some of these products are also sold in the open market to gain more income. Others mentioned herbs and medicinal plants to be of high priority. Apart from providing clean water, the forest provides beautiful views, waterfalls for recreation purposes to them, and enhances the fauna in their area (i.e. birds, squirrels and etc.). In contrast to the town people, the villages also opined that problems stemming from the forest included mosquitos and spirits lives. The people's perception of the present threats faced by the forest, encompassed land use expansions as the most threats followed by river pollution and soil erosion respectively.

The overall differences between town and village peoples perception, can be explained by different dependence upon forest resources. Nevertheless both agreed that conservation and protection of the forest is a priority.

7.0 Classification of Urban Forest and Green Spaces Functions

The success of biodiversity conservation in protected or unprotected areas will depend upon how well these individual areas are integrated into the wider landscape context. By proper planning at the landscape level, natural or managed areas may be suitably integrated into the cultural landscape in order to reconcile human activities with the goals of biodiversity conservation. In order to best integrate the multiplicity of objectives within these areas, and to properly manage and coordinate multi-use areas for the benefit of all interests and land managers need effective planning tools.

Landscape ecology is the study of environmental factors and interactions at a scale that encompasses more than one ecosystem at a time. Because landscape ecology helps to understand how different parts of the landscape mosaic are formed and how they interact, it may also provide a basis for the effective management of green spaces within urbanised areas. Landscape planning provides an approach for the integration of ecological, environmental and conservation aspects into urban and suburban landuse in order to minimize negative impacts and consequences like habitat fragmentation and to confer the beneficial aspects of biodiversity to urban-ecosystems (Gliessman, 1999).

The tools commonly used in landscape planning are land use and mapping, either purely terrestrial or - where available - by using aerial photography, satellite images and geographical information system analysis. Such tools provide a means through which historical, current and proposed landscape features and land-use activities may be contrasted to specific conservation goals.

With this information, recommendations for changes in land-use practices and agriculture-ecosystem design may be made. Impact to critical habitats and sensitive areas may be mitigated or minimized and greater coherence between urban habitats and the surrounding landscape may be made (Smeding, 2000). Such management tools may also serve in monitoring the effects of specific land-use practices in order to gauge the effectiveness of interventions.

Landscape ecology and planning may be used at various scales. At a larger scale of analysis, landscape planning may be used to determine the most appropriated placement of agriculture and other land-use activities when attempting to reconcile human livelihoods and habitat needs for biodiversity conservation. By looking at individual green areas, key ecological features (e.g. plant associations/vegetation patterns) may be identified to determine appropriate urbanized habitat restoration efforts that may best serve to re-establish continuity of habitat types and thereby reduce habitat fragmentation. If such ecological features are managed successfully and with consideration of contiguous green areas and natural surroundings, the landscape will remain compatible with the needs of a larger number of plants and animals. Nevertheless, the principles of landscape features as mention above should be taken into consideration, in order to classify important urban forest and green spaces functions. These features will be described in the following paragraphs, before the forest functions classification process is explained.

7.1 Landform and Soil Classification

The soils of Sabah as described in the reconnaissance soil survey reports provided by the Sabah Agriculture Department (1975) are based on a culmination of nearly two decades of regional soil survey projects. The soil data and information from the inventory were correlated and compiled to a standardised soil map of Sabah. During the correlation activities, the diagnostic characteristics and properties of the soils, which were recognised and recorded in the field, were redefined and standardised based on Food and Agriculture Organisation (FAO) guidelines. The soil mapping units defined as a total of 51 soil associations served as the baseline for producing the soil map of Sabah at a scale of 1:250,000. Their designation is based on the following themes: parent materials of the soils, landforms and the existence of dominant *Soil Types* (refer to appendix 24 – 26).

The parent materials of the soils found in Sabah consist of coralline limestone, beach deposits and alluvium (recent, subrecent and old); sedimentary rocks (shales, mudstone and sandstone); igneous rocks (intermediate, basic and ultrabasic); and volcanic rocks. Parent material basically and distinctly determine both, physical as well as the chemical characteristics and properties of the soils. Details of parent materials in Sabah are shown in table 47.

Table 47: Main Parent Materials of Soils in Sabah *(Source: Agriculture Department Sabah (1976), further forwarded by ICZM (1999))*

GROUP		SOIL DISTRIBUTION/CHARACTERISTICS
1.	Alluvium	*Alluvium is soil or sediments deposited by a river or other running water. Soils that derived from recent alluvium and on flat land (e.g. the Tuaran, Kinabatangan associations) are more fertile than sub-recent and older alluvium (e.g. the Sook, Brantian and Kepayan associations) which is developed on terraces.*
2.	Sandstone / Mudstone	*Sandstone/mudstone is a sedimentary rock composed mainly of sand-size mineral or rock grains. Most sandstone is composed of quartz and/or feldspar because these are the most common minerals in earth's crust. Soils derived from sandstone/mudstone are the most extensive in Sabah but vary widely in fertility (e.g. the Lungmanis, Silabukan and Kalabakan association have a higher nutrient status than the Dalit, Lokan, Crocker and Maliau associations).*
3.	Limestone	*Limestone is a sedimentary rock composed largely of the mineral calcite (calcium carbonate: $CaCO_3$). Soil associations on limestone are limited in extent in Sabah (e.g. the Semporna and Gomantong associations) and are generally shallow and well drained.*
4.	Acid igneous rocks	*Igneous rocks are formed when molten rock (magma) cools and solidifies. Limited to the summit zone of Mount Kinabalu and a few lower areas in the upper Sugut drainage. Unsuitable for agriculture.*
5.	Intermediate igneous	*Also form from molten rock (magma) and are separated on the basis of the type of feldspar present. These rocks occur in the Tawau and Lahad Datu areas. The soils are unsuitable for agriculture.*
6.	Basic igneous	*Extensive in distribution with soils of variable characteristics and fertility. Includes steep mountains (e.g. Mentapok association) and lava flows (e.g. Table association at Tawau).*
7.	Ultrabasic	*Ultramafic (or ultrabasic) rocks are igneous rocks with very low silica content (less than 45%), generally >18% MgO, high FeO, low potassium and are composed of usually greater than 90% mafic minerals (dark colored, high magnesium and iron content). Scattered through northern, central and south-eastern Sabah. Soils are rich in metals, with relatively low silica content, and unsuitable for agriculture.*

Landforms have been broadly defined as being residual or depositional and expressed in terms of relief, form and areas extend. Relief includes both, absolute altitude above sea level and relative relief which is the difference in altitude between valley bottom and hill crest.

Table 48: Terrain Classes based from amplitude *(Source: Sabah ICZM, 1998)*

Terrain Classes	**Examples of Soil Associations**	**Amplitude (meters)**
Very low hills	Lungmanis, Semporna	0-15
Low hills	Silabukan, Rumidi, Sipit	15-30
Moderate hills	Kalabakan, Kretam, Tengah Nipah, Dalit, Dagat, Apas	60-150
High Hills	Kennedy Bay, Beruang	150-300
Very high hills	Gomanting, Lokan, Bang	300-600
Mountains	Bidu-bidu, Mentapok, Meliau, Crocker	>600

Note: Depositional landforms include terraces, plateaus, floodplains, swamps and beaches.

Residual landforms include mountains and hills. Mountains are characterised by an absolute elevation greater than 300 m and by steep or very steep slopes with an inclination greater than 25°. Hills have an absolute elevation of less than 300 m and their main groups are differentiated in terms of relative relief and slopes. Steep hills are hills of high relief and steep slopes; moderate hills are hills of moderate relief and moderate slopes, and low hills are hills with low relief and gentle slopes. The amplitudes of the sloping are defined in table 48, and presented in figure 39.

The basic soil maps showing the nature, location and extent of the soils are grouped in soil associations. These soil associations form the basis for the soil resource maps which reflect an interpretation with regard to agricultural crop performance. The present groupings of soils to show their suitability for agricultural use is based on the limitations assumed by various soil characteristics such as drainage, nutrient status, topography, soil depth, peat depth and texture. This soil map also directly important features as it been considered in the catalogs of critera and indicators in chapter 7.5.3.

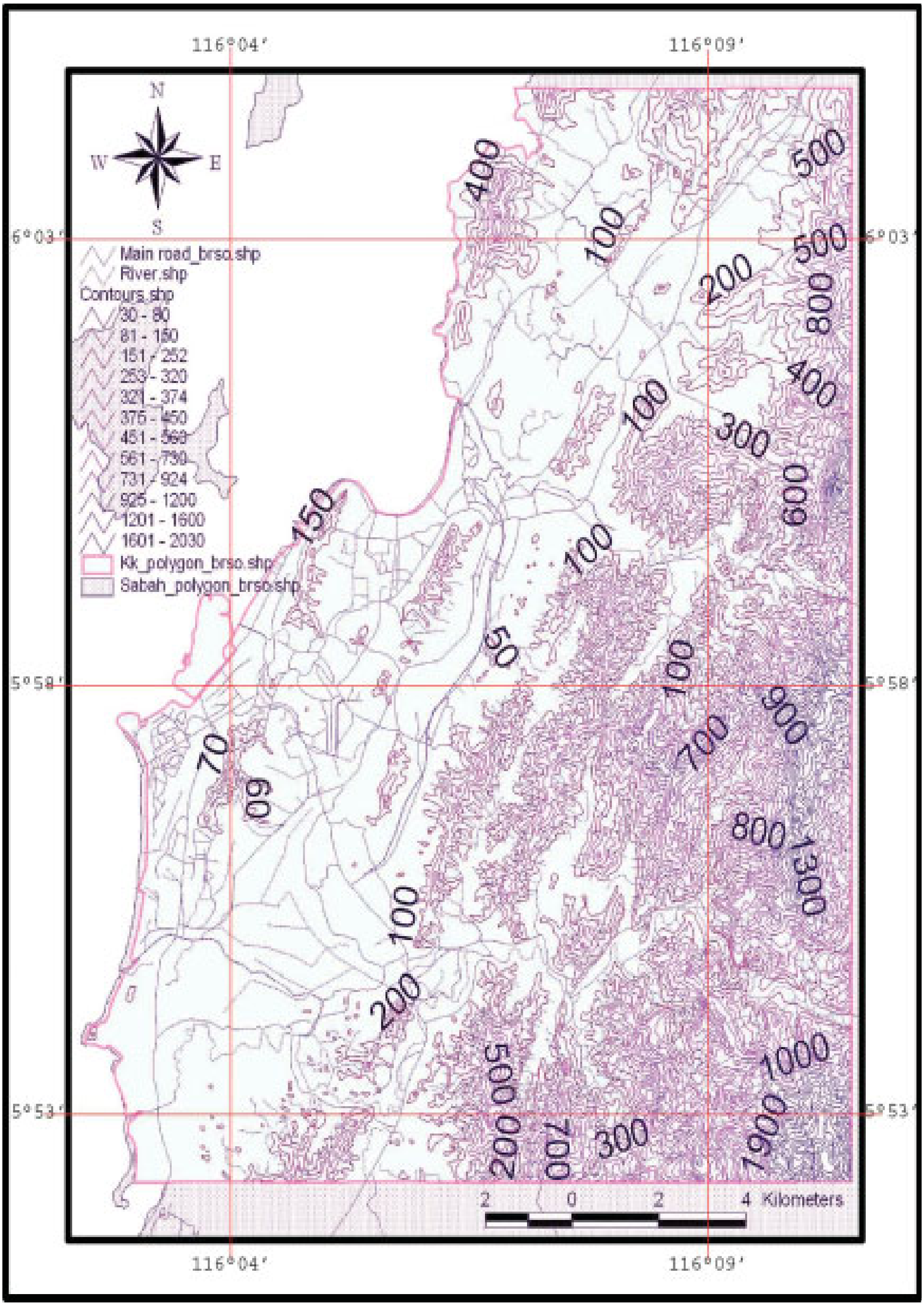


Figure 39: Characteristics of terrain classes in Kota Kinabalu (scale 1: 50,000)
(Source: Own presentation)

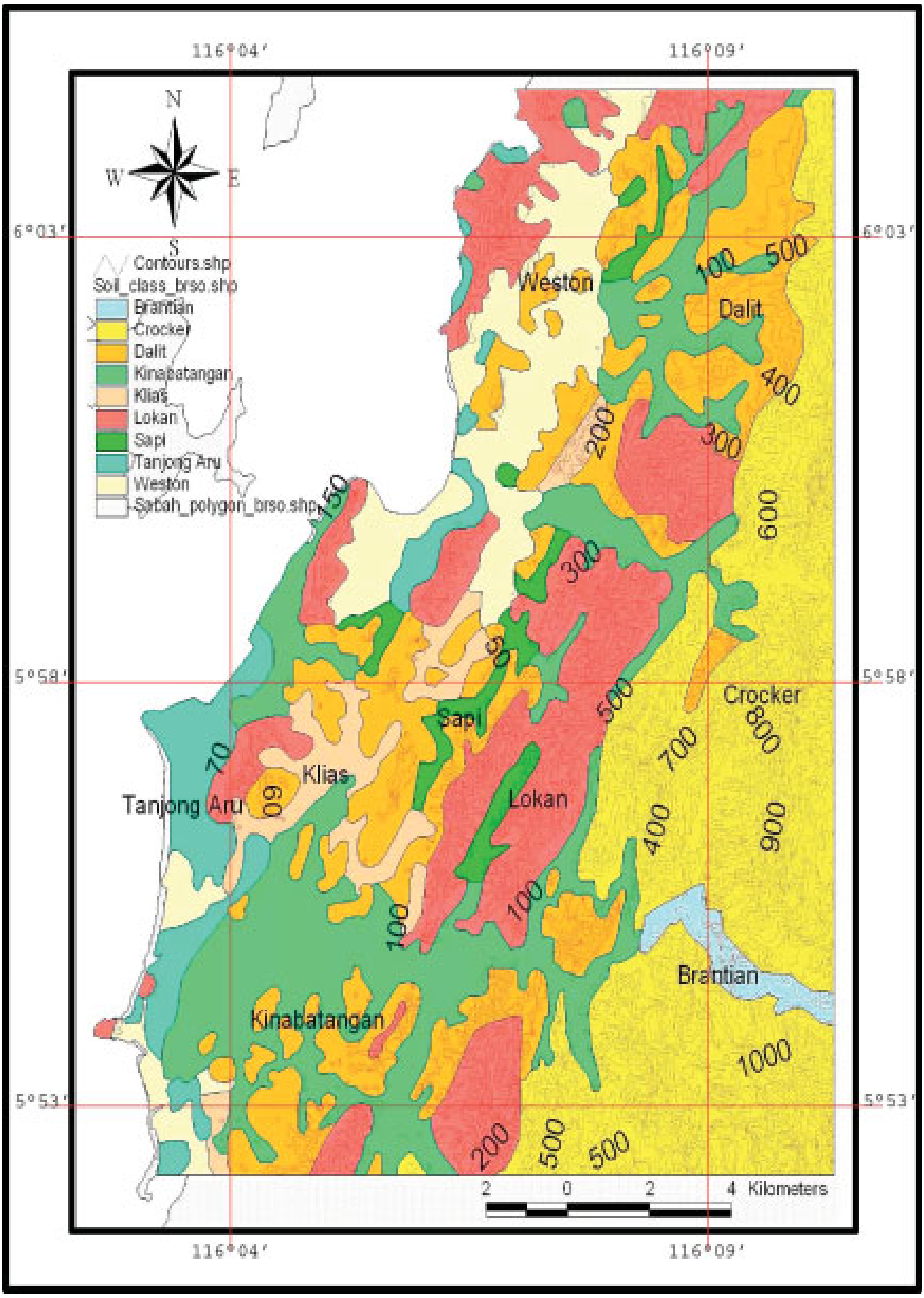
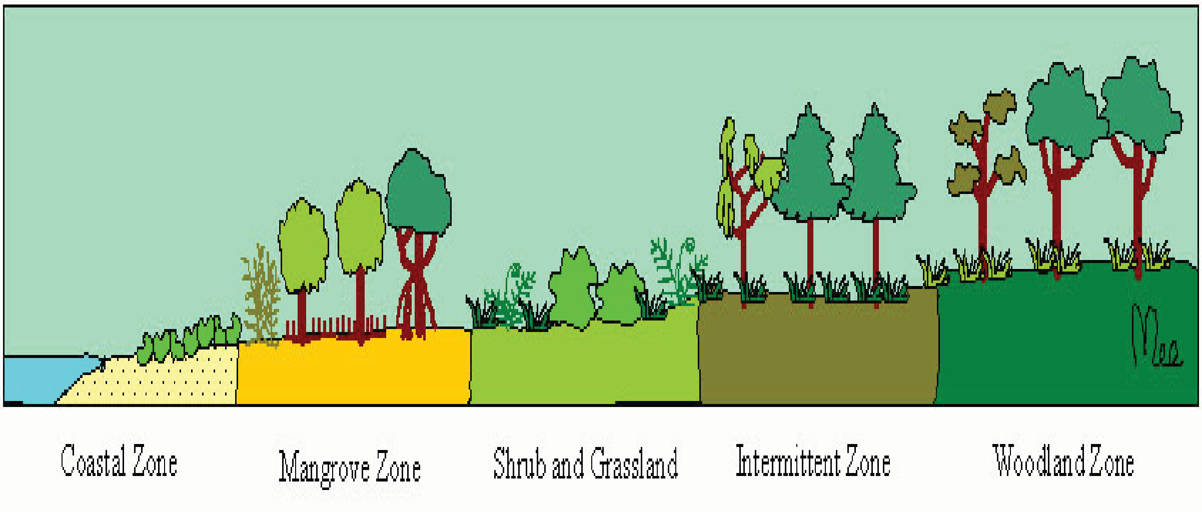


Figure 40: Soil association classes in Kota Kinabalu (scale 1:50,000)
(Source: adapted and modified from Agriculture Department Sabah (1976))

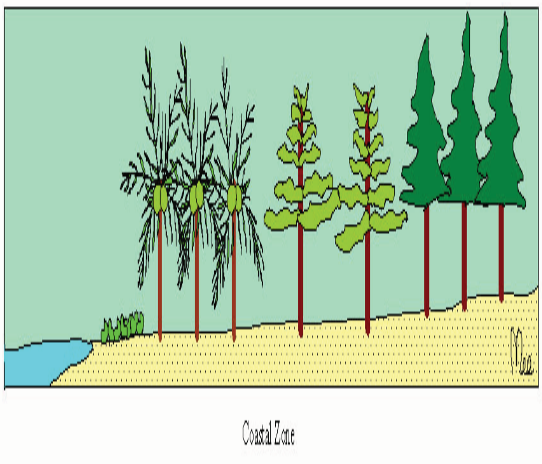
7.2 Vegetation Zones

As a result from the survey in the investigated plot areas and ground experience, the occurrence of the common tree species in Kota Kinabalu can be classified by altitude, leading to five main zones: coastal zone (<5 m asl), mangrove zone (5–15 m asl), scrub and grassland zone (15–30 m asl), intermittent zone (30–60 m asl), and woodland zone (>60 m asl). Figure 41 shows these different vegetation zones by their different altitude level and the common tree species.



<u>Vegetation Classification (Overall Profile)</u>

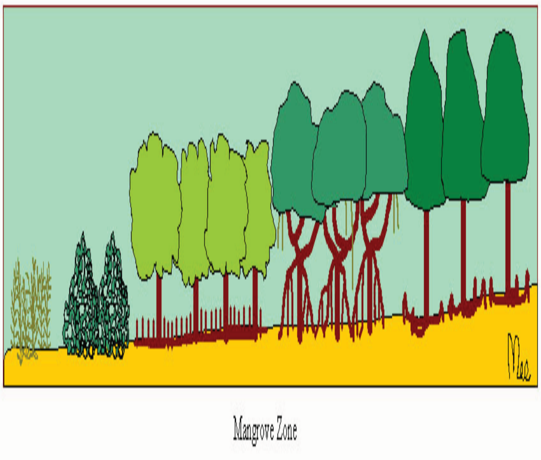
a) Coastal Zone Profile (< 5 m asl)



Common species	**Local name**
Ipomoea sp	Seri Pagi
Pandanus odoratissimus	Mengkuang
Cocos nucifera	Kelapa
Cerbera odollam	Pong-pong
Casuarina equisetifolia	Ruh Pantai
Terminalia cattapa	Ketapang
Hibiscus tiliaceus	Bebaru
Leucaena leucocephala	Petai Belalang

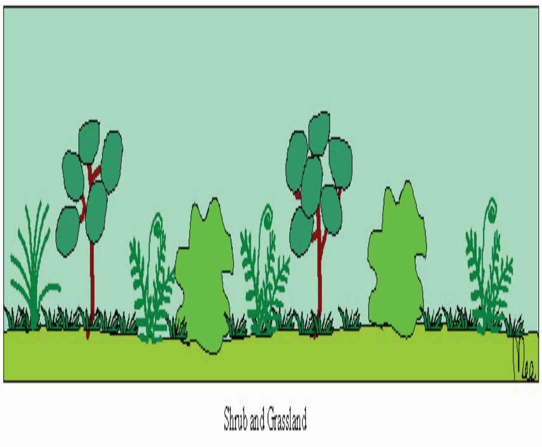
Figure 41: Vegetation Classification of Kota Kinabalu (Contd.)
(Source: Own presentation)

b). Mangroves Zone Profile (5 – 15 m asl)



Common species	**Local name**
Acrostichum sp	Piairaya
Avicennia sp	Api-api
Nypa fruticans	Nipah
Lumnitzera racemosa	Teruntum Putih
Lumnitzera littorea	Teruntum Merah
Bruguiera parviflora	Lenggadai
Rhizophora apiculata	Bakau Minyak
Rhizophora mucronata	Bakau Kurap

c) Scrub and Grassland Zone Profile (15 – 30 m asl)



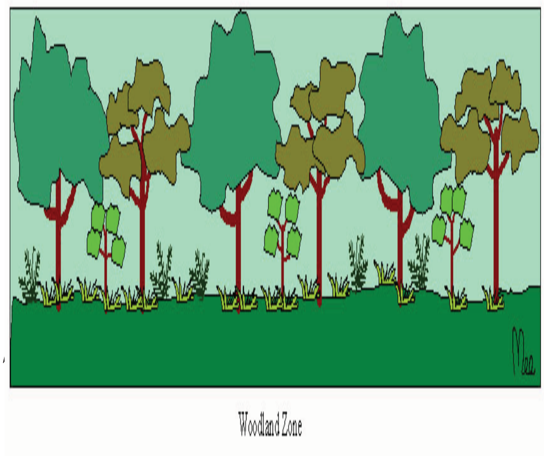
Common species	**Local name**
Mimosa pudica	Rumput Semalu
Melastoma malabathricum	Senduduk
Cledimia hirta	Senduduk Umang
Imperata cylindrica	Rumput Lalang
Dryoptheris thelypteris	Paku Pakis
Chrysopogon aciculatus	Rumput Sundal
Desmos chinensis	Pisang Monyet
Similax mavrophylla	Kalam Udang
Bambusa sp	Bambu

d) Intermittent Zone Profile (30 – 60 m asl)

Common species	**Local name**
Acacia mangium/ auriculiformis	Akasia
Dillenia suffroticosa	Simpoh
Eugenia sp	Jambu-jambu
Ficus sp	Ara
Vitex pebescens	Kulimpapa
Gluta sp	Renghas
Callophylum sp	Bintangor
Macaranga triloba	Mahang/ Sedaman

Figure 41: Vegetation Classification of Kota Kinabalu (Contd.)
(Source: Own presentation)

e) Woodland Zone Profile (> 60 m asl)



Common species	Local name
Hevea brasiliensis	Getah
Alstonia macrophylla	Pulai Besar
Alstonia angustiloba	Pulai Bukit
Canarium sp	Kedondong
Dipterocarpus sp	Keruing
Garcinia sp	Manggis Hutan
Sindora beccariana	Sepetir
Shorea parvifolia	Meranti Punai
Mangifera caesia/ panjang	Beluno/ Bambangan
Koompasia sp	Manggaris

Figure 41: Vegetation Classification of Kota Kinabalu
(Source: Own presentation)

Kota Kinabalu`s general vegetation pattern may be described as a sequence from coastal beach and mangrove to lowland forest, hill forest and eventually old rubber plantations in the mountainous areas.

The coastal vegetation zone (454 ha) occurs the greater part along of Kota Kinabalu's coastline as well as on some of the offshore islands. However, it is depleting due to the rapid coastal development schemes. Mangrove Forests (1,251 hectares) concentrate mostly on the north and south-west coast of Kota Kinabalu district. They are important for the physical protection of the coastline and act as nurseries for the early stages of fish and prawn. Species identification from 1:50,000 scale aerial photographs is only possible in few cases, mainly in the mangrove forests. Mangrove species often occurre in pure stands of Bakau (*Rhizophora mucronata*) and Bangkita (*Rhizophora apiculata*) in which can be easily recognised from aerial photos.

Others zones, indicated as scrub-grassland to sporadic transitional woodland zones, are found in the more elevated areas, where prominent tree species include *Hevea brasiliensis, Alstonia spp, Canarium sp, Macaranga sp, Dipterocarpus sp* etc. as shown in figure 41. These vegetation zones provide important functional features as considered in the catalogs of critera and indicators for green spaces function in chapter 7.5.

7.3 Agriculture Capabilities

Landscapes do comprise conditions of the physical environment including climate, relief, soils, hydrology and vegetation to an extent that these influence the potential for land use. Most of the land within the coastal zone is characterised by an undulated shape where the hill slopes range between 6 to 20 degrees only. Land with slopes within the range of 20 to 25 degrees is relatively limited in distribution. The soils developed here are generally deep (above 120 centimetres) with favourable nutrient and moisture retention capacities. This land is suitable for agricultural development.

Terrains where the hill slopes are steeper than 25 degrees are characterised by shallow soils (below 75 cm) and very susceptible to erosion and to water stress during dry season. Here, the medium for root growth and for anchorage is severely limited. This land is considered not to be suitable for agricultural development. However, it has been assumed that a moderate intensity of agriculture can be practiced within the capability of the average farmer.

Concerning soil suitability, five soil groups with differing degrees of limitations for agriculture have been characterised by the Sabah Agriculture Department (1976) as shown in table 49 and the respective soil associations of Kota Kinabalu have been mapped as shown in figure 40.

The land where the soils are purely composed of coarse sand (coarse sand fraction, 1-2 millimeters) is generally not suitable for any agricultural development because of very low nutrient and water retention capabilities. However, when soils are characterised by the presence of fine sand (fine sand fraction, 50 microns to 1 millimeter), the land is potentially suitable for market gardening and for diversified annual crops.

Table 49: Soil Suitability Groups for Agriculture
(Source: Agriculture Department Sabah (1976))

Soil suitablity		Soil associations	Main features
1.	No limitation	Bingkor	Deep, well-drained soils; good reserves of moisture and inherently fertile or responsive to fertilisers. Suitable for a wide range of crops. Occupies 0.1% of Sabah's land area.
2.	Few minor limitations	Binalik, Labau, Brantian, Tapang, Semporna, Lungmanis, Table, Silabukan,	Soils exhibiting one or more of the following features: poor drainage; rocky between 0.5 and 1.2 m of the soil surface; extremely coarse texture; peat layer to a depth of 0.5 m; slopes within the range 5 - 15°. Suitable for a moderate range of crops. Occupies 7.5% of Sabah's land area.
3.	One serious limitation	Tuaran, Kinabatangan, Karamuak, Brantian, Tungku, Orchid, Rumidi, Sipit, Kalabakan, Dalit, Tengah Nipah, Kretam, Beruang, Dagat, Bang	Soil exhibiting one of the following features: slopes within the range 15 - 25°; peat layer 0.5 to 1.2 m in depth; very poorly drained (sometimes swampy); very poor structure; rocky at less than 0.5 m depth; acute plant nutrient deficiencies. Requires very careful management. Occupies 19.5% of Sabah's land area.
4.	More than one serious limitation	Usukan, Tanjung Aru, Sapi, Kepayan, Sook, Sinarun, Tawai, Apas, Lokan	Soil exhibiting one or more of the following features: shallow soils on strongly sloping sites; shallow and with acute plant nutrient deficiencies; salinity; permanent swampy conditions. Marginal land & normally unsuitable for agriculture. Occupies 10.2% of Sabah's land area.
5.	Very serious limitations	Weston, Klias, Sipitang, Pinosuk, Keneddy Bay, Tiger, Gomantong, Lokan, Bidu-bidu, Mentapok, Tinagat, Malubuk, Wullersdorf, Gumpal, Crocker, Maliau, Serudong, Trusmadi, Kinabalu	Soils exhibit any of the following features: slopes predominantly greater than 25°; extremely stony and rocky, toxic levels of certain elements; peat layer to a depth of more than 1.2 m. Unsuitable for agriculture. Occupies 62.7% of Sabah's land area.

The land where the soils are permanently waterlogged (not feasible to drainage), with deep (>150 centimeters) overlying peat layer, and where the soils are prone to brackish water intrusions, are also not suitable for agricultural development. In general, however, the lands within the *Coastal Zone* (including the existing forested area) consist of soils with characteristics and properties which conform to the requirements of most of the agricultural crops.

The agriculture capabilities are also directly important features as it has been considered in the catalogs of critera and indicators for green spaces functions in chapter 7.5. Excluding the mangrove swamps and the deep peat swamps the land is generally suitable for agricultural development. However, the choice of agricultural crops for this land is determined by the local climatic conditions, the feasibility to drain the water, and by the moisture and nutrient retention of the soils. The agriculture capabilities of these soils and their respective limitations are presented in table 50.

Table 50: Agriculture Capability Assessment Related to Soil Associations
(Source: Agrictulture Department Sabah, 2003)

Soil Association	Description	Agriculture Capability
Weston	Tidal swamp	*Very low or no capability to support agricultural crops and permanent inundation with slow-moving waters.*
Usukan and Tanjung Aru	Beach sand deposits	*Low capability to support vegetables and cash crops cultivation. Requires high levels of capital (fertilizer) and management inputs.*
Tuaran and Kinabatangan	Alluvium	*High capability to support a wide range of agricultural crops. Requires medium level of capital (drainage) and management inputs.*
Sapi	Alluvium and peat	*Potentially capable to support oil palm where the land is raised above sea level. Requires very high levels of capital (drainage) and management inputs.*
Brantian	Raised alluvium	*Medium capability to support oil palm, cocoa, coconut, fruit trees and cash crops with optimum capital and management inputs.*
Rumidi, Lung-manis, Tengah Nipah, Silabukan, Kalabakan, Kretam, Sipit	Soils derived from mixed sedimentary rocks	*High to very high capability to support a wide range of agricultural crops including oil palm. Proven to support oil palm yield of 26 to 28 tons per hectare per year of Fresh Fruit Bunches, with optimum capital and management input.*
Klias	Peat Swamp	*Not capable to support any agricultural crop. Exception is raised land within the Kinabatangan Flood Plain is potentially capable to support oil palm with very high capital (drainage) and management inputs.*
Tungku	Calcareous alluvium	*High capability to support coconut, cocoa and oil palm cultivation.*
Semporna	Soils derived from coralline limestone	*Soils deeper than 75 centimetres highly capable to support oil palm, cocoa and coconut. Shallow soils capable to support vegetables and cash crops.*
Table	Soils derived from basalt	*High capability to support wide range of agricultural crops. Proven to support cocoa yield of 2.5 to 3 tons dried beans per hectare per year.*
Others	Skeletal or very shallow soils	*Very susceptible to sheet erosion and low to very low capability to support agricultural crops.*

7.4 Land Use and Biotope Classification

Many urban habitats are sensitive to human-caused disturbances, and need to be managed cautiously or protected. Thus, the consideration of biotope patterns in land-use planning is important both for the well-being of urban residents and for the maintenance of biodiversity.

The distinction between biotope cover and land use is fundamental. For further classifications and legends the two are often confused. They are now defined as follow:

Biotope cover is the observed physical cover, as seen from the ground or through remote sensing, including the vegetation (natural or planted) and human constructions (buildings, roads, etc.) which cover the earth's surface. It represents a set of environmental conditions that support a particular ecological community of plants and animals.

Land use is based upon function, the purpose for which the land is being used. Thus, a land use can be defined as a series of activities undertaken to produce one or more goods or services. A given land use may take place on one, or more than one, pieces of land and several land uses may occur on the same piece of land. Definition of land use in this way provides a basis for precise and quantitative economic and environmental impact analysis and permits precise distinctions between land uses, if required.

On the other hand, all of these land use types provide at the same time, space and resources for wild fauna and flora as well as options for certain ecological processes and interrelationships. In this respect, they represent biotopes which is why they have been declared as “land-use and biotope types” following Bürger and Sittler (1990).

The biotope and land use cover will be mainly derived from visual interpretation of recent aerial photograph and high resolution satellite images digitally enhanced. It should be carried out according to a homogenized and hierarchical classification system. For the purpose of this study, the classification legend of land use types from the

Agriculture Department Sabah (2003) were adapted and modified. The geographic reference was derived from existing topographic maps and updated from remote sensing documents and ground surveys geo-referenced with GPS points.

The results of land-use and biotope classification from the settelite images are given in figure 43. A general land classification has been derived and distinguished, namely: *urban and developed areas, mixed horticulture and grassland, paddy and riverside, old rubber and scrub, forest and mangrove areas, and water* (figure 43)

Adapted from the Agriculture Department Sabah (2003), these were further devided into different landuse/biotope types, namely: 1) urban areas, settlements and associated non-agricultural areas, 2) horticultural lands, 3) trees, palm trees and other permanents crops, 4) croplands, 5) improved permenant pastures, 6) grasslands, 7) forest lands, 8) swamps, mangroves and wetland forests, and 9) unused lands. Within this classification, each type then was subdivided again into *land use types*. The detailed land-use/ biotope classification is shown in table 51.

In order to facilitate the land-use - biotope identification and mapping process, a mapping code was produced based on consecutive numbers following the manual from Stadtbiotop Kartierung Freiburg (1991). The mapping codes thus start from number 1.000 to 6.000 concerning the general land classification (level 1). They further represent the respective biotope and landuse types, 1.101 – 6.101 (level 2 + 3) as shown in table 51.

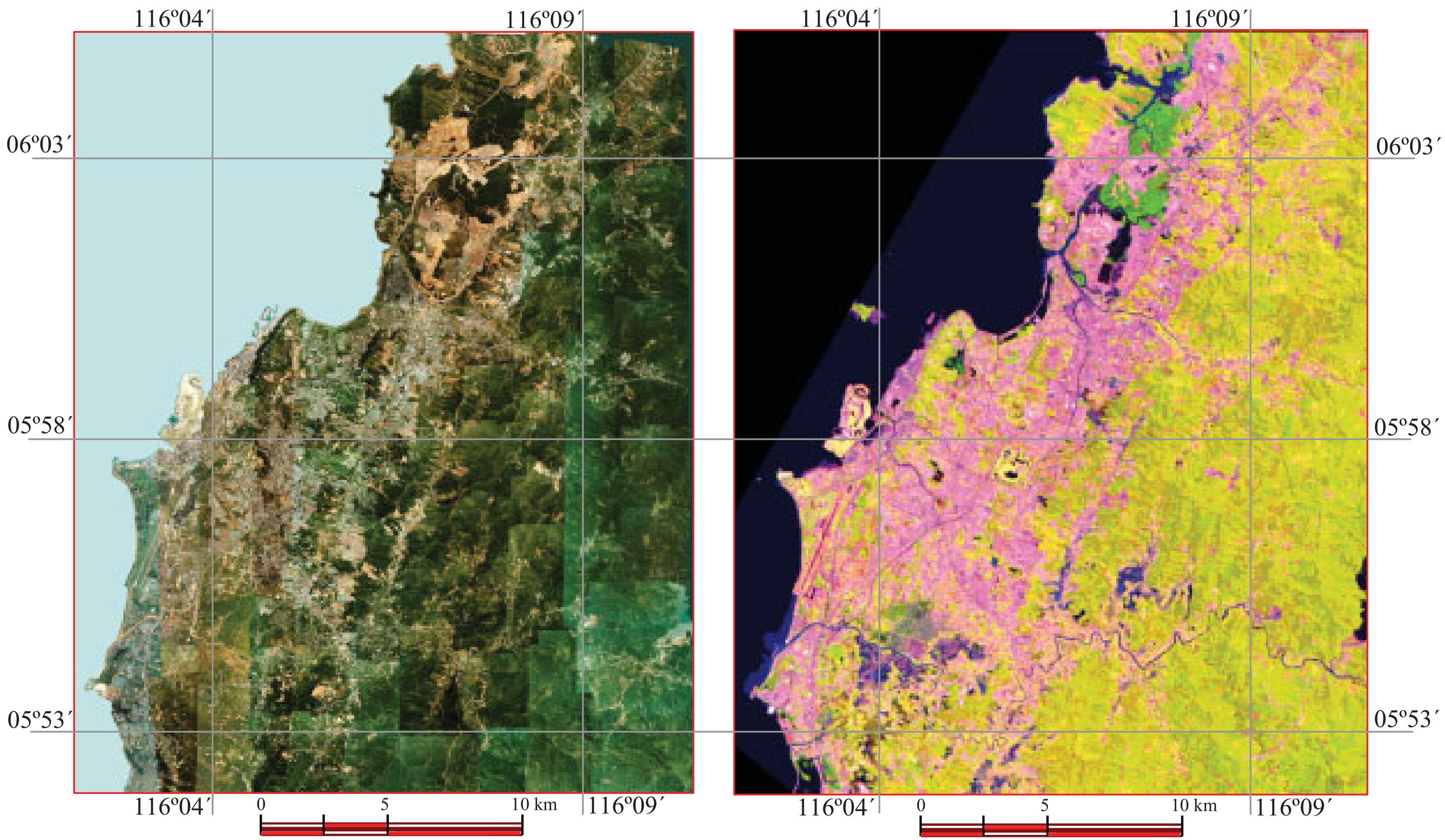


Figure 42: Aerial photograph 2000 (left) and SPOT image satellite 2002, (band 4:3:2, right) of Kota Kinabalu (Scale 1:50,000) was used for visual interpretation and analysis of land cover classification (*Source: Own presentation)*

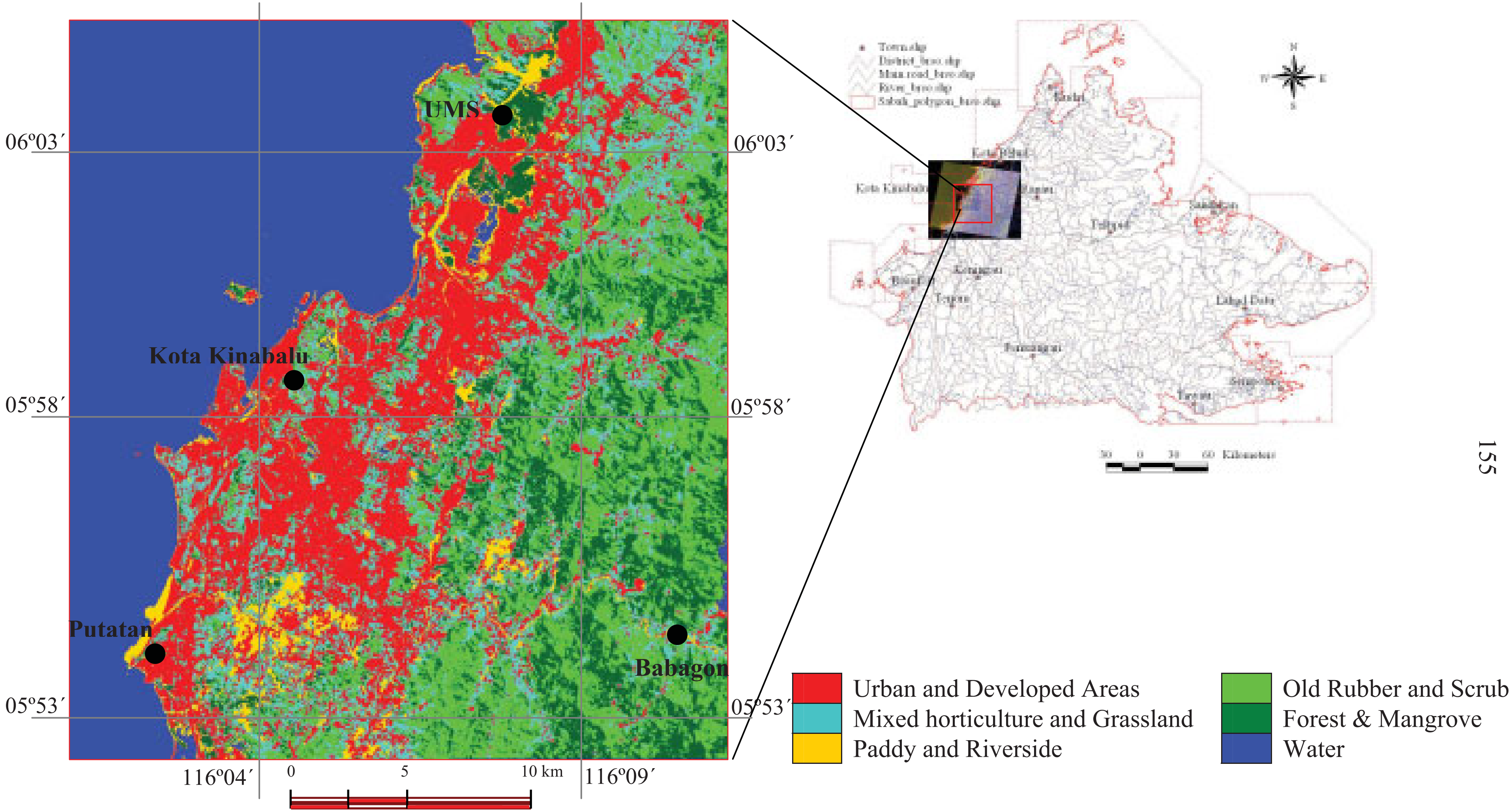


Figure 43: General land classification derived from remote sensing SPOT satellite image data (scale 1:50,000)
(Source: Own presentation)

Table 51: Biotope and land-use types in Kota Kinabalu *(Source: Agriculture Department Sabah (ADS); (2003), adapted and modified)*

LEVEL I	GENERAL LAND CLASSIFICATION (according to figure 49)	LEVEL II	BIOTOPE TYPE (source: adapted from ADS, (2003))	LEVEL III	LANDUSE TYPE (source: adapted from ADS, (2003))
1.000	Urban and developed areas	1.100	Settlements and asssociated non-agricultural areas	1.101	Urban and Associated areas
				1.102	Estate buildings and Associated areas
				1.103	Tin mining areas
				1.104	Other mining areas
				1.105	Power line right of way
2.000	Mixed horticulture and grassland	2.100	Horticultural lands	2.101	Mixed horticulture
				2.102	Market gardening
				2.103	Agricultural stations
		2.200	Improved permanent pasture	2.201	Improved Permanent Pasture
		2.300	Grasslands	2.301	Lalang, Unimproved Pasture and / or Scrub-Grassland
				2.302	Fallow land (Grasses and Scrub Forest)
				2.303	Grass Covered Erosion Scars and Landslides
3.000	Paddy and riverside	3.100	Cropland	3.101	Paddy
				3.102	Diversified Crops
				3.103	Shifting Cultivation
4.000	Old rubber and scrub	4.100	Tree, palm and other permanent crops	4.101	Young Rubber
				4.102	Mature Rubber
				4.103	Senile Rubber
				4.104	Young Oil Palm
				4.105	Mature Oil Palm
				4.106	Senile Oil Palm

(Contd.)

Table 51: Biotope and land-use types in Kota Kinabalu *(Source: Agriculture Department Sabah (2003), adapted and modified)* (Contd.)

LEVEL I	GENERAL LAND CLASSIFICATION (according to figure 49)	LEVEL II	BIOTOPE TYPE (source: adapted from ADS, (2003))	LEVEL III	LANDUSE TYPE (source: adapted from ADS, (2003))
4.000 (contd.)	Old rubber and scrub	4.100	Tree, palm and other permanent crops	4.107	Young Coconut
				4.108	Mature Coconut
				4.109	Senile Coconut
				4.110	Pineapple
				4.111	Tea
				4.112	Coffee
				4.113	Cocoa
				4.114	Black Pepper
				4.115	Sugar Cane
				4.116	Orchards – Rambutan, Durian, Citrus, Cloves, Nutmeg, etc
				4.117	Fibre crops
				4.118	Sago
				4.119	Banana
				4.120	Areca nut palm
5.000	Forest and mangrove	5.100	Forest lands	5.101	Forest
				5.102	Cultivated Forest
				5.103	Scrub Forest
				5.104	Recently Cleared Land (Areas generally cleared from Forest or Senile Rubber)
				5.105	Cleared Land With Delayed Agricultural Development
		5.200	Swamps, marshlands and wetlands forests	5.201	Includes Mangrove, Nipah, Gelam and other Wetland Forest Associations
6.000	Water	6.100	Unused lands	6.101	Unused Land
				6.102	Fish and hyacinth ponds

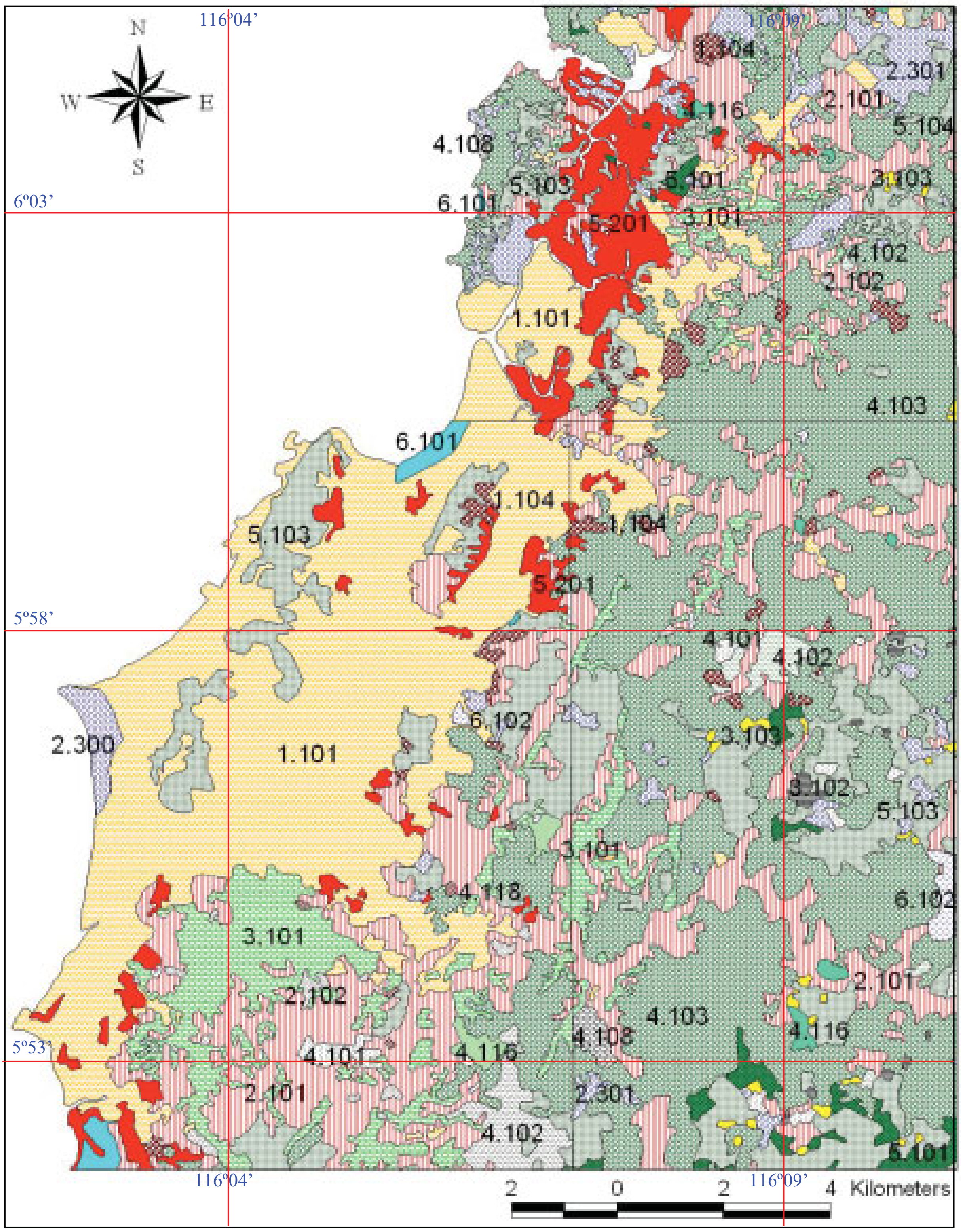
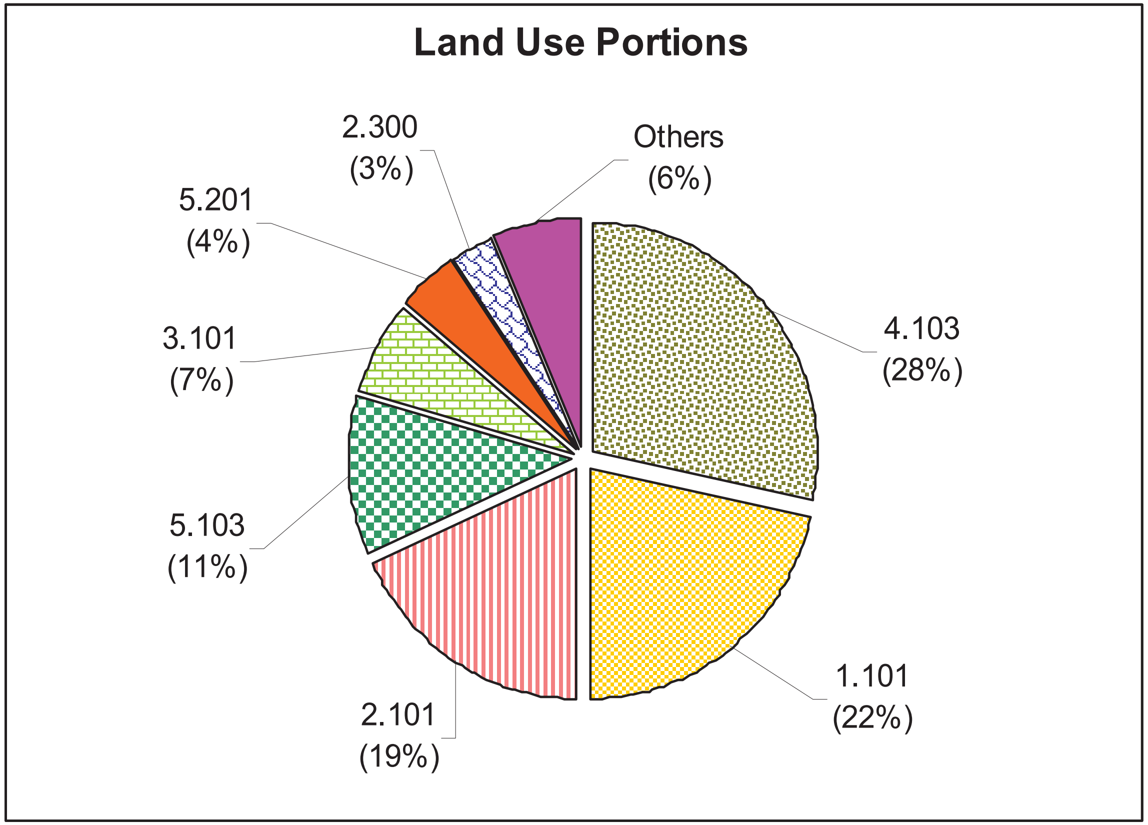


Figure 44: Land-use map described in mapping codes derived from biotope and land-use types as classified as in Table 51 (refer legend at figure 45)
(Source: own presentation, Scale 1:50,000)



Code	Land-use type
4.103	Senile Rubber
1.101	Urban & Associated area
2.101	Mixed Horticulture
5.103	Scrub Forest
3.101	Paddy
5.201	Mangrove & Wetland area
2.300	Grassland
4.102	Mature Rubber
1.104	Mining area etc.
5.101	Forest
4.116	Fruits Orchard
4.101	Young Rubber
6.000	Water & Lake
6.102	Fish & Hyacinth ponds
3.103	Shifting Cultivation
2.102	Market Gardening
4.108	Mature Coconut
3.102	Diversified Crops
5.104	Cleared Forest area
4.118	Sago area

Others

Figure 45: Seven most important land-use/biotope types in Kota Kinabalu *(Source: Own presentation)*

Based on the aerial photograph analysis and terrestrial validation in the respective investigation areas, these biotope/land-use types can further be characterised as follows:

1.100 Settlements and associated non-agricultural areas

Built-up and settlement associated areas generally are distributed at the coastal fringes facing the harbours. Settlement centres also exist within the large oil palm plantations. Settlement may refer to a balloon of colonization or the resulting in communities. The important criteria in distinguishing this major category include the existence of infrastructures, the existence of public buildings and the provision of utilities for the urban population. The following subcategories (Level II) can be distinguished:

1.101 Urban and Associated areas

Urban area is a term used to define an area where there is an increased density of human-created structures in comparison to the areas surrounding it. This term is at the one end of the spectrum of suburban and rural areas. An urban area is more frequently called a city or town. Urban areas are created and further developed by the process of urbanization. Further differentiations as proposed for large scale urban biotope and land-use mapping (Institute für Landespflege der Universität Freiburg, 1991) did not seem necessary in this study.

1.102 Estate buildings and associated areas

An estate comprises the houses or other out buildings, farmland and woods that surround the gardens and grounds of a very large property, such as a country house or mansion. It is an "estate" because the profits from its produce and rents are sufficient to support the household in the house at the centre. Thus "the estate" may refer to all other cottages and villages in the same ownership as the mansion itself.

1.103 Tin mining areas

Tin is a chemical element in the periodic table that has the symbol Sn (*L. Stannum*) and atomic number 50. This silvery, malleable poor metal that is not easily oxidized in air and resists corrosion is found in many alloys and is used to coat other metals to prevent corrosion. Lands comprises with tin mining usually covered with tree vegetation and have been degraded by near-surface mineral mining. This has progressed over substantial areas in the plains and foothills of Sabah as gravel pump tin mining. Part of exhausted mining areas is being reconstituted as residential areas or for vegetable gardening near urban centres.

1.104 Other mining areas

Mining is the extraction of valuable minerals or other geological materials from the earth, usually (but not always) from an ore body, vein, or seam (coal). In Sabah, most deposits of metallic minerals are found along a central belt extending from the northern islands of Banggi, through Taritipan, Crocker range, Gunung Kinabalu and the Labuk valley to the upper Segama Valley-Darvel Bay area and Semporna Peninsula. The minerals found include bauxite, coal, diamonds, iron, precious metals, lead, limestone, nickel, phosphate, rock salt, and uranium. In Kota Kinabalu, mining areas usually found in batches along the centerpart of hilly areas concists of rock mining, became important sources for construction purposes.

1.105 Power line right of way

Usually power transmission is executed / realised between the power plant to a substation in the vicinity of a populated area. In Kota Kinabalu usually occurs along road path, highways crossing urbanized areas to the suburban areas. Electric power transmission is one process in the delivery of electricity to consumers. It refers to the 'bulk' transfer of electrical power from place to place.

2.100 Horticultural areas

The Latin words hortus (garden plant) and cultura (culture) together form horticulture, classically defined as the culture or growing of garden plants. Horticulturists work in plant propagation, crop production, plant breeding and genetic engineering, plant biochemistry, plant physiology and the storage, processing and transportation of fruits, berries, nuts, vegetables, flowers, trees, shrubs and turf. In Kota Kinabalu, the horticultural areas usually located along the foothills of valley occur mainly on roadside, near village and people settlements. The following subcategories (level II) can be distinguished:

2.101 Mixed Horticulture

Mixed horticulture defined as a diversified garden cultivation areas found in a haphazard pattern around a dwelling. The essential basis is the settlement dwelling with emphasis on the production of diversified crops for family needs with the possibility of small surpluses from being sold locally. Included are mixed vegetable, yams, tapioca, chillies, pineapples, fruit trees, bananas, papayas, coconuts, etc. The most common location is along roads and riverbanks. Frequently, this type forms buffer strips between estates and smallholding crops in Kota Kinabalu.

2.102 Market gardening

Market gardening areas are designated for commercial production of fresh vegetables. The pattern is of intense neatness of use, with individual units being small. Most market garden areas occur in or near large urban centers.

2.103 Agricultural Stations

Agricultural Stations are defined as areas with wide activities which may include demonstration plots, field verification trials, research into newly introduced crops, production of planting materials and stock seeds or multiplication of stock materials for research, hybridization and large scale production. The outline of an agricultural station was usually taken from maps since some stations still have land reserves that are yet undeveloped.

2.200 Improved Permanent Pasture

2.201 Improved Permanent Pasture:

Pasture is land with lush herbaceous vegetation cover used for grazing of ungulate livestock as part of a farm or ranch. Prior to the advent of mechanized farming, pastures were the primary source of food for cattle and sheep. Pasture growth can consist of grasses, legumes or a mixture. Alfalfa, clover, and birdsfoot trefoil are legumes used in intensive pasture management. Many grasses, including ryegrass (*Lolium*), meadow-grass (*Poa*), foxtails (*Alopecurus*), and bents (*Agrostis*) are used, depending on site conditions, of which soil type, minimum annual temperature and rainfall amount are the most important. These areas are all categorised by sowed grassland vegetation for the purpose of pasture.

2.300 Grasslands

Grassland is one of several types of terrestrial biomes, where grasses form the predominant vegetation, usually mixed with herbs and sometimes with shrubs, but without big trees. Areas were only included when shrubs and trees (generally below 5 meters) cover less than 50% of the area. Of the scrub component covers more than 50% of the area, it is designated as Scrub Forest and put under category Forest land. The following subcategorised (level II) can be further distinguished:

2.301 Lalang, Unimproved Pasture and / or Scrub-Grassland:

Lalang or scrub grasslands may occur naturally or as the result of animal husbandry and pasturing. Apart from this influence, the vegetation has developed naturally and is mostly dominated by *Imperata cylindrical* grass. Usually found idle on the top of hilly areas towards the flatlands.

2.302 <u>Fallow land (Grasses and Scrub Forest)</u>:

The accumulating degradation of soil quality due to the continuous harvesting of crops often enforces to let the land remain idle for a period of time in order to allow mineralisation and subsequent deliver of nutriens or nutrient-rich eolian (wind deposited) and other silt to be deposited and rejuvenate the soils productivity.

2.303 <u>Grass Covered Erosion Scars and Landslides</u>:

Intensive agricultural practices have contributed to high rates of soil erosion on hillslopes. Bare soil, erosion scars and landslide areas exposed in the foreground has been prepared for the development of grass covers. Although most landslide scars in the watershed have become revegetated with grasses, patches of bare soil remain and contribute to the high sediment yields of the watershed.

3.100 Cropland area

A cropland is the basic unit in agriculture. It is a section of land devoted to the production and management of food, either produce or livestock. It may be an enterprise owned and operated by a single individual, family, or community, or it may be owned by a corporation or company. Cropland areas can be a holding of any size from a fraction of a hectare. In Kota Kinabalu croplands comprises with annually production of rice paddy, tapioca, sweet potatoes etc. for household and small scale farmer. The following subcategories (level II) can be distinguished:

3.101 <u>Paddy</u>

A paddy field is a flooded parcel of arable land used for growing rice. Mostly found on the river plains and flat areas of the west coasts i.e. Kepayan, Penampang, Putatan and south-west of Kota Kinabalu district, most paddy fields are smaller than 2 hectares. The rain-fed paddy is cultivated by subsistence farmers. The irrigated fields intensively use land however produce the double cropping yields (3 to 5 tons per hectare).

3.102 Diversified Crop

Mainly annual crops such as maize, tapioca, bananas, yams, sweet potatoes, tobacco, water melon, etc. The small size of the fields makes it difficult to interpret the actual crop, especially when the same crop is present at different stages of maturity within a mixed crop area which may also contain areas of fallow.

3.103 Shifting Cultivation

Describes the occurrences of clearings (often overgrown with scrubs and coarse grasses which are indications of fallow) of very irregular shape and such areas are usually found on the steep slopes of high hills and mountains in forested areas. Small scale farmer or village people planted hill paddy and potatoes for only family uses.

4.100 Tree, palm and other permenant crops

Palms and Tree Crops include crops at all stages of growth under various forms of management. The crops under this category are oil palm, cocoa, coconut, rubber, coffee, orchards, bananas, fish and hyacinth ponds, pineapple and sago palm. Sometimes form into large scale of plantation areas in hectares. The areas usually occupied and managed by individuals, private own land and the government. Under the government scheme, most areas located along pathes, roadsides, riversides and stateland reserves. Sometimes the permanent crops was grow associate with ground cover to kept the soil fertile.

4.101 – 4.103 Rubber:

Rubber plantations occur mostly on the foot slopes and hilly areas of Crocker Ranges on the West Coasts extending from Kota Belud southward to Sipitang. These areas can be categorised by young rubber, mature rubber and senile rubber under the management Agriculture Department and Rubber Farm Board Sabah. Nevertheless, some land also belongs to individual’s people, and usually this land sometimes was left become idle or unsupervised. The natural re-growth of pioneer wild trees usually takes places in these areas after some times.

4.104 – 4.106 *Oil Palm:*

The oil palms (*Elaeis*) comprise two species of the *Arecaceae*, or palm family. They are used in commercial agriculture for the production of palm oil. The oil Palm *Elaeis guineensis* usually found mainly planted in the west coast i.e. Pitas, Kota Marudu and Beaufort. The areas usually with fertile soil consists small scales until thousand hectares adjoining forest areas. The plantation scheme can be distinguished by young oil palm, mature and senile.

4.107 – 4.109 *Coconut:*

The Coconut Palm (*Cocos nucifera*), is also a member of the Family *Arecaceae* (palm family). It is the only species in the Genus Cocos, a large palm tree, growing up to 30 m height, with pinnate leaves 4-6 m long, pinnate 60-90 cm long. Old leaves break away, cleanly leaving the trunk smooth. The term coconut refers to the fruit of the coconut palm. Most stands can be found in Kuala Penyu, Kota Marudu plain and on small islands around Banggi Island. Coconut is a smallholder crop. Most of the growers live on a subsistence earning.

4.110 *Pineapple:* (*Ananas comosus*)

Is a tropical bromeliad (family Bromeliaceae), a short herbaceous perennial with 30 or more spined and pointed leaves 30-100 cm long, surrounding a thick stem. The fruit was named "pineapple" because of its resemblance to a pine cone. Sometimes found planted on hilly teresses areas, field size usually consists 2 – 5 hectare and by a small scale farmer.

4.111 *Tea:*

Tea is a product made from the leaves or buds of the tea bush *Camellia sinensis*. Mostly found on hilly and mountainous areas, whereas the climate is more humid and cool. Belong to small scale farmer 2 – 5 ha and cultivate by hand and sometimes adjoining with other crops like pinapple and *Saccharum.*

4.112 *Coffee:*

There are two main species of the coffee plant namely: *Coffea arabica* and *Coffea canephora* (robusta). Cultivated on basis of medium estates of plantation (more than 10 ha) but also by small farmer and can be found mostly in along the west coast Beaufort, Tenom and Keningau district. In Kota Kinabalu, usually planted by small scale farmer for household uses and intergrated near riverside areas.

4.113 *Cocoa:*

Cocoa is the dried and partially fermented fatty seed of the cacao tree (*Theobroma cacao*) from which chocolate is made. 'Cocoa' also often refers to cocoa powder, the dry powder made by grinding cocoa seeds and removing the cocoa butter from the dark, bitter cocoa solids. By itself it has an extremely bitter flavor. Mostly be found in Tawau, Semporna and Kunak coasts. Cultivator can some also found in Sandakan Peninsula and Lahad Datu coasts. Most of cocoa crops are planted in medium estates and some smallholdings. Since cocoa cultivation as a mono-crop is not profitable at the current bean market price, particularly for the smallholdings, this crop is maintained in a mixed-crop system where crop diversification is economically viable.

4.114 *Black pepper:* (*Piper nigrum*)

Is a flowering vine in the family *Piperaceae*, cultivated for its fruit, which is usually dried and used as spice and seasoning. The same fruit is also used to produce white pepper and green pepper. Belong to small scale farmer 1 – 2 ha and cultivate by hand and sometimes adjoining with other crops like coffee and cocoa. Usually planted near roadsides or along path and found mostly in along the west coast like Beaufort.

4.115 <u>*Sugar cane:*</u> (*Saccharum*)

Genus of between 6–37 species (depending on taxonomic interpretation) of tall grasses (family *Poaceae*, tribe *Andropogoneae*) and became important source of sugar. Most of sugar cane is planted in medium estates and some smallholdings consists 2 – 5 hectare. Planted rather on flat lands, nearly wet areas and riversides and usually found in Papar, Kinarut and Beaufort district.

4.116 <u>*Orchards:*</u>

Is an intentional planting of trees or shrubs maintained for fruit production. Most orchards comprise either fruit or nut-producing trees (*Rambutan, Durian, Citrus, Cloves, Nutmeg*, etc), for commercial production. Orchards are also sometimes featuring as large gardens, where they serve an aesthetic as well as a productive purpose. Found mainly associates adjoining mix horticultural, paddy and village settlement areas. Occures mainly on flatland and supervised by individuals.

4.117 <u>*Fiber crops:*</u>

Field crops are grown for their fibers, which are used to produce paper, cloth or rope. Usually associate with genus *Acacia, Bambusa* and *Artocarpus*. Planted in flatland towards hilly areas and consist of medium estates and some smallholdings. These crops are generally harvestable after a single growing season, as opposed to trees which are typically grown for many years before being harvested for wood pulp fiber and found mostly in Kinarut and Kawang areas.

4.118 <u>*Sago:*</u>

Is a starchy, a granular substance used in cooking. Sago is the pith found inside the stems of some cycad plants of the genus *Cycas*, the most notable being *Cycas revoluta*. The pith is ground to coarse flour, washed carefully to leach out natural toxin and the portion that is removed during washing is dried and cooked. Best planted in association with peat soil, and found mainly in Beaufort and Kuala Penyu. Sometimes was occupies with small holder to medium farmer.

4.119 *Banana:*

Herb plants from the genus *Musa*. The stems grow up to 4–8 m height, with large leaves (2–3 m long). Planted by individual for local consumption and sometimes consists of 1-2 ha mainly on flatland or near riverside areas. Individuals usually planted with other crops like rubber, cocoa and coffee for the purpose shading.

4.120 *Areca nut palm:*

Known as 'pinang' or Areca nut, is the seed of the Betel Palm (*Areca catechu*), a species of palm which grows throughout the Pacific, Asia and parts of east Africa. It is a medium-sized tree growing to 20 m tall, with a trunk 20-30 cm diameter. The leaves are 1.5-2 m long, pinnate, with numerous crowded leaflets. Sometimes form as a belt between mixed horticulture and paddy areas, and small scales planting at the back of houses for household uses only.

5.100 Forest Lands

Land at least 10 percent stocked by trees of any size or formerly having had such tree cover and not currently built-up or developed for agricultural use. Forestlands may include natural regrowth forest, scrub, cultivated forest, mangroves, wetland and other forest association. Forest area sometimes managed for the production of timber and other forest products or maintained as wood vegetation for such indirect benefits as protection of water catchment areas or recreation. The following subcategories (level II) can be distinguished:

5.101 *Forest*:

All dryland primary and secondary forests or high '*belukar*[4]' above 5 meters in height are included in this sub-category. Found in more rural areas of district of Kota Kinabalu adjoining the Kinabalu and Crocker Range Parks in the middle of Sabah. Vegetation usually are consists of natural regrowth with pioneer and semi shade tolerant trees (*Dipterocarpa*). However, the occurrences of natural forest area in Kota Kinabalu is difficult to be distinguished in the aerial photograph are due to mix trees and the establishment of large scale of rubber plantations.

5.102 *Cultivated Forest*:

This unit consists of introduced pulp wood forests, which may attain a height similar to the mature primary *Dipterocarpa*. Because the trees are cultivated like plantation crops, the tree crowns appear even in growth and the canopy has a smooth texture when viewed from aerial view. These areas usually found in Kinarut towards Papar where the cultivate forest consists of species *Acacia Mangium, Acacia auriculiformis* and *Paraseriantes falcataria* been planted under the Sabah Forestry Development Authorities (SAFODA). Sometimes this area consists of more than 10 hectare.

5.103 *Scrub Forest*:

Consists of areas which are more than 50% covered by shrubs, bushes and young or dwarf trees having a height of less than 5 meters. It includes low belukar or secondary growth, which is in the first stage of regeneration and development towards a mature forest. This area usually formed dinamicly after long period of times in burn forest area, grasslands and shifting agriculture areas, further associated in the hilly towards mountainous areas adjoining with forest area.

5.104 *Recently Cleared Land:*

In recently cleared forest areas it is often impossible to determine the future land use. It forms a ptches of scars in the aerial photograph bodering forest areas. A very clean appearance as well as the presence of felled trees and traces of burning can be recognised in these areas.

5.105 *Cleared land with delayed agricultural development*:

Areas generally cleared from forests or senile rubber plantations for the purpose of other land use practices and mostly under government management.

[4] *'Belukar' is Malaysian word and means bush; shrub; found in uncultivated land with wild woody trees*

5.200 Swamps, marshland and wetlands forests

This category includes all poorly drained land exhibiting seasonal or permanent water logging or flooding. Vegetation types are based on xerophytic with special edaphic characteristics to the plants to like prop root, pneumatophor which enable plants to breath air in habitats that have waterlogged soil.

5.201 *Mangrove, nipah, gelam and other wetland forest associations*:

This category includes all poorly drained land exhibiting seasonal or permanent water logging or flooding. Wetland grass, heath and forest associations (including *Mangrove, Nipah* and *Gelam*) occur in this category. Wetland areas which usually found near the coastal areas of Kota Kinabalu adjoining the riverside areas and this sites is important refuge and feeding ground for many species of resident birds, as well as several migratory species from northern Asia.

6.100 Unused lands

Unused areas which do not give any due in which of the above mentioned ways they might be used.

6.101 *Unused land:*

Unused land for any development and consists with water, downstream of river bank, buffering with coastal sea and large lake areas and estuaries.

6.102 *Fish and hyacinth ponds:*

Fish and hyacinth ponds usually consists with plant of genus *Hyacinthus*, which are bulbous herbs formerly placed in the lily family Liliaceae but now regarded as the type genus of the separate family Hyacinthaceae. Usually found of colonies and mostly associated with fish ponds natural lake. This areas sometimes unused with any development and occurs usually along flat lands bordering with wetlands and mangroves areas. Sometimes scattered and occupies an area of 1 – 2 hectares each.

The results of the land use and biotope mapping in Kota Kinabalu district are given in figure 44 (above). The overall portions of land use types are differing greatly. Corresponding to the land-use analysis, there are 21 types of land use that cover Kota Kinabalu district areas with the highest portions reached by *senile rubber* (Old Rubber Plantation)*,*of *Hevea brasiliensis* (code 4.109). This land use type amounts to 8,062 ha as shown in figure 45. The stand analysis results reffered in chapter 4 also proved that rubber tree is the most frequent and that most of the areas are covered by rubber trees.

The second biggest land use type is *urban associated areas* (code 1.101) with an overall area of 6,195 ha. Most of these areas are densly populated, like Kota Kinabalu city, Luyang, Kapayan, Tg.Aru, Likas, Putatan and Dongonggon area.

The third rank is taken by *mixed horticulture areas* (code 2.101) with 5,228 ha which are usually associated with local people settlements and unsupervised gardening areas.

The fourth and following shares belong to *scrub forest area* (code 5.103) with 3,110 ha, *Paddy area* (code 3.101) with 1,920 ha, *mangrove, swamps, marshland and wetland forests* (code 5.201) with 1,251 ha, and *grassland* (code 2.300) with 911ha. While the other land uses are represented with small portions as shown in figure 45.

The map in figure 44 also reveals the spatial land-use and biotope pattern. It shows a prolate belt of urbanized areas that stretches from the coast to the hilly back-up areas, capturing more or less the entire flat coastal area and tending to expand northwards. The urbanization encounters mangroves and corresponding wetlands in the northern part of the district. Other wetland areas are found in close neighbourhood, mostly at the bottom of slightly hilly areas. The old rubber plantations occupy mostly the mountainous areas in the eastern part bordering mixed-horticulture areas on flat and valley areas. While the rice paddy fields mostly adjoin on flat course sometimes form batches at the south west of the district. Grasslands and scrub forests are usually found idle to recently cleared forest, shifting agriculture or burning areas that can be distinguished from the hilly towards the urbanized areas.

All described landscape features should be taken into consideration as an important feature that are directly significant to classify important urban forest and green spaces functions.

7.5 Classifying urban green spaces and forest functions in Kota Kinabalu

Since classifying urban green spaces and forest functions takes all land characteristics into account i.e. landform characteristics, vegetation zones, agriculture capabilities, land use and biotope classification, forest stands (chap 4), bird habitat and management (chap5), and human perceptions (chap 6), it can be used to organize guidelines for safeguarding these functions for public benefits.

The spatial pattern of the urban forests was closely linked to the general zoning of different land uses and to the building density. The relationship between cover, size, and woody vegetation and the incidence of woodland indicator birds was significant. Furthermore, it was mentioned that the urban forest can effectively reduce air temperatures during hot days and as well as annoying noises coming from the industries and traffic lines. Leaving some of the forest, jungle, bush and shrub undisturbed can help to keep the river's water clean, to prevent soil erosion problems and to safeguard some of the bird habitats protected and unharmed.

Using the *poly-functional assessment method* – PFAM – (after URGE, 2001), 18 larger functional areas, conflated with respect to their administrative dissection stratification, finally serves as spatial pattern and units to analyse their important functions and subfunctions as defined in table 52.

For each of these functions, criteria and indicators were determined and the analysis results were mapped using GIS software. The criteria of each function are described in the following paragraphs and the respective functional zonation map is presented after each description.

Table 52: The functions and corresponding assessment criteria applied for classifying urban forest function in Kota Kinabalu *(Own presentation)*.

Level 1 (function)	**Level 2 (subfunction)**
Bird habitat function	• Bird corridor forest • Bird feeding area • Migrating bird area • Bird risk area
Nature conservation function	• Forest surface with special function for nature conservation • Forest surface with special function for research and genetic resources
Protection function	• Watershed protection forest (watershed) • Soil and coastal protection forest (erosion) • Climate protection forest (cooling, shadowing) • Protection from noise (noise abatement) • Protection from immission (gases & pollution)
Recreation function	• Recreation function forest • Outdoor recreation area
Utility function	• Fuel wood • Timber • Non-wood forest product

7.5.1 Bird habitat function

Important bird areas are sites that provide essential habitats for a high number of bird species. These sites have been identified as ‘potential rich birdlife area’ (see chapter 5), not only looking at the ascertained birdlife but also taking landscape features into account. The sites may serve for breeding, wintering, and/or migrating birds and may reach from a few acres to a thousand of acres in size. Usually they are discrete sites that stand out from the surrounding landscape. Potentially rich birdlife areas may include public or private lands, or both, and they may be either protected or unprotected yet.

When the habitats are split up into parts, due to road construction, shifting cultivation, logging or other operation, habitat fragmentation occurs. Nevertheless, the seriousness of habitat fragmentation increases with body volume and specialisation of the species. If the feeding or nesting sites, especially rare ones, are destroyed, the impact on the biodiversity is supposed to be high. Even construction activities which are not directly affecting any breeding or nesting sites, may prevent individual birds from coming to these places or cause others which are already there to leave the area, due to noise and other disturbances.

The criteria for analysing bird habitat function areas in Kota Kinabalu district include: 1) Bird corridor forests, 2) Bird feeding grounds, 3) Migrating bird areas, and 4) Bird risk areas. The definition of each criterion is given below and the results of bird habitat classification in different areas are presented in figure 46.

a) Criterion: Bird corridor forest

Definition:

A bird corridor forest provides a potential connection between fragmented habitats within forested and cultivated or even settlement and infracture areas. It helps to increase the gene flows between the individual habitats that improve the fitness of the species. Bird corridors can be provided and optimised by means of conservation and improvement of birdlife conditions. Potential bird corridor forests were assessed in 3 different categories, namely as "very important", "medium important" and "less important". Very important bird corridor forests have been considered as significantly important areas for the important kind of birds (see table 32), while the others categories range between medium and less important.

Verifier/ Indicator:

- Presence of potentially rich birdlife area with density, D > 15 birds/ km² (see figure 28).
- Presence of green areas within urbanized area e.g. wetlands, swamps, primary forest, coastal area and grassland.
- Presence of endangered or various bird species proven by bird survey or observation in the respective area (further research is needed).
- Additional suggestion from bird experts, local and village communities.
- Presence of species listed in IUCN and protection categories (see table 34).
- Presence of protected species by Malaysian wildlife law (see table 34).

b) Criterion: Bird feeding ground

Definition:

Area which potentially provides bird food such as seed, nectar or fruit from certain tree species or insects and fish.

Verifier/ Indicator:

- Presence, locality and types of potential bird feeding grounds within the green area i.e. presence of fruits trees, seeds or flowers form trees, herbs for lowland and acuatic animals, crustaceans for coastal and water bird (see table 31; further research needed).
- Statement from bird experts, local and village communities concerning the presence of bird feeding areas.
- Occurrences of bird type species by survey and it relation to vegetation species (habitat) found in the respective area.
- Number of different types of bird habitats in the respective area (figure 27).

c) Criterion: Migrating bird area

Definition:

Migration is the seasonal movement of birds, generally between breeding and non-breeding areas. Migrating bird areas are places where migrating birds occure periodically. In Kota Kinabalu they are usually visited by many sea bird species e.g. gulls, waders and herons and found near the coastal, swamp and rice field areas.

Verifier/ Indicator:

- Presence of specific migratory bird species (water birds).
- Presence of potential habitats in the area.
- Statement from bird experts, local and village communities concerning the presence of migration birds.

- Number of recorded migrating bird species by bird survey in the respective study area.

d) Criterion: Bird risk area

Definition:

Areas with significant risk potential to disturb or threaten individual birds like highways, hunting areas, human impact areas and predator occurence.

Verifier/ Indicator:

- Areas with potential threat e.g. highways, hunting areas, enhanced human impact and predator occurence.
- Presence of clearing, burning and shifting cultivation areas (need for further survey).
- Statement from local people.
- General reports about bird risk and locations they have been spotted.

Table 53: Classifying bird habitat function areas in different locations in Kota Kinabalu, Malaysia

Area/ Location	Functions			
	Bird corridor forest	*Bird feeding area*	*Migrating bird area*	*Risk bird area*
Sepanggar	**X**	**X**	**X**	**X**
Signall Hill	**X**	**X**	**X**	
Bukit Padang	**X**			
Tg. Aru	**X**	**X**	**X**	**X**
Putatan	**X**	**X**	**X**	**X**
Kg. Banka Banka	**X**		**X**	**X**
Kg. Kebambangan	**X**			
Kg. Babagon	**X**			
Kg. Kipouvo	**X**			
Kg. Kionsom	**X**			**X**
Kg. Lampugo	**X**			
Kg. Kokol	**X**			
Kg. Kituau	**X**			
Kg. Inobong	**X**			
Kg. Tindai	**X**			
Kg. Kitabu	**X**			
Kg. Pulutan	**X**			
Kg. Bendolan	**X**			

Note: X = Present and important

Table 54: Proposed map legend for bird habitat function areas in Kota Kinabalu, Malaysia (Contd.)

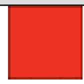
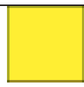
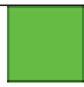
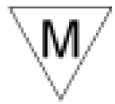
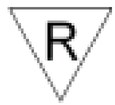
Criteria	***Indicator/ Description/ Area (ha)***		***Legend***
a) Bird corridor forest	Very Important *(of great significance or value)*	18,278 ha	
	Medium Important *(of considerable significance or value)*	5,795 ha	
	Less Important *(of no significance extra value)*	4,953 ha	
	• Presence of potentially rich birdlife area with density, D > 15 birds/ km² (see figure 28). • Presence of green areas within urbanized area e.g. wetlands, swamps, primary forest, coastal area and grassland. • Presence of endangered or various bird species proven by bird survey or observation in the respective area (further research is needed). • Additional suggestion from bird experts, local and village communities. • Presence of species listed in IUCN and protection categories (see table 34). • Presence of protected species by Malaysian wildlife law (see table 34).		
b) Bird feeding area	• Presence, locality and types of potential bird feeding grounds within the green area i.e. presence of acuatic animals for coastal bird and fruits, seed or flowers form trees for lowland bird (see table 31; further research needed). • Statement from bird experts, local and village communities concerning the presence of bird feeding areas. • Occurrences of bird type species by survey and it relation to vegetation species found in the respective area. • No. of different types of bird habitats in the respective area (figure 27).		

Table 54: Proposed map legend for bird habitat function areas in Kota Kinabalu, Malaysia

Criteria	*Indicator/ Description/ Area (ha)*	*Legend*
c) Migrating bird area	• Presence of specific migratory bird species (water birds). • Presence of potential habitats in the area. • Statement from bird experts, local and village communities concerning the presence of migration birds. • Number of recorded migrating bird species by bird survey in the respective study area.	
d) Bird risk area	• Areas with potential threat e.g. highways, hunting areas, enhanced human impact and predator occurence. • Presence of clearing, burning and shifting cultivation areas (need further survey). • Statement from local people. • General reports about bird risk and locations they have been spotted.	

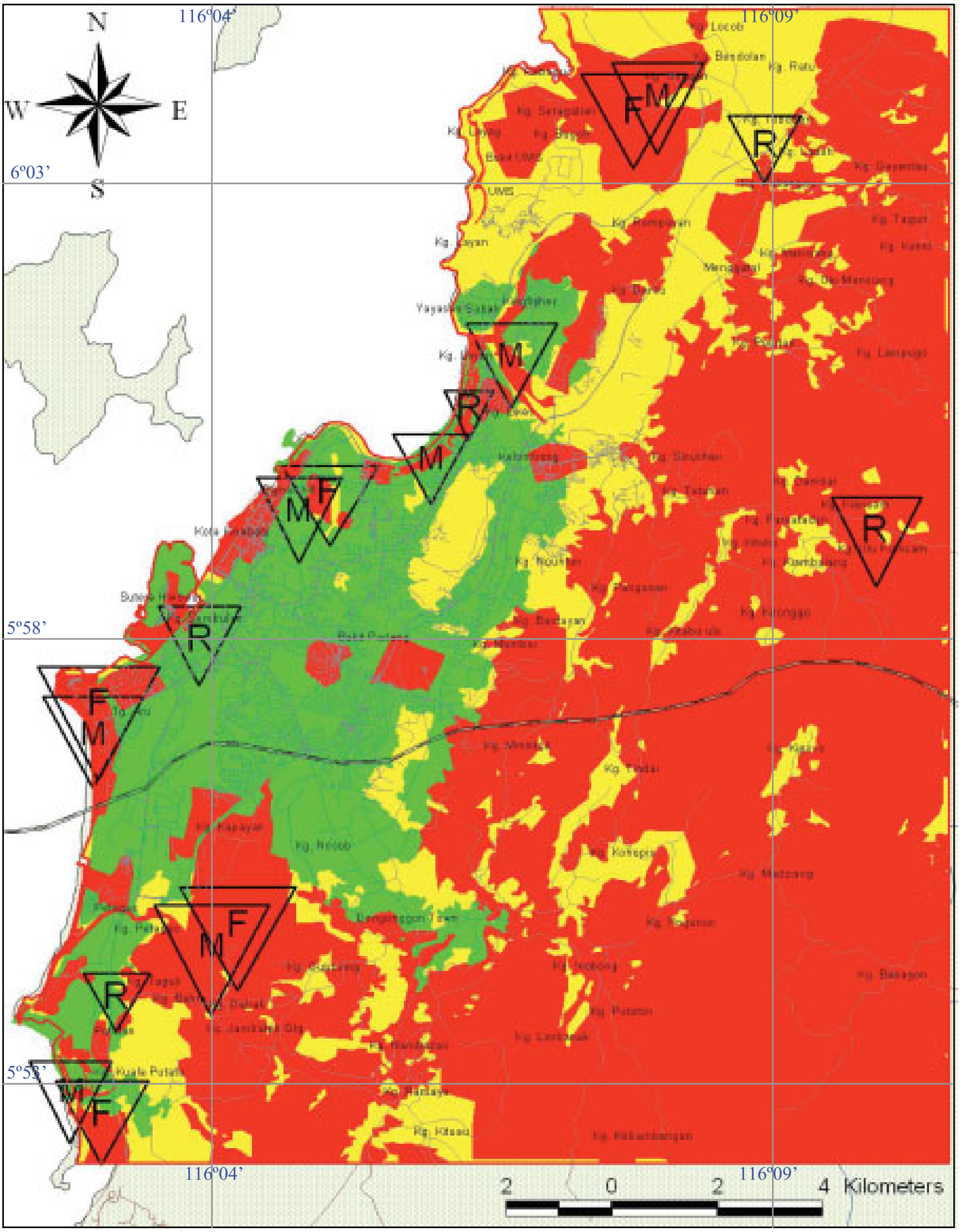


Figure 46: Proposed bird habitat function map in Kota Kinabalu, Malaysia (partly similar to potentially rich birdlife areas as mapped in figure 27)
(Source: Own presentation, Scale 1:50,000)

7.5.2 Nature conservation function

Forests are common in most of Sabah's landscapes and in their capacity as widespread network of ecosystems that are still fairly close to nature, they are essential for the conservation of biotopes and species. Nature conservation function of forests must aim at warranting the dynamics of the forest as ecosystem with all its ecologically characteristic features and processes in all its stages in space and time.

The nature conservation forest not only calls for the safeguard of particularly worthy areas (e.g. protected area by law), but also for the forest management to be executed with such care that no species existence is jeopardised. Whereas applicable, research activity should be conducted in the nature conservation forest to maximize safety measures of the ecosystem that are worth to be protected.

The criteria for analysing nature conservation function in Kota Kinabalu district includes: 1) Forest surface with special function for nature and landscape conservation, and 2) Forest surface with special function for research, and genetic resources. The definition of each criterion are given below and as the result of classifying nature conservation areas for the locations mentioned in table 55, a proposed nature conservation function map in Kota Kinabalu is presented in figure 47.

a) Criterion: Forest surface with special function for nature conservation

<u>Definition:</u>

Forest surfaces with special function for nature and landscape conservation served as preservation of special kinds of habitats. They also retain the characteristic, variety and beauty of certain ranges of nature and the culture landscape. (e.g. unique ecosystems, cultural sites, forest reserves, bird sanctuary, national park, mangrove reserve and wildlife reserve).

Verifier/ Indicator:

- Occurences of important vegetation types, wildlife species, and sites with special interest that might be needed to be conserved (need for further research).
- The status (rare, threatened, endangered, or extinct) of dependent species which are at the risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment (Wildlife Conservation Enactment Sabah, 1987).
- Sites that are important for preserving the cultural landscape and also become important refuge and feeding grounds for many species of fauna i.e. birds, acquatic animals and mammals.
- Sites of an important regulatory function (creating unique ecosystems) which also create an important living sanctuary for specific trees, plants, birds and fishes. i.e. wetlands, swamps and mangroves.
- Occurences of core zones that are protected (by respective individual's bodies) with or without binding.

b) Criterion: Forest surface with special function for research and genetic resources

Definition:

Forest surfaces with special function for research or with genetic resources serve the attempt for research education purposes, dealing with scientific institutions and government bodies in the country which promoted research and enhance awareness amongst peoples e.g. the universities, professional environmental education schools etc. They serve the scientific-ecological forest research in different fields. They also may provide a special function as genetic resources areas, to serve as preservation and use of the genetic variety of forests and forest products.

Verifier/ Indicator:

- Forested or green area that is important for research and education purposes which emphasises on educational and awareness activities.
- Sites of special scientific interest, e.g. areas of long-standing research related to environmental bodies.
- Area for the inventory and survey of tree species, wildlife species and sites with special interest.
- An important site that serves as a dynamic formation and gene bank for flora and fauna.
- Forest areas (core zones) that are already categorised as reservations area (e.g. Kota Kinabalu wildlife sanctuary, state parks, restricted-access forests, etc).

Table 55: Classifying nature conservation function areas in different locations in Kota Kinabalu, Malaysia

Area/ Location	Functions	
	Forest surface with special function for nature and landscape protection	Forest surface with special function for research, and genetic resources
Sepanggar	**X**	**X**
Signall Hill	**X**	**X**
Bukit Padang		
Tg. Aru	**X**	**X**
Putatan	**X**	**X**
Kg. Banka Banka	**X**	
Kg. Kebambangan		
Kg. Babagon	**X**	**X**
Kg. Kipouvo		
Kg. Kionsom		
Kg. Lampugo		
Kg. Kokol		
Kg. Kituau		
Kg. Inobong		
Kg. Tindai		
Kg. Kitabu	**X**	**X**
Kg. Pulutan		
Kg. Bendolan		

Note: X = Present and important

Table 56: Proposed map legend for nature conservation function areas in Kota Kinabalu, Malaysia

<table>
<tr><th>Criteria</th><th colspan="2">Indicator/ Description/ Area (ha)</th><th>Legend</th></tr>
<tr><td rowspan="3">Forest surface with special function for nature conservation</td><td>With legal binding
(Enforced with certain laws, enactments or guidelines: body of rules for the society that are enforceable through a system)</td><td>2,636 ha</td><td></td></tr>
<tr><td>Without legal binding
(Without enforcement with certain laws, enactments or guidelines)</td><td>856 ha</td><td></td></tr>
<tr><td colspan="2">• Occurences of important vegetation types, wildlife species, and sites with special interest that might be needed to be conserved (need further research).
• The status (rare, threatened, endangered, or extinct) of dependent species which are at the risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment (Wildlife Conservation Enactment Sabah, 1987).
• Sites that are important for preserving the cultural landscape and also become important refuge and feeding grounds for many species of fauna i.e. birds, acquatic animals and mammals.
• Sites of an important regulatory function (creating unique ecosystems) which also create an important living sanctuary for specific trees, plants, birds and fishes. i.e. wetlands, swamps and mangroves.
• Occurences of core zones that are protected (by respective individual's bodies) with or without binding.</td><td></td></tr>
<tr><td>Forest surface with special function for research and genetic resources</td><td colspan="2">• Forested or green area that is important for research and education purposes which emphasises on educational and awareness activities.
• Sites of special scientific interest, e.g. areas of long-standing research related to environmental bodies.
• Area for the inventory and survey of tree species, wildlife species and sites with special interest.
• An important site that serves as a dynamic formation and gene bank for flora and fauna.
• Forest areas (core zones) that are already categorised as reservations area (e.g. Kota Kinabalu wildlife sanctuary, state parks, restricted-access forests, etc).</td><td>C</td></tr>
</table>

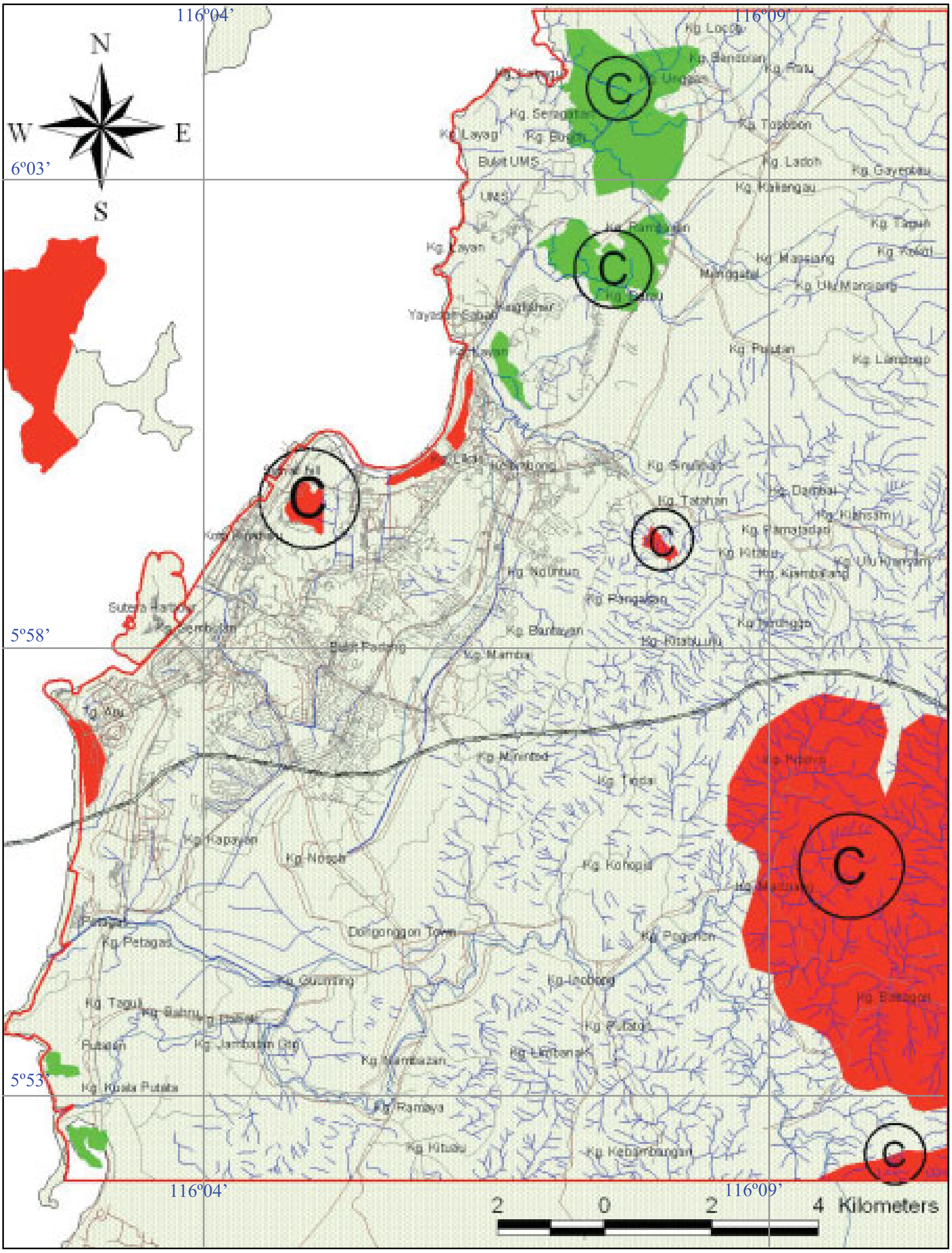


Figure 47: Proposed nature conservation function map in Kota Kinabalu, Malaysia
(Source: Own presentation, Scale 1:50,000)

7.5.3 Protection function

The natural environment suffers from continuous adverse impacts caused by the growth of industries, settlements and traffic. Climate changes have become evident. Consequently the protective functions of forests and green spaces become more mandatory.

An unmanaged forest would probably be able to sufficiently warrant the larger part of protective functions, in particular the regulation of water and local climate features, the prevention of erosion or the protection from noise and immissions. For the purpose of fostering the protective functions of the remaining urban green spaces and forests as described below, certain measures to prevent potentially dangerous impacts should also be implemented. The following protective functions have particularly to be kept in mind in Kota Kinabalu:

a) Regulation of the Water Balance

Forests and forest soils filter and store water, thus aiding the replenishment of the ground water. A particularly favourable effect is given by the fact that the stored water is released into the environment in a very slow and steady manner. In this way, forests can also contribute to flood protection.

b) Regulation of the Climate

Forest can affect the local or regional climate very directly, for instance by acting as wind brake or by providing cool and fresh air, thus reducing temperature amplitudes. Further, forests extract CO_2 from the atmosphere by their natural growth (photosynthesis) and store it in the wood of their trees for a long time to come. Therefore, the United Nations, last but not least by way of the Kyoto Protocol of the Climate Convention, have ascribed the forests a vital role as carbon sinks.

c) Protection from Erosion

The function of forests for the protection of coastal areas, man-made structures (roads, villages, etc.) and steep slopes from erosion is largely confined to the hilly and undulating topography of Sabah, and thus of particular significance.

Forests mainly serve to prevent landslides from starting, but they are also capable of slowing down or even stopping landslides once they fall. On the other hand, the significance of the forest's function of protection from soil erosion applies not just to the mountains, but also to the hilly country making up a large portion of Sabah's topography.

d) Protection from Noise

Forests serve to protect people from noise and to reduce excessive noise impact, which becomes particularly relevant in the vicinity of residential and recreation areas.

e) Protection from Immissions

By absorbing, degrading, and modifying airborne pollutants (aerosols, gases, and radiation) or by acting as a simple filter for dust, forests help to preserve or improve air quality.

The criteria for analysing the protection (protective) function of forests and green areas in Kota Kinabalu district include: 1) Watershed protection, 2) Climate protection, 3) Soil and coastal protection, 4) Protection from noise, and 5) Protection from immission. The definition of each site criterion is given in the following paragraphs. The results of classifying protection function areas are presented in figures 48 - 52.

1. a) Criterion: Watershed protection forest

Definition:

A watershed area is a region of land where water drains downhill into a specified body of water, such as a river, lake, sea, ocean or wetland. A watershed includes both the waterway and the land that drains to it. Watershed protection forest secures and improves the quality of the groundwater as well as standing and flowing surface waters. It improves the steadiness of the water and at the same time reduces the danger of flood damages and erosion.

Verifier/ Indicator:

- Number and percentage of creeks that flow into the water bodies in the respective investigation areas (e.g. river, stream, lake, pond).
- Interview with counsellors, chief villagers and local community in the area concerning the presence of water bodies, historic uses, villager's needs and further information.
- Super position pattern of rivers using settelite images and aerial photograph to analyse.
- Field survey and identification/investigation of river type, distribution and flow in the respective investigation areas.
- Statement from dependent villagers concerning the importance of rivers as a source of drinking water supply, as well as freshwater springs (further survey needed).

1. b) Criterion: Flood risk area

Definition:

Area with potential flood hazards that result from desertification, clearing or landuse activities. These areas were previously important for watershed protection that is determined to be a base of flood protection. They are identified as subject to more than one hazard (i.e. flood, mudslide, mudflow and flood-related erosion) and will be designated by use of the proper symbols in combination.

Verifier/ Indicator:

- Area where flooding usually occurred or might happen if the forests are cleared (i.e. judge by looking at the landform and topography characteristics with slopes more than 25° and also river pattern moving downward from higher terrain).
- Interview with counselors, chief villagers and local community in that respective area concerning the occurrences of flooding in the past (need for further research).
- Super-position and analyzing of water flow and terrain by using aerial photograph and digital data (satellites images) the potential prone area (need for further study).
- Field survey and identification/investigation of river type, distribution and flow.

2. a) Criterion: Soil and coastal protection forest

Definition:

Soil protection forest controls its own location as well as neighbouring terrains from the effects of water and wind erosions, soil slips, earth aborts, soil creeping and falling rocks. Coastal protection forest protects the direct coastal range as well as the neighbouring ranges (settlements and shores) from the effects of tidal waves and wind erosions as well as scouring, soil blowing, soil slips and earth aborts.

Protection from soil erosion mainly serves to prevent displacement of solids (soil, mud, rock, and other particles) by the agents of wind and water movement in response to gravity, or living organisms. Protection from soil abrasion (erosion) or landslides applies not just to the mountains, but also to the hilly country and coastal area. Too much erosion can cause problems, clogging streams with gravel, filling reservoirs with sediments, reducing soil fertility and water quality. The factors controlling soil erosion (steepness, slope length, soil erodibility, nature of plant cover, etc.) were analysed. High-risk erosion areas are marked on the map to be put under intensive care against clearing, logging, development, or even exclusion and excision from any development.

Verifier/ Indicator:

- Field survey and site investigation of areas with steep slopes which might be susceptible to erosion by using altimeter and suunto-clinometer.
- Soil test for analyzing the physical properties and texture of the soil aggregate.
- Super-position of aerial photograph, digital data (satellites images) and topographic map to analise prone areas.
- Urban land with significant soil compaction or change in physical soil properties resulting from human activities.
- Percentage of hilly and undulating areas with slopes more than 25º which should not be disturbed or distracted with any development.
- Percentage of coastal area without vegetation barrier, mangrove and coastal tree which are potentially affected from tidal waves and wind.
- Sites of special importance that prevent from erosion (coastal or tidal erosion, soil and wind erosion).

2. b) Criterion: Soil erosion risk area

Definition:

The risk of soil erosion is a serious and long term problem. Nuisance problems caused by soil being eroded from the fields and deposited onto roads, urban areas and into rivers. In addition to these nuisance problems there are even more serious concerns as to the effect of continually losing topsoil from forest areas. The impacts of soil loss on forest areas are that the long term fertility of the soil is slowly replenished by natural soil-forming processes. Nevertheless, mainly urban areas located in elevated area, in where green form is still left with value for soil protection and if these areas are cut, problem towards landslide and unfertile soil in future.

Verifier/ Indicator:

- Super-position in map and analysis of the presence of important topography characteristics in the respective areas i.e. steep slopes terrain of more 25° (figure 39).
- Using satellites images and topographic map to analise prone areas prior to field investigation.

- Field investigation of potentially soil erosion risk areas i.e. analyzing the physical and texture properties of the soil.
- Interview with counselors, chief villagers and local community in that respective area of the occurrences of soil erosion in the past.
- Presence of affected areas by tidal or river erosion.

3) Criterion: Climate protection forest

Definition:

Forests and green areas store vast amounts of carbon. As forests are cleared, carbon dioxide (CO_2), the most abundant greenhouse gas is released. Conversely, conserving forests, planting new ones, restoring grasslands, and reducing forest disturbances, removes carbon dioxide from the atmosphere and stores it in plants.

Thus, forests and greens can, if managed properly, act as a carbon "sink," helping curtail global warming. Indeed, carbon sequestration in forests and greens lands can provide an effective, low-cost way to offset a portion of greenhouse-gas-emissions. The criterion for climate protection forest in this study includes both aspects, namely: local climate protection *(protection of climate between interior of town, residentials and settlements areas)* and regional climate potection forests *(more generally significant to all geographical area)*.

Verifier/ Indicator:

- Percent and number of tree dominated or forested area inside the city and settlements ranges.
- Interview with counselor, public and local people concerning the benefit and importance of tree dominated and forested areas for the urban environment.
- Inventory and identification/investigation of tree species in that area.
- Super-position and analysis of the area covered by trees, shrubs and grassland with significance to climate abatement by using several maps, aerial photograph and digital data (satellites images).

- Super-position and analysis of the presence of important topographic characteristics in the respective areas i.e. steep slopes terrain as an abatement of the climate changes.
- Using climate data by comparing several climatic stations within the study area (source from Metereology Department Kota Kinabalu).

4) Criterion: Protection from noise

Definition:

Forests can serve to protect from noise and to reduce excessive noise impact. The trees absorb noises thus decreasing the sound pressure level, which becomes particularly relevant in the vicinity of residential and recreational areas. In general, noise distribution function decreases with distances and noise pollution refers to any noise which may irritate one's ear but noise pollution can also be annoying and harmful to animals. High levels of noise may interfere with the natural cycles of animals, which may change their migration paths to avoid the sound.

Verifier/ Indicator:

- Forested area which adjoins noise sources like industrial plants, highways and other, traffic lines, road conjunctions etc. and may serve as a noise barrier or shield/wall with limit to 100 m away (need for further survey).
- Areas that are specifically susceptible to noise pollution, like residential and recreation areas and depend on sufficient distances from main noise source.
- Percentage of industrial plants which produce excessive noises near the settlement ranges, villages and recreation areas.
- Using the sound measurement equipment e.g. Sound Level Meter (SLM) to measure the degree and unit of affected noises (dB) in the selected urban area and usually measured up to 100 m from source (Volk & Schirmer, 2004) (need for further survey).

5) Criterion: Protection from immission

Definition:

Forests help to preserve or improve air quality by absorbing, degrading, and modifying airborne pollutants (aerosols, gases, and radiation) produce by large industrial area or by acting as a simple filter (for dust) from the traffic. Forests, which serve the immission control, reduce harm-causing or troubling effects, which might reach humans directly or indirectly by means of filtering the air. They thus protect living, work and recreation ranges, settlements and economical effective areas against the unfavourable effects from gases, types of dust, and aerosols. Local immission forest is defined by its location between an emitter and the surrounding areas which might need to be protected.

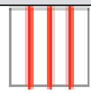
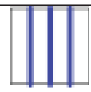
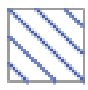
Verifier/ Indicator:

- Percentage of industrials plants which produce excessive immission near the settlement ranges, villages and people recreation area.
- Forested areas adjoining pollution sources like city or industrial areas, highways, traffics and road conjunctions.
- Areas with significant and susceptible immission problems more specifically concentrated on vulnerable ‘urban’ areas where protection is needed: residential and village areas.
- Literatures and reports where these areas are found.

Table 57: Proposed map legend for protection function areas in Kota Kinabalu, Malaysia (Contd.)

<table>
<tr><th>Criteria</th><th colspan="2">Description/ Area (ha)</th><th>Legend</th></tr>
<tr><td rowspan="4">1) Watershed protection forest</td><td>Very Important</td><td>12,527 ha</td><td></td></tr>
<tr><td>Important</td><td>3,188 ha</td><td></td></tr>
<tr><td>Less Important</td><td>1,457 ha</td><td></td></tr>
<tr><td colspan="2">• Number and percentage of creeks that flow into the water bodies in the respective investigation areas (e.g. river, stream, lake, pond).
• Interview with counsellors, chief villagers and local community in the area concerning the presence of water bodies, historic uses, villagers needs and further information.
• Super-position pattern of rivers using settelite images and aerial photograph to analyse.
• Field survey and identification/investigation of river type, distribution and flow in the respective investigation areas.
• Statement from dependent villagers concerning the importance of rivers as a source of drinking water supply, as well as freshwater springs (further survey needed).</td><td></td></tr>
<tr><td>1.1) Flood risk area</td><td colspan="2">• Area where flooding usually occurred or might happen if the forests are cleared (i.e. judge by looking at the landform and topography characteristics with slopes more than 25° and also river pattern moving downward from higher terrain).
• Interview with counselors, chief villagers and local community in that respective area concerning the occurrences of flooding in the past (need further research).
• Super-position and analyzing of water flow and terrain by using aerial photograph and digital data (satellites images) the potential prone area (need further study).
• Field survey and identification/investigation of river type, distribution and flow.</td><td>F</td></tr>
</table>

Criteria	***Description/ Area (ha)***		***Legend***
2) Soil and coastal protection forest	Very Important	12,430 ha	
	Important	5,557 ha	
	Less Important	5,298 ha	
	• Field survey and site investigation of areas with steep slopes which might be susceptible to erosion by using altimeter and suunto-clinometer. • Soil test for analyzing the physical properties and texture of the soil aggregate. • Super-position of aerial photograph, digital data (satellites images) and topographic map to analise prone areas. • Urban land with significant soil compaction or change in physical soil properties resulting from human activities. • Percentage of hilly and undulating areas with slopes more than 25º which should not be disturbed or distracted with any development. • Percentage of coastal area without vegetation barrier, mangrove and coastal tree which are potentially affected from tidal waves and wind. • Sites of special importance that prevent from erosion (coastal or tidal erosion, soil and wind erosion).		
2.1) Soil erosion risk area	• Super-position in map and analysis of the presence of important topography characteristics in the respective areas i.e. steep slopes terrain of more 25° (figure 39). • Using satellites images and topographic map to analise prone areas prior to field investigation. • Field investigation of potentially soil erosion risk areas i.e. analyzing the physical and texture properties of the soil. • Interview with counselors, chief villagers and local community in that respective area of the occurrences of soil erosion in the past. • Presence of affected areas by tidal or river erosion.		E

Criteria	*Description/ Area (ha)*		*Legend*
3) Climate protection forest	Local climate protection *(Protection of climate between interior of town, residentials and settlements areas)*	1,981 ha	
	Regional climate protection *(more significant to all geographical area)*	12,527 ha	
	• Percent and number of tree dominated or forested area inside the city and settlements ranges. • Interview with counselor, public and local people concerning the benefit and importance of tree dominated and forested areas for the urban environment. • Inventory and identification/investigation of tree species in that area. • Super-position and analysis of the area covered by trees, shrubs and grassland with significance to climate abatement by using several maps, aerial photograph and digital data (satellites images). • Super-position and analysis of the presence of important topographic characteristics in the respective areas i.e. steep slopes terrain as an abatement of the climate changes. • Using climate data by comparing several climatic stations within the study area (source from Metereology Department Kota Kinabalu).		
4) Protection from noise	• Forested area which adjoins noise sources like industrial plants, highways and other, traffic lines, road conjunctions etc. and may serve as a noise barrier or shield/wall with limit to 100 m away (need for further survey). • Areas which are specifically susceptible to noise pollution, like residential and recreation areas and depend on sufficient distances from main noise source. • Percentage of industrial plants which produce excessive noises near the settlement ranges, villages and recreation areas.		

	• Using the sound measurement equipment e.g. Sound Level Meter (SLM) to measure the degree and unit of affected noises (dB) in the selected urban area and usually measured up to 100 m from source (Volk & Schirmer, 2004) (need for further survey).		
5) Protection from immission	• Percentage of industrials plants which produce excessive immission near the settlement ranges, villages and people recreation area. • Forested areas adjoining pollution sources like city or industrial areas, highways, traffics and road conjunctions. • Areas with significant and susceptible immission problems more specifically concentrated on vulnerable 'urban' areas where protection is needed: residential and villager areas. • Literatures and reports where these areas are found.		
Resedential areas, settlement and urban associates	Major town	Population density > 600 per km²	
	Minor town	Population density < 600 per km²	
	Village	Population density < 100 per km²	

Table 58: Classifying protection function area based on different locations in Kota Kinabalu, Malaysia

Area/ Location	**Function**						
	Watershed protection forest	*Soil and coastal protection forest*	*Climate protection forest*	*Protection from noise*	*Protection from immission*	*Risk flash flood area*	*Risk soil erosion area*
Sepanggar		X	X				X
Signall Hill		X	X	X	X		
Bukit Padang		X	X	X	X		
Tg. Aru		X	X	X	X		
Putatan		X	X	X			X
Kg. Banka Banka					X		
Kg. Kebambangan	X	X	X				
Kg. Babagon	X	X	X			X	X
Kg. Kipouvo	X	X	X				
Kg. Kionsom	X	X	X			X	X
Kg. Lampugo	X	X	X				
Kg. Kokol	X	X	X				X
Kg. Kituau						X	
Kg. Inobong	X	X	X			X	X
Kg. Tindai	X	X	X			X	
Kg. Kitabu	X	X	X			X	X
Kg. Pulutan	X	X	X		X	X	
Kg. Bendolan							

Note: X = Present and important

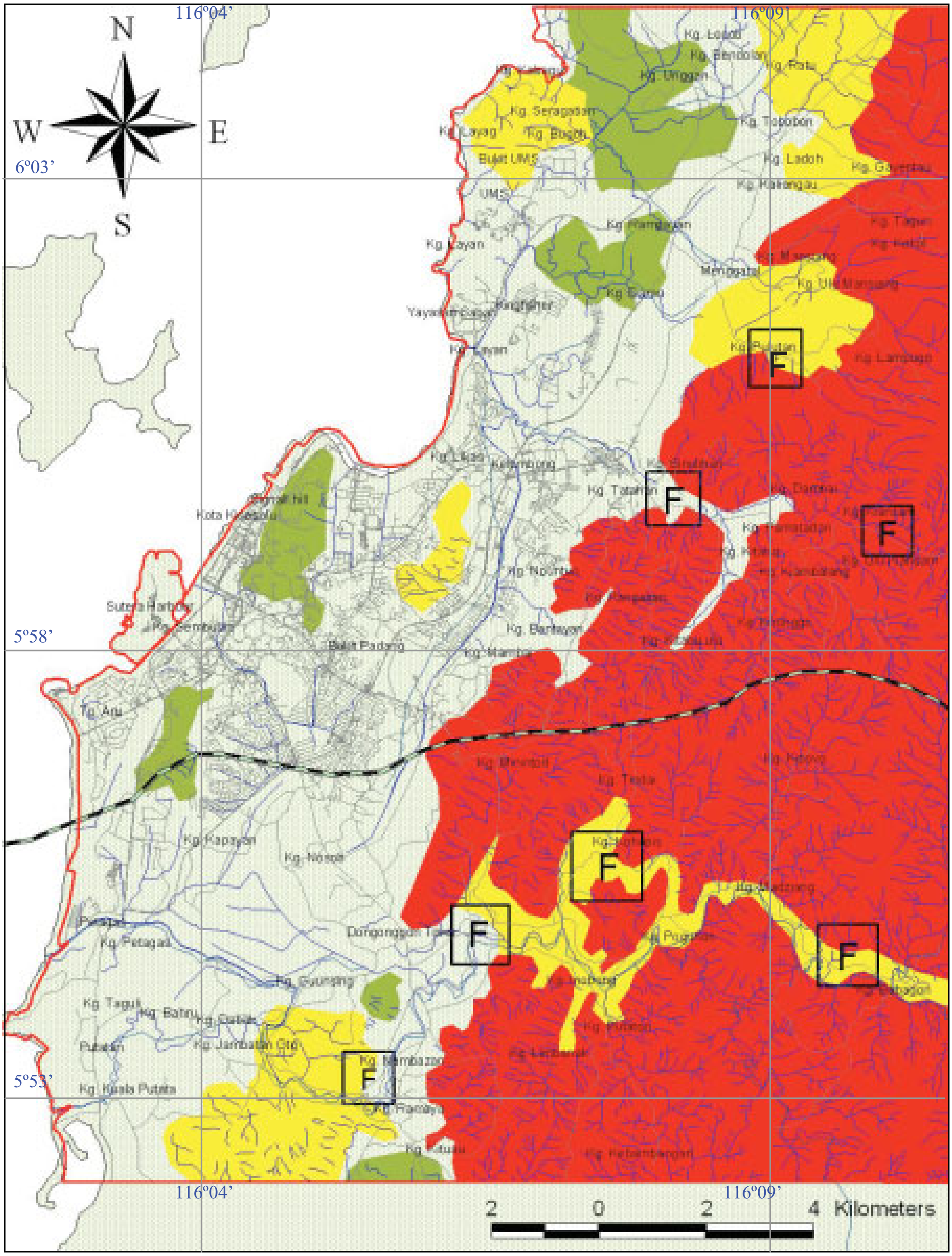


Figure 48: Proposed watershed protection forest in Kota Kinabalu, Malaysia
(Source: Own presentation, Scale 1:50,000)

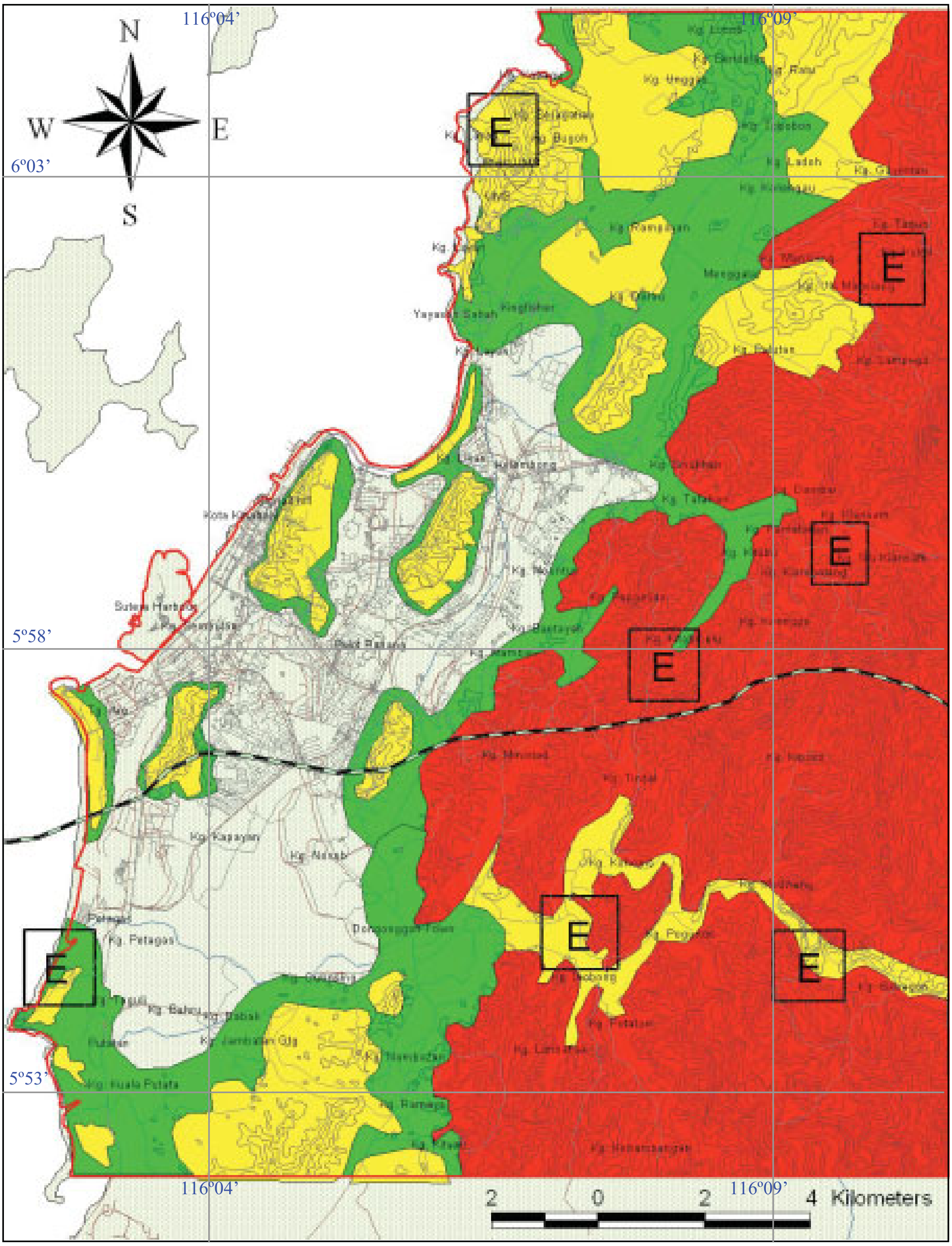


Figure 49: Proposed soil protection forest in Kota Kinabalu, Malaysia
(Source: Own presentation, Scale 1:50,000)

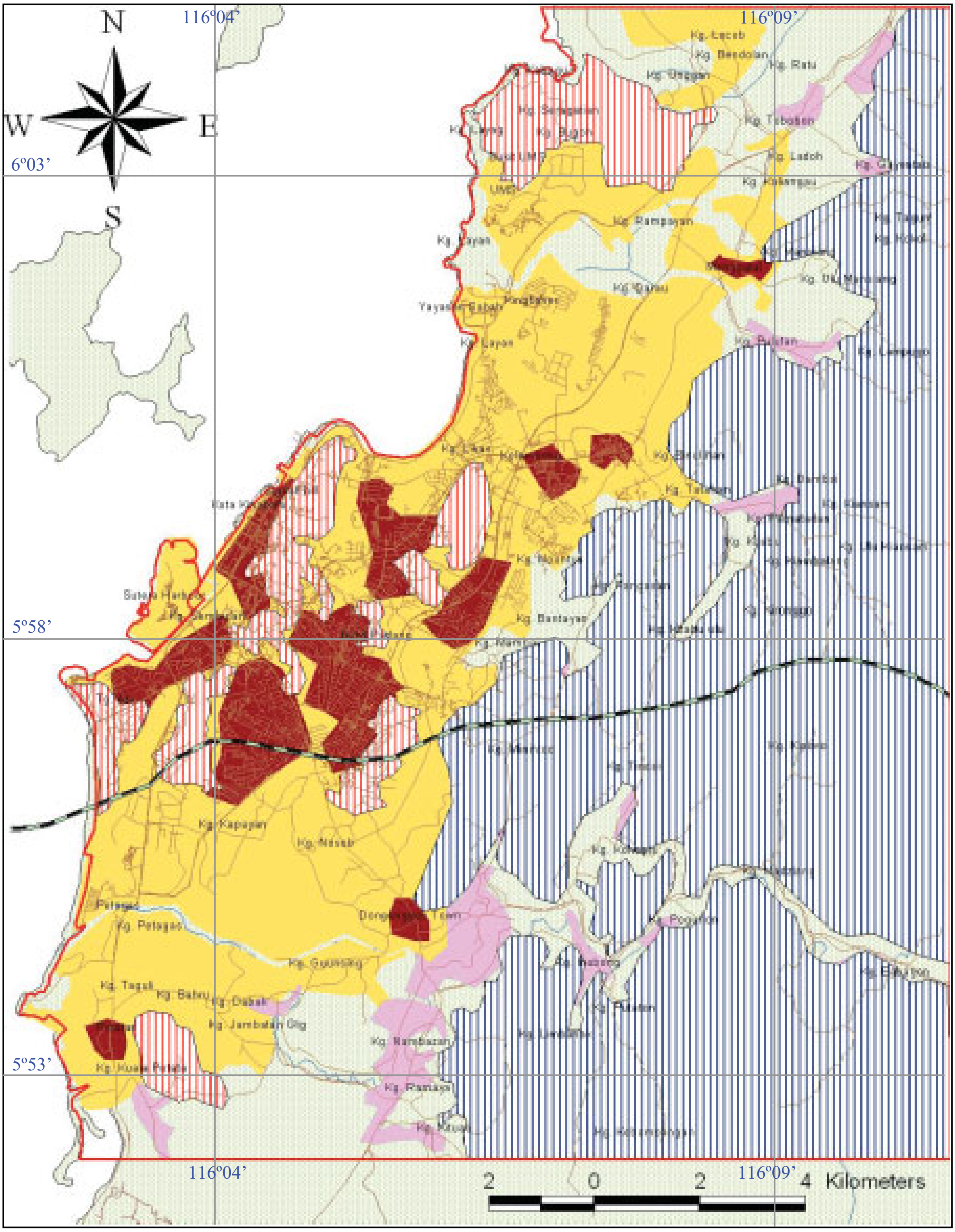


Figure 50: Proposed climate protection forest in Kota Kinabalu, Malaysia
(Source: own presentation, Scale 1:50,000)

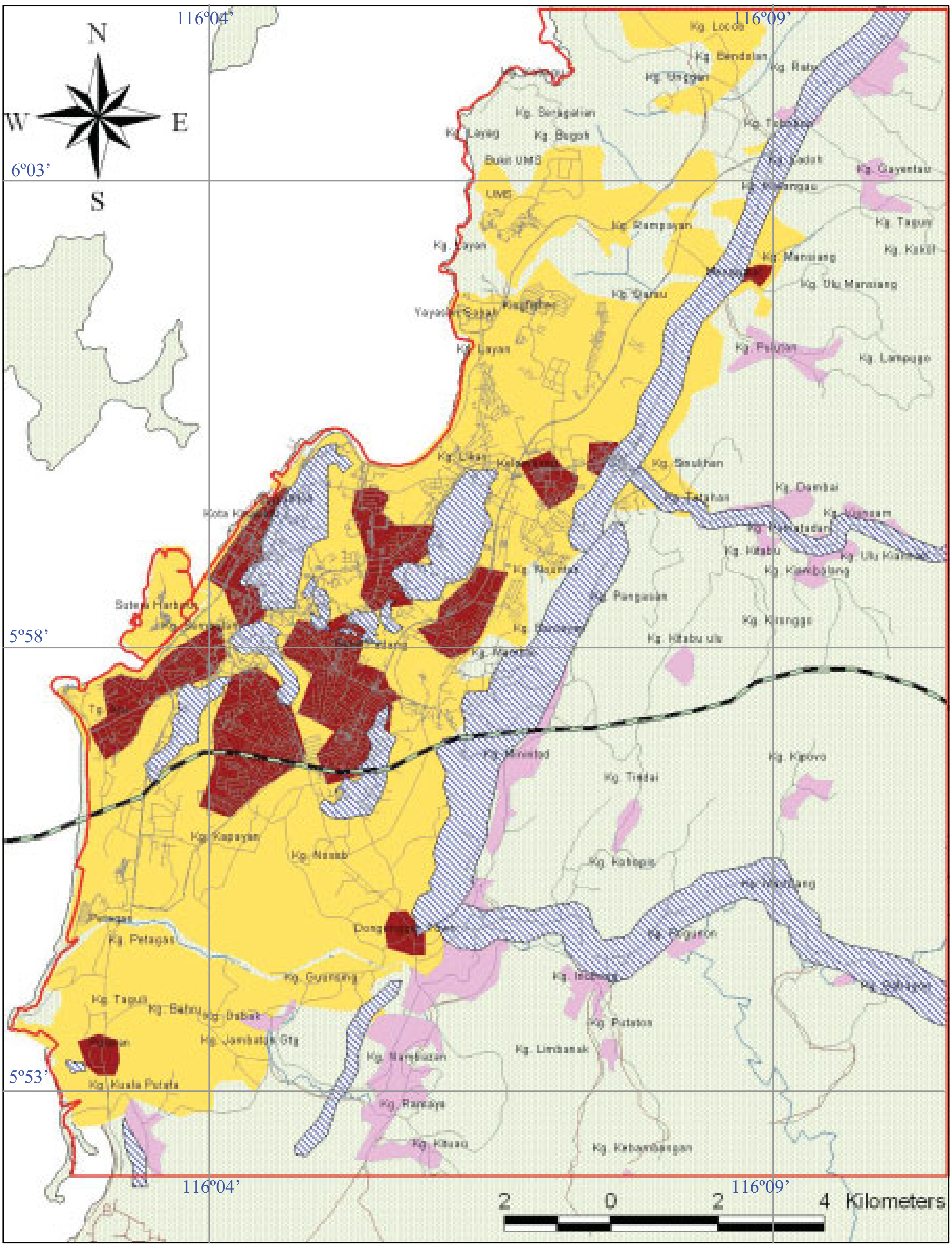


Figure 51: Proposed noise protection forest in Kota Kinabalu, Malaysia
(Source: Own presentation, Scale 1:50,000)

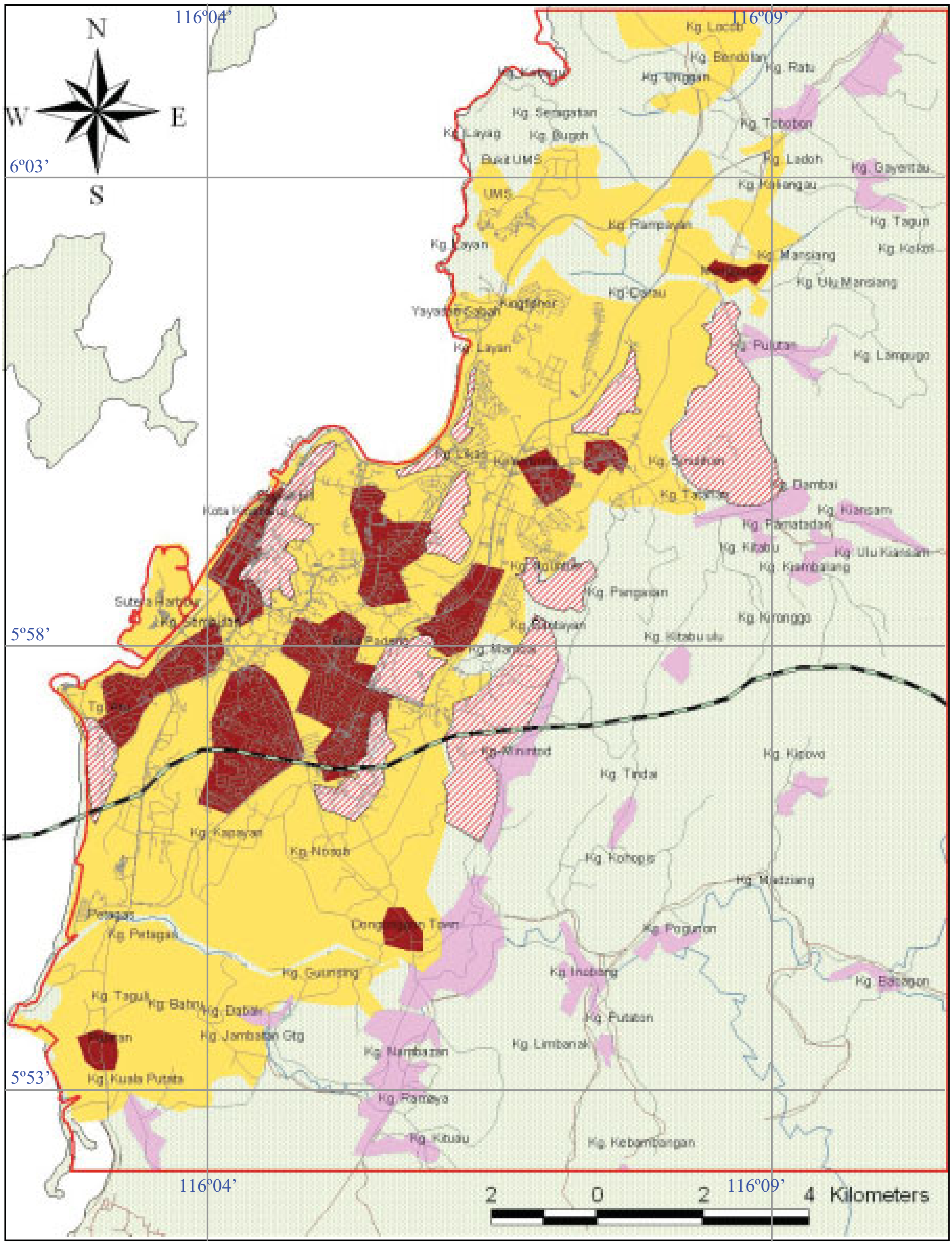


Figure 52: Proposed immission protection forest in Kota Kinabalu, Malaysia
(Source: Own presentation, Scale 1:50,000)

7.5.4 Recreation function

Unlike the conservation functions of forests, recreation activities in forests in many cases, depend on the prior services of forestry. Access to the forest provided via roads and tracks is a prerequisite to recreation for the majority of visitors (e.g. picnicking, fishing and wildlife observation).

Outdoor sports which involve the forest (e.g. hiking, trekking, jogging, mountain biking, climbing, etc.) are becoming increasingly popular, frequently leading to new conflicts with nature conservationists. In the eyes of most recreation-seekers, it is out of question that forests do contribute considerably to the favourable appearance of the landscape. Moreover, forests, or groups of trees, can act as screen, helping to offset visual nuisances or to structure the landscape.

The criteria for analysing the recreation function areas in Kota Kinabalu district include: 1) Recreation forests, and 2) Outdoor recreation spots. The definition of both criteria is given in the following paragraphs and the proposed recreation function map for Kota Kinabalu is presented in figure 53. The result of classifying recreation function areas is given in table 59. Not all of the needed information for classifying the recreation function is already available in this study, thus further research is needed.

a) Criterion: Recreation forest

<u>Definition:</u>

Recreation forests provide physical and psychological benefits to recreation-seekers, as well as nature experience. Such forests can play an important role in increasing public awareness and appreciation of the multiple roles that forests offer to society. Recreation is the use of time in a non-profitable way, in many ways also therapeutic refreshment of one's body or mind.

Verifier/ Indicator:

- Distances from the residential areas to the respective forest (need for further survey)
- Statement of the citizens about the frequency they use the forest for recreation purposes (further research needed).
- Availability of good infrastructure in the area (i.e. asphalt road and with public transportation).
- Presence of forestland already managed for general recreation and tourism, in relation to the total forested area (need for further survey).
- Number of visitors per month in specific recreation areas (need for further survey).
- Specific forested areas with potentially important visitor attractions e.g. waterfall area, river, wildlife observation area, scenic views etc (need for further survey).

b) Criterion: Outdoor recreation spot

Definition:

An outdoor recreation spot is an area with significant places for certain recreation activities and outdoor sports. All activities that can be done in nature, such as camping, birding, hiking, mountain climbing, fishing, and swimming etc. are included.

Verifier/ Indicator:

- Numbers of outdoor recreation spots within a forested and green space areas (need for further research).
- Recreation activities practiced in the forested area or green spaces closed to the city.
- Percentage of green space devoted specifically to formal sport activities e.g. hiking, climbing and camping etc. (need for further research).
- Type of facilities available for general recreation and outdoor recreation spots in the forest area.
- Statement and perception from the public involved in outdoor recreation activities near the forest (need for further research).

Table 59: Classifying recreation function areas in different locations in Kota Kinabalu, Malaysia

Area/ Location	**Functions**	
	Recreation forest	*Outdoor recreation spot*
Sepanggar	**X**	
Signall Hill	**X**	**X**
Bukit Padang	**X**	**X**
Tg. Aru	**X**	**X**
Putatan		
Kg. Banka Banka		
Kg. Kebambangan	**X**	**X**
Kg. Babagon	**X**	**X**
Kg. Kipouvo	**X**	
Kg. Kionsom	**X**	**X**
Kg. Lampugo	**X**	
Kg. Kokol	**X**	
Kg. Kituau		
Kg. Inobong	**X**	
Kg. Tindai	**X**	
Kg. Kitabu	**X**	
Kg. Pulutan		
Kg. Bendolan		

Note: X = Present and important

Table 60: Proposed map legend for recreation function areas in Kota Kinabalu, Malaysia

Criteria	***Indicator/ Description/ Area (ha)***		***Legend***
Recreation forest	Very Important	3,167 ha	
	Important	10,724 ha	
	Less Important	2,311 ha	
	• Distances from the residential areas to the respective forest (need for further survey) • Statement of the citizens about the frequency they use the forest for recreation purposes (further research needed). • Availability of good infrastructure in the area (i.e. asphalt road and with public transportation). • Presence of forestland already managed for general recreation and tourism, in relation to the total forested area (need for further survey). • Number of visitors per month in specific recreation areas (need for further survey). • Specific forested areas with potentially important visitor attractions e.g. waterfall area, river, wildlife observation area, scenic views etc (need for further survey).		
Outdoor recreation spot	• Numbers of outdoor recreation spots within a forested and green space areas (need for further research). • Recreation activities practiced in the forested area or green spaces closed to the city. • Percentage of green space devoted specifically to formal sport activities e.g. hiking, climbing and camping etc. (need for further research). • Type of facilities available for general recreation and outdoor recreation spots in the forest area. • Statement and perception from the public involved in outdoor recreation activities near the forest (need for further research).		R

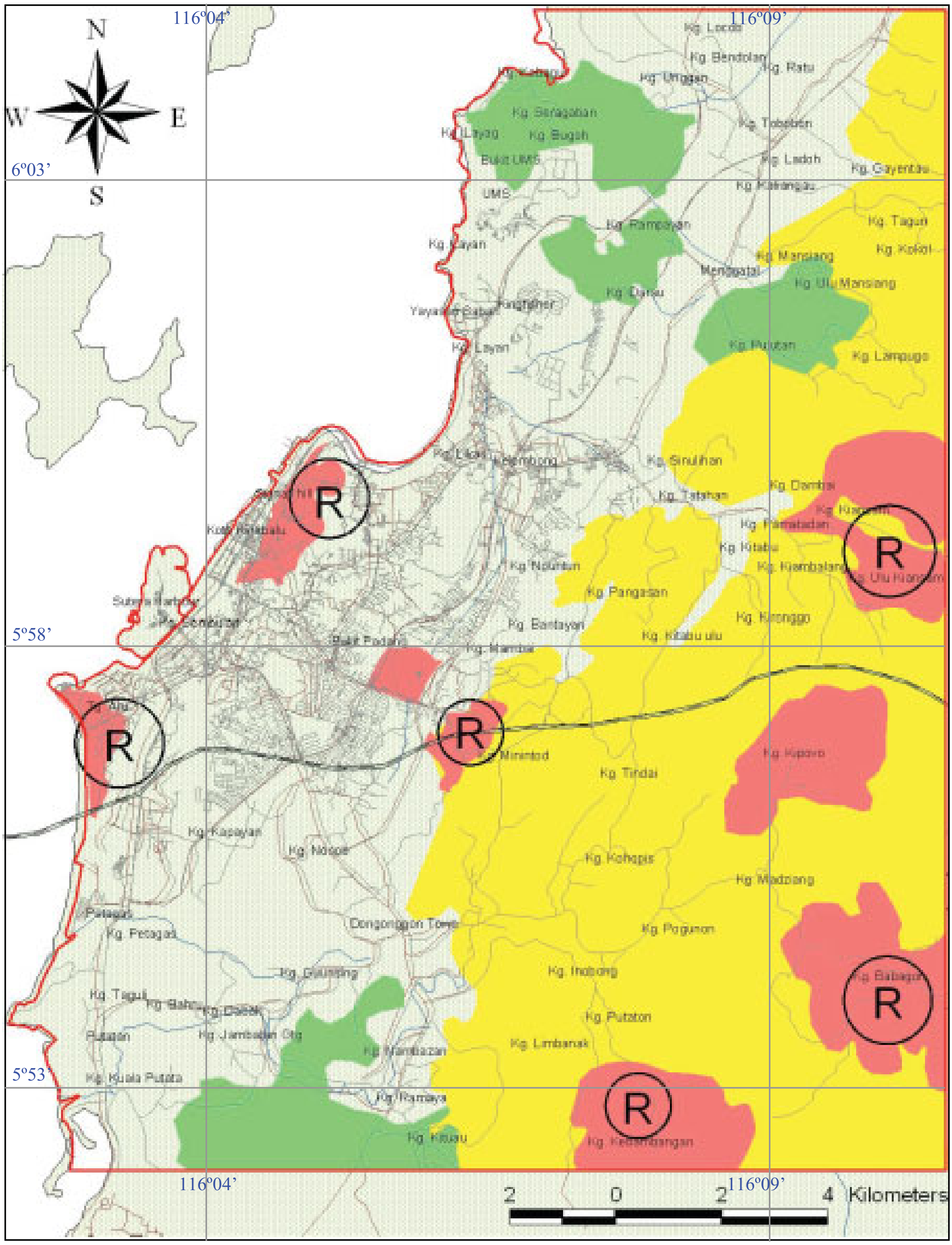


Figure 53: Proposed recreation function map in Kota Kinabalu, Malaysia
(Source: Own presentation, Scale 1:50,000)

7.5.5 Utility function

The utility function in a narrow sense of the word implies economic utilization, i.e. the utilization of natural resources. These resources are wood (fuel wood, timber, etc.) and other non-wood forest products such as medicinal plants etc. Usually, the local communities in Sabah take all these for economic and local consumption purposes.

The criteria for analysing utility areas in Kota Kinabalu district include: 1) Fuel wood, 2) Timber, and 3) Non-wood forest products. The definitions of each criterion are given in the following paragraph and as the result of classifying utility areas based on different locations as shown in table 61. The proposed utility function map is presented in figure 54.

a) Criterion: Fuel wood

Definition:

Usually the wood is used as a solid fuel for cooking. The amount depends on several considerations including the socio-economiy of local communities, their geographic location, the availability of wood resources, costs of fuel wood species for consumption and local communities preferences regarding the qualities of various wood types.

Verifier/ Indicator:

- Statement from public, local people in dependent communities by survey and interview (need further survey).
- Numbers of villages within a green area which use fuelwood for cooking purpose.
- Field survey and observation in the respective investigation area.
- Literatures and reports where these areas can be found.

b) Criterion: Timber

Definition:

Timber is a term used to describe wood for use either standing or already processed, from the time when trees are felled to its end product, as a suitable material for industrial use and structural material for construction e.g. pole, pillar, sawn wood production.

Verifier/ Indicator:

- Area of forest land used for timber production, under the respective organisation bodies (need for further study).
- Area with growing stock of plantations of native and exotic tree species.
- Statement from local people who chopp and use trees for any construction purpose.
- Field survey, observation and interview in the investigated areas.
- Numbers and type of ground spots within a green area, where clearing, burning and shifting cultivation is executed (aerial photograph interpretation).

c) Criterion: Non-wood forest products

Definition:

Non-wood forest product resources refer to market or subsistence goods and services for human or industrial consumption derived from renewable forest resources and biomass, bearing promise for augmenting rural household incomes and employement. The products include the use of plants for food, beverages, forage, fuel and medicine

Verifier/ Indicator:

- Statement from local people in dependent communities by survey and interviews.
- Type of non-wood forest products been used by the local villages and locations where they are taken (i.e. rattan, bamboo, medicinal plants, chemical from trees, and fruit trees etc. (see appendix 15).
- Literatures and reports where these areas can be found.

Table 61: Classifying utility function areas in different locations in Kota Kinabalu, Malaysia

Area/ Location	Functions		
	Fuel wood	*Timber*	*Non-wood forest products*
Sepanggar	**X**	**X**	
Signall Hill			
Bukit Padang			
Tg. Aru			
Putatan			**X**
Kg. Banka Banka			
Kg. Kebambangan	**X**		**X**
Kg. Babagon			
Kg. Kipouvo	**X**		**X**
Kg. Kionsom	**X**		**X**
Kg. Lampugo			
Kg. Kokol	**X**		**X**
Kg. Kituau			
Kg. Inobong		**X**	
Kg. Tindai			
Kg. Kitabu			**X**
Kg. Pulutan			
Kg. Bendolan			

Note: X = Present and important

Table 62: Proposed map legend for utility function areas in Kota Kinabalu, Malaysia

<table>
<tr><th>Criteria</th><th colspan="2">Indicator/ Description/ Area (ha)</th><th>Legend</th></tr>
<tr><td>Fuel wood</td><td colspan="2">• Statement from public, local people in dependent communities by survey and interview (need further survey).
• Numbers of villages within a green area which use fuelwood for cooking purpose.
• Field survey and observation in the respective investigation area.
• Literatures and reports where these areas can be found.</td><td>F</td></tr>
<tr><td>Timber</td><td colspan="2">• Area of forest land used for timber production, under the respective organisation bodies (need further study).
• Area with growing stock of plantations of native and exotic tree species.
• Statement from local people who chopp and use trees for any construction purpose.
• Field survey, observation and interview in the investigated areas.
• Numbers and type of ground spots within a green area, where clearing, burning and shifting cultivation is executed (aerial photograph interpretation).</td><td>T</td></tr>
<tr><td>Non-wood forest products</td><td colspan="2">• Statement from local people in dependent communities by survey and interviews.
• Type of non-wood forest products been used by the local villages and locations where they are taken (i.e. rattan, bamboo, medicinal plants, chemical from trees, and fruit trees etc. (see appendix 15).
• Literatures and reports where these areas can be found.</td><td>N</td></tr>
<tr><td rowspan="3">Resedential areas, settlement and urban associates</td><td>Major town</td><td>Population density > 600 per km²</td><td></td></tr>
<tr><td>Minor town</td><td>Population density < 600 per km²</td><td></td></tr>
<tr><td>Village</td><td>Population density < 100 per km²</td><td></td></tr>
</table>

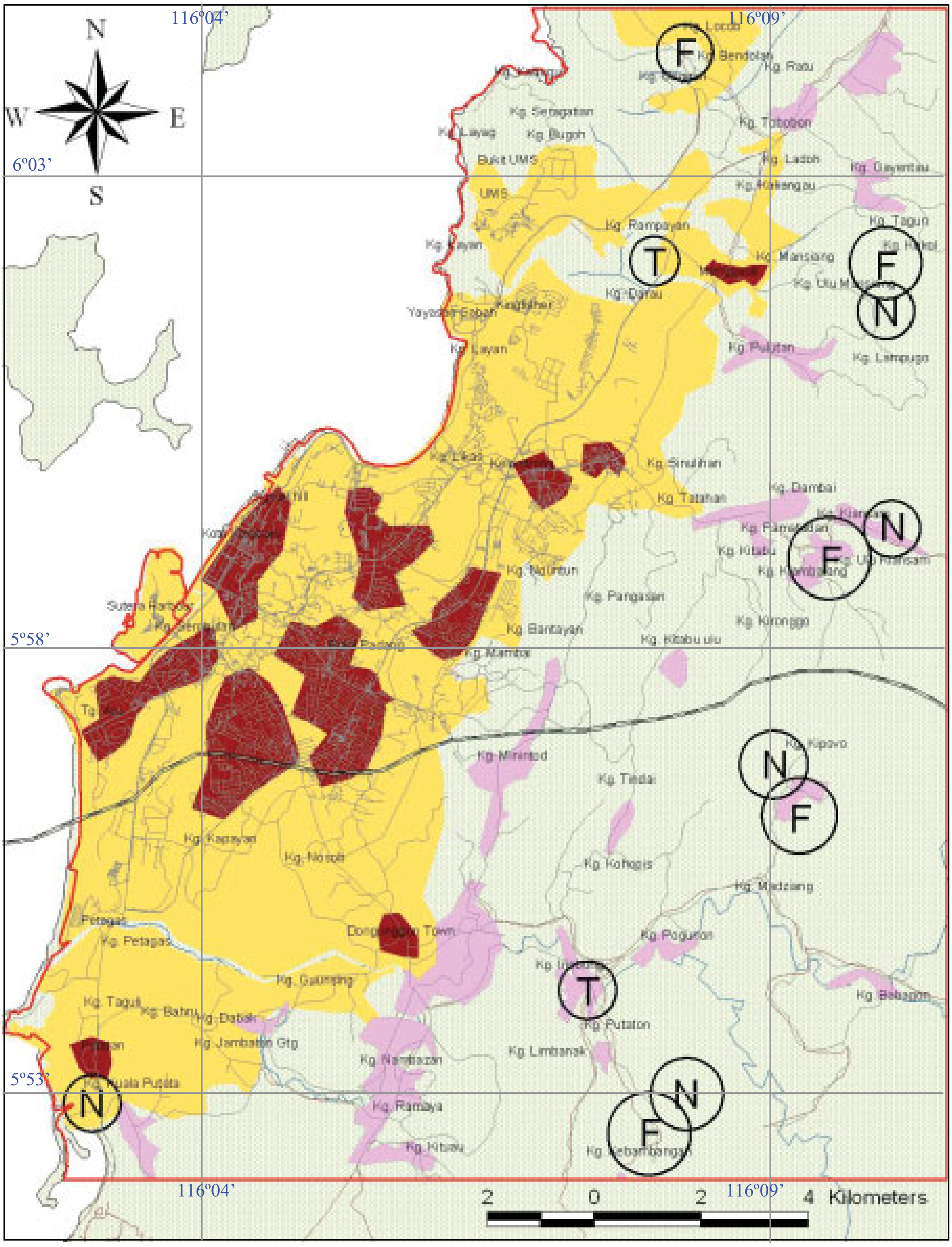


Figure 54: Proposed utility function map in Kota Kinabalu, Malaysia
(Source: Own presentation, Scale 1:50,000)

8.0 Interpretations, discussions and recommendations

The impact from the major landuse practices in Kota Kinabalu did already put a pressure on the biodiversity - not only in the urban but also in the surrounding suburban areas. The entire district tends to become more and more urbanised.

The impacts outlined below are predicted to be the most significant and important environmental impacts if clearing and harvesting activities of forest areas in Kota Kinabalu continues without proper management:

- Increasing erosion rates occur when the tree canopy and litter layer are disturbed, and when the soil surface is exposed. Erosion starts with the detachment of soil particles by rainfall splash and progresses in the form of sheet, rill and gully erosion.

- Water quality impairment is a result of pushing earth and debris into streams during the clearing activities, housing development, construction of roads and waste disposal along the stream channels.

- The expansion of agricultural activity has led to the destruction of huge areas of natural habitats, including forests, grasslands and wetlands. The expansion and development of urban areas and infrastructure also reduces natural habitats, and new roads give access to additional areas, which results in further losses. The relative importance of these factors varies, but all play a significant part in the destruction of habitats and therefore in driving ecosystem change.

- Social dissatisfaction results from immission (dust pollution), climate change and polluted water sources due to clearing activities especially during dry weather and passing through village settlement.

Urban green areas suburban forests need to be managed sustainably and with great care because they play an important role in providing various goods and services to the urban and rural population.

The presented results of tree stand analysis, bird survey analysis, public perception analysis and analysis of forest functions can serve as a basis for sustainable landuse management as well as a reference for impact assessment of future developments.

The following chapter intends to recapitulate and reflect the main results of the study in a comparative summary in order to draw conclusions and derive recommendations for the future management and safeguarding of urban greens and forests in Kota Kinabalu.

8.1 Tree stands

The overall tree species diversity revealed by the stand analysis and indicated by the Shannon index of diversity (*E*) recorded a value of 0.87 in secondary re-growth stands and 0.83 in mixed horticulture stands. The primary conclusion is that urban green areas in Kota Kinabalu district have a relatively high diversity of tree flora above 10 cm dbh. With up to 88 tree species per ha in secondary re-growth and 95 in mixed horticulture, biodiversity in those secondary vegetation types is higher than in natural forests in Sabah as indicate by Kammesheidt et al., (2004), where (*E*) reaches 0.87 and the number of recorded tree species above 10 cm dbh is around 50.

The relatively high species diversity is typical for former woodland areas, which regenerate after having been deforested, undergone shifting cultivation or used for agriculture. The natural succession processes undergo phases, which are rather rich in structure and species composition and include also areas of scrub, grassland, old grown plantations, former shifting cultivation areas, left behind areas, and idle land with mixed tree species. The mixed horticultural areas experience more intensive human influences. People usually develop these lands as a horticulture areas dwelling with the production of diversified crops for family needs. The vegetation includes fruit trees, tapioca, pineapples, bananas, papayas, coconuts, etc. The most common location is along roads and riverbanks. In general, after the forest canopy has been opened, more light demanding tree species take over and species numbers increase.

Compared to this, the mangrove stands have only low numbers species and family (23 species and 12 families). This is due to the specific characteristics of the edaphic factors in the mangrove which are favoured only by a few species (soil factors, aeration, mineral contents of surface and soil water movement, changes in water levels and extreme water regime). Also, Lamprecht (1989) mentioned that the mangrove might be rather poor in terms of species in comparison to other natural forests.

The relatively low species and family numbers of the town stands can be explained by limiting suitability and resistence of tree species concerning the urban environment. All trees are periodically maintained and managed by the respective department (i.e. pruning and trimming of long branches for the purpose of safety), and most of them are exotic for the purpose of beautification and greening.

In secondary re-growth stands, *Hevea brasiliensis* forms the abundance species with the highest Important Value Index (IVI) of (20.9) followed by *Acacia mangium* (17.2), *Macaranga tanarius* (13.2), *Artocarpus anisophyllus* (13.2) and *Alstonia angustilobia* (12.5). In mixed-horticulture stands, *Acacia mangium* forms the highest IVI value of (33.8) followed by *Acacia auriculiformis* (20.1), *Hevea brasiliensis* (14.3), *Mangifera indica* (11.6) and *Cocos nucifera* (10.7).

In mangrove stands, *Rhizophora apiculata* is the abundance species with the highest value of IVI of (63.8), followed by other most common species such as *Rhizophora mucronata* (45.3), *Acacia mangium* (40.1), *Nypa fruticans* (26.3) and *Bruguiera parviflora* (15.7). In town plantation, most of the trees are planted trees, with the highest value of IVI is *Pterocarpus indicus* (87.2). Other tree species follow with much lower values, like *Veitchia merillii* (15.2), *Delonix regia* (14.5), *Roystonea regia* (9.9) or *Tabebuia rosea* (8.7).

The *Leguminosae* family species are numerous and can be found in all stands of the secondary re-growth, mixed horticulture and town plantation, whereas the *Rhizophoraceae* family dominates in mangrove stands. Tree abundance in the representative plots was 336 trees ha^{-1} in secondary re-growth stands, 434 trees ha^{-1} in mixed horticulture stands, 118 trees ha^{-1} in mangrove stands and 1266 planted trees per 70 ha in the town areas. The total basal area in secondary re-growth was 28.4 m^2 ha^{-1} which is almost as good as in the natural forests (range between 26-43 m^2 ha^{-1}) and indicates a forest-like stocking of these stands (Kammesheidt et al., 2004). In mixed horticulture, mangrove and town stands, the basal area was measured as 14.5 m^2 ha^{-1}, 11.6 m^2 ha^{-1} and 1.5 m^2 ha^{-1} respectively, a value that underlines the optical impression of sparsely stocked stands. Diameter distribution in secondary re-growth stands follows the ideal inverse J-shaped function indicating a good structural stability.

The natural regeneration shows an abundance of 261 individual's species in the investigated plots of secondary re-growth which facilitates a sustainable use of the trees. Promising natural regeneration encompasses *Dillenia suffroticosa, Macaranga, Acacia mangium, Alstonia angustilobia, Hevea brasiliensis* and *Artocarpus anisophyllus.* These species are widely distributed in Sabah especially occurring naturally in secondary forests. Consequently, they were pioneer trees. Most of the regenerating species do have an abundance that is similar to the one of mature trees in the stands.

In mixed horticulture stands the natural regeneration is even much higher (367 individual's species). This might be due to human activities which introduced new species (e.g. perennial crops, fruit trees and vegetables) and also disperses seeds by foraging animals (i.e. birds). Most abundant species are *Acacia mangium, Hevea brasiliensis, Eugenia cerasiformis* and *Melastoma malabathricum* respectively. The fast colonization of wild *Acacia* species is also promoted by burning and clearing of the land, since burning activities help to break the seed dormancy in legumes to regenerate naturally.

In mangrove stands, the natural regeneration shows an abundance of 117 individual's species encompassing *Rhizophora apiculata, Rhizophora mucronata*, *Nypa fruticans, Bruguiera parviflora* and *Combretocarpus rotundatus* respectively. Again, the regenerating species mostly show an abundance similar to the one mature trees in the stands. Town plantations do not perform natural regeneration but are planted.

8.2 Bird life

Concerning the birdlife survey, the most frequent bird category found in Kota Kinabalu were *Waders* (14.07%); secondly *Herons, Storks and Bitterns,* (12.59%); thirdly *Raptors* (8.15%) and *Bulbuls* (7.41%) respectively.

The presence of *Waders, Herons, Storks* and *Bitterns* are abundant, usually forms in clusters, and found intact near to coastal areas with swamps, mudflats and associated mangroves. On the other hand, this area also is an important habitat for *Raptors* which eat small fishes (Mudskipper *Boleophthalmus boddarti*), crustaceans (Mud Lobster *Thalassina anomala*) and small mammals (Plantain Squirrel *Callosciurus notatus*), like the Lesser Fish Eagle *(Ichthyophaga humilis),* Osprey *(Patidion haliaetus)* or Brahimy Kite *(Halistur Indus)* they can usually be observed near the coast or river mouths. While, *Bulbuls* can be found associated to more inland areas because of the available food sources from seeds, fruit trees (i.e. *Hevea brasiliensis*, *Acacia mangium* and *Mangifera indica*) and trees that attract insect that provided food (i.e. *Macaranga tanarius*, *Artocarpus anisophyllus* and *Alstonia angustilobia*).

Most of the recorded bird species belong to the family of *Ardeidae* (16 species), *Nectariniidae* (11 species), *Pycnonotidae* (10 species), *Accipitridae* (9 species) and *Scolopacidae* (9 species) respectively. *Herons, Bittern and Storks* belong to the *Ardeidae* family and were found as 'waterbirds' associated with water, usually at the coastal and mangrove areas. *Flowerpeckers*, *Sunbirds* and *Spiderhunters* belong to the *Nectariniidae* family and *Bulbuls* belong to *Pycnonotidae* family, which prefers more to the natural lowland forest.

Most of the birds observed in Kota Kinabalu (66%) are resident birds. Migratory birds form 32% whereas 2% are both resident and migratory. *"Resident birds"* means, the bird species is breeding and stays in the same area throughout the year without migrating. Migration occurs with birds moving from one biome to another. In most cases birds migrate to avoid local shortages of food which is usually caused by winter seasons. The species that periodically migrate are called *"migratory birds"*

Safeguarding or bringing back the birds can improve the city's amenities by providing nature experience. This amenity will not only be appreciated by the people who live and work in the city, but also by tourists and other visitors. "Green area" is regarded to be the most important that provides migration corridors, habitats and breeding areas for birdlife. The spatial analysis reveals that "green areas" still amount to 18,482 ha (64.14% of the district). The green areas encompass important birdlife areas namely: *secondary growth areas; grassland & scrub; hill vegetation; plantation areas; rice paddy fields; coastal mangroves; swamp areas; riverside areas; pond, lakes & pools; coastal areas; town areas and residential areas*.

Secondary growth, plantations and mangrove areas were analysed to be most important areas for birdlife. Many plants species in the secondary growth and overgrown plantation provide foods and attract insects in which serve as bird foods. Mangrove areas also appear as highly productive ecosystems, inhabited by a large variety of crabs, small fishes, worms and molluscs, which form the basis of a food chain that supports a large variety and abundance of water bird species.

The analysis of bird abundance using distance sampling software estimated a population density of 14 birds per km² which belong to an overall 135 species. This corresponds to a total population of 3526 individuals covering the research area of about 280 km². Compared to these results, other studies in Kinabalu Park indicate a bird population density which ranges between 11 - 19 birds per km² related to an area of 750 km² (Mustafa et al., 1998). This indicates that the birdlife in Kota Kinabalu seem to be better than in many other natural protected areas.

Within the chosen distance of 100 m from the randomly chosen survey point, a sufficient detection probability was only given up to a distance of 75 m. Some birds' species are very difficult to detect, while other species are easy to find. As an example, a *woodpecker* bird is known to be shy and very difficult to be seen in closed canopy forest. However an experienced surveyer can identify the singing or burrowing sound of the *woodpecker*, and then estimate the distance in which the bird was heard. Species that are easier to be spotted are *Waders, Herons, Storks* and *Bitterns*. They often occur in clusters or groups and do not hide away in bushes or trees. In this survey, rare species that were difficult to be spotted belong to *Woodpeckers, Wablers* (*Tailorbird and Snipe*), and *Sunbird & Spiderhunters*, while the remotes detected birds are *Raptors* (*Hawk, Eagle and Harrier*). Sometimes they were spotted flying far (≥ 75 m distance) in the sky and only could be identified using binoculars.

Sampling error also influence the detection probability, that not all individuals bird species could be detected in the investigated areas, due to numerous variables such as the observer's visual acuity, hearing ability, and experience, the length of time spent at a station, the season of the year, the time of the day, wind, temperature, and other weather conditions, the habitat features and the bird's reproductive status and behaviour. These variables affected the detection function and the occurrence of birds in each survey

Based on the analysis, potentially important birdlife areas in Kota Kinabalu were mapped and categorized into 3 major criteria namely: rich birdlife area, medium rich birdlife area and poor birdlife area. Most of the birdlife areas in Kota Kinabalu (IBAK) are located outside the city area, including secondary growth areas, hill vegetation areas, grassland & scrub areas, and mangroves. It can be assumed that rich birdlife areas provide important micro-features of bird habitats. The presence of natural and left behind green areas results in corridors and foods for birds to live and fly.

One of the developed rich birdlife areas in Kota Kinabalu (IBAK) is the Kota Kinabalu City Bird Sanctuary (KKCBS) which was gazette under the Sabah wildlife conservation enactment. However, the results indicate that KKCBS is not only important birdlife area but that there are other IBAK which need to be integrated into a careful preventive and precautionary management, which also has to include “poor birdlife areas” that would need upgrading measures.

As mentioned earlier, the presence of wildlife in urban and suburbans environments is a testimony to the quality of the environment. It is an indicator for some kind of balance between the natural and the built environment. While some species will clearly never be able to live in densly populated and settled areas, others seem to be quite adaptable. Nevertheless, they do still require far more natural elements than a city usually provides.

Unlike the natural protected areas, the urban environment requires to concentrate on those species that people like to have them around and for which it is possible to provided suitable habitat. Birds are obviously animals which are relatively easy to spot. This amenity will not only be appreciated by the people who live and work in the city, but also by tourist and other visitors. Bird-watching (including photography) has been essentially a western pursuit until recently, but it is becoming very popular in Japan and has a growing number of adherents in South-east Asia also (Lee et al., 2004).

The management of birdlife can be enhanced and supported by developing specific management guidelines for the following types of urban landscapes:

Sites for bird management - having made the decision to improve the conditions for urban and suburbans birdlife, it is necessary to decide on the localities and methods to be used. In this context, tree particular types of areas need to be considered:

a) More or less natural areas that are still rich in birdlife and may act as “reservoirs” or source areas to populate other urban areas. These reservoirs will usually not be preserved within the actual urban areas but must be connected with each other by vegetated corridors like urban parks and green through which the birds can move safely.
b) Parks and other green areas where improvements would be of immediate benefit to the bird population. These include public parks where the existing configuration is not particularly suitable for bird life; and
c) Vegetated corridors along which birds may move between the reservoirs and the areas that are to be enhanced. These corridors can be areas of low density housing, with tree-lined avenues and large gardens, or carefully planted reserves alongside roads, railways, rivers, electricity lines, etc.

Structural Diversity - the diversity or heterogeneity of vergetation structure is an important determinant of bird density and diversity. The layering or structuring of the vergetation is the most important factor affecting birds in urban areas. Any area should contain a ground or bush layer of vegetation. Interlocking or overlapping canopies should lie above this up to the height of the majority of the trees. Finally, one or two emergent trees can stand clear of the rest. Diversity can also be achieved by planting as wide a range of indigenous species of trees and bushes as appropriate. Current planting practices usually leads to an even canopy layer, often rather shallow, with no undergrowth and no emergent trees. This provides little opportunity for diversification of the avifauna.

Food supply - different types of birds feed on different items, including fruit and seeds, nectar from flowers and a wide range of insects. Two aspects will be achieved by planting an appropriate array of trees, shrubs, climbers, herbs and grasses. First, more bird species that are dependent upon certain plant species will be catered for. Second, the plants will more likely fruit and flower all over the year, without leaving some bird species without food for a period of time. In this respect provision should also be made to leave a certain proportion of long grass in any planted area.

Successional Phases and Spacing - the natural succession from grasses and herbs to bushes and finally to trees of various sizes should always be present in any area. Different species of birds live in different sections of this natural succession or in the boundary zones between stages. The succession provides a gradient of vegetation height which can easily be incorporated into plantings. In situations where only a limited number of trees can be incorporated into an area, it is far better to clump the trees into dense refuges than to have them spaced evenly over a given area.

Present planting practice is often adjusted to space ornamental trees evenly over an area. This spreads available resources very thinly and evenly with the result that birds have to expend much time and energy traveling between trees in order to obtain resources. Further, the territories may not contain sufficient resources or may be too large to be defended. Thus trees should always be grouped together rather than spaced out evenly. A proper structuring of the vegetation requires planting trees in clumps.

Physical Continuity and Size of Planted Area - areas of prime bird habitats must be connected by vegetated corridors or *'Laluan'* to ensure a habitat network where birds can move around. Where possible, these corridors should be realised along rivers, drains or other water-courses, tracks and footpaths. The relationship between habitat size and numbers of bird species is not linear. A doubling of size of planted areas will more than double the number of bird species which may occur. With this in mind any area to be managed for birds should be made as large as possible in order to derive maximum diversity.

Inclusion of Water - where possible, ponds, streams of drainage canals should be included in any areas designed for birds. These will insure or provide water supply for wildlife and also act as supplies for insects which require water in their life cycles. Some tree branches should overhang the water to provide perches for *kingfishers* (pekaka) and *flycatchers* (sambar). Footbridges should have small ledges inserted in the base to encourage nesting by *swallows* (sualo). Water bodies should have sloping, vegetated banks where possible. Hard, vertical banks (e.g., concrete) render lakes, rivers or canals are inaccessible to some bird species. Many species such as *Tern* (*Larus ridibundus*) and *Waders* (*Tringa nebularia, Actitis hypoleucos* and *Gallinago sp*.) nest in waterside vegetation.

8.3 Public perception

The public perception analysis indicates that the major ethnicity backgrounds of the respondents in Kota Kinabalu are Kadazandusun. They form the biggest community among other ethnicities with a total population of 519,800 in 2005. The Kota Kinabalu suburban areas namely: *Telipok, Manggatal, Penampang* and *Putatan* are mainly the 'shelter' of the native Kadazandusun people. Although Kota Kinabalu is often considered as a stronghold of the Kadazandusun communities, the Chinese communities must be considered as majority in the town areas.

The results also indicate that most of the town communities highly appreciate the importance and benefits of trees for their well-being. Above all they acknowledge that forests help to reduce warmth and heat from the sunlight. They also mention beautification and aesthetic value, recreation effects, obstruction for rubbish and other annoyances (e.g. noise and dust pollution). Their favourite recreational activities include *walking and sightseeing, jogging, hiking and walking for sports, picnicking and informal outdoor recreation activities as well as collecting plants.*

In addition to beautification, the presence of green spaces close to the town has become an attraction to people from all over Kota Kinabalu district to participate in recreational activities. This can particularly be seen in areas like *Tanjong Aru, Signall Hill, Bukit Padang* and *Kota Kinabalu City Bird Sanctuary* (KKCBS) during weekends and holidays when people come to this areas (general observation by the author from the year 2000 until 2005).

The village communities also place a high emphasis on the environmental benefits of forests. They appreciate in particular that trees provide clean and fresh air, and provide drinking water, food sources and forest products differing from the town community. Half of the rural population (50%) still uses forests as a source of fruits, rubber, rattan and dammar, while 32% use it for medicinal purpose. Some of the respondents also expressed that they take wild fruits and roots and sell them in the open market to gain financial income. Interesting species in this respect are: *Garcinia hombroniana* (akob-akob), *Bambusa sp* (Bamboo tuber), *Parkia pinnata* (Petai-petai), *Zingiber sp* (Wild Ginger) and *Eurycoma longifolia* (Tongkat Ali) etc.

Concerning conservation and protection issues, town communities agreed that the government should conserve the green and forest areas. Moreover, they opined that environmental awareness programs and green campaigns should be stressed, especially to the young and in schools. Concerning the decision-making process, however most of them were not willing to be involved, and they withdraw everything related to conservation and protection issues to the government decision.

Compared to this, many village people expressed their interest in helping the government and over third-forth explained that they were interested to be involved in decision making concerning conservation efforts in their areas. The analysis further revealed that female respondents were the ones with substantially higher levels of interest.

About 82% of the village respondents agreed with nature protection and conservation issues. They stated that the government should conserve and protect the remaining natural environment, and that there should be an educational and awareness programme to educate people about the importance of forests for the environment.

The interviewees indicated that when forests are cut, trees may grow back, but that it takes hundreds of years to re-create a healthy forest ecosystem. Forest ecosystems are destroyed and even recovering forests are threatened by logging and development. To restore a healthy ecosystem, forest management must focus on restoring the complex, natural system of trees, plants, wildlife, and soils that provide the essential services, like clean water and fresh air, that can be rely on.

Many of the respondents also expressed their concern that the major threats to forests are unsustainable land use practices and conversion. Unsustainable practices that change the forest area to slash-and-burn agriculture or shifting cultivation causes erosion that can deplete the soil surface, which then lead to overexploitation, pollution, and destruction of natural resources. The second problem stated was river pollution. Most of the people in villages are river dependent, including *Kg. Kitabu, Kg. Kokol, Kg. Kibambangan, Kg. Babagon* and *Kg. Kiansam.* If forest areas were cleared, the silt or clay sediments from the bare surface will be washed into the river during heavy rainfall. They will directly pollute and increase the sediment in the river, thus making the water unsafe for drinking. Others view suggested that, cutting of trees in the hilly region will affect the physical structure of the soil, which in the end increases the susceptibility to landslide problem. Other minor problems expressed were the problems of deforestation, forest fire, and decreasing of wildlife through hunting activities.

The town respondents seemed to be satisfied with the current tree management activities (beautifications, preserving old trees and enrichment plantings) and they stated that the “right choice of tree species” in town is necessity, when it comes to the governmental effort to plant more trees in town.

The most important differences between town and village peoples perception, in significance can be thus be seen in their different dependence upon forest resources. Nevertheless both confirmed their interest concerning conservation and protection of forests and green spaces. From the statistical point of view more sophisticated results which differentiate between groups of respondents with respect to their ethnicity, age, religion, education etc. cannot be confirmed and sampling error assumption has to be taken into consideration. To reduce or minimize the error, one should probably take more samples which reflect the total population at present time and which represent the opinion from different ethnicities of inhabitants.

8.4 Biotope and land use

The remote sensing based analysis of biotopes indicates that the general vegetation cover in Kota Kinabalu can be categorised into five major classes, namely: *urban and developed areas; mixed horticulture and grassland; paddy and riverside; old rubber and scrub; and, forest and mangrove.* Further classification followed the land use classes from the Sabah Agriculture Department (2003) and led to an overall 43 different land-use types which were then mapped using GIS software.

The results of the land use and biotope mapping give the overall portions of land use types which are differing greatly to each other. Corresponding to the land-use analysis, the highest portions reached by *Senile rubber* (Old Rubber Plantation) of *Hevea brasiliensis*. This land use type amounts to 8,062 ha (28 % of the entire land cover) proving that rubber tree is still the most frequent tree which coves most of the investigated areas.

According to one of the interviewed heads of village, the rubber production was introduced by the Sabah government and initiatiated by British Colonial rulers during the early 1900. It aimed at upgrading the socio economic lively hood of the people in Kota Kinabalu. The *Hevea brasiliensis* tree is important to produce rubber latex for local consumption and export (Baya Dakurak, 2005, Pers.com). The species is most suitable for the site conditions in Kota Kinabalu, particularly with regard to soil conditions (Alluvium and Peat). At present, the rubber trees get mixed with other forest and crop trees which make it better resist to the attack of insect pests and diseases. Nowadays, the old rubber plantations have become senile and do regenerate. Thus most of the former plantations are likely to form more natural secondary re-growth areas.

The second biggest land use type is *urban associated areas* with an overall area of 6,195 ha (22 %). Most of these areas are densly populated, like Kota Kinabalu city, Luyang, Kapayan, Tg.Aru, Likas, Putatan and Dongonggon area. Nevertheless vast green areas remained as private properties, mostly covered the more hilly parts of the residential areas. Unfortunately, these private lands could not be considered in the detailed stand and birdlife surveys, although they certainly do play a very important role for urban ecology and urban space functioning.

The third rank is taken by *mixed horticulture areas* with 5,228 ha (19 %). These areas are usually associated with village people settlements, unsupervised crop and gardening areas. The fourth and following shares belong to *scrub forest areas* with 3,110 ha (11 %) and *Paddy areas* with 1,920 ha (7 %). *Mangrove swamps, marshland and wetland forests* amount to 1,251 ha (4 %), *and grasslands* covered 911 ha (3 %). Other remaining land uses occure with small portions only.

The principles of landscape features should be taken into contemplation, urban greens and suburban forests can provide an important features that directly significant to the urban environment. They should be considered in the catalogs of criteria and indicators to classify important urban forest and green spaces functions. By safeguarding some of the forest, jungle, bush and shrub undisturbed can help to keep the river's water clean, to prevent soil erosion problems and to preserve some of the bird habitats protected and unharmed.

8.5 Green area and forest functions

Five functions for urban forests and green areas in Kota Kinabalu have been identified, namely: *bird habitat, nature conservation, protection, recreation and utility*. From each of these functions, criteria and indicators were determined for the spatial analysis and mapped using GIS software. Each function was discussed as the following:

***The bird habitat function* –** takes into consideration the important birdlife areas as sites that provide essential habitats for a high number of bird species. The sites are also assumed to be 'potential rich birdlife area' when landscape features are taken into account. They serve for breeding, wintering, and/or migrating birds and may reach from a few acres to a thousand of acres in size. Usually they are discrete sites that stand out from the surrounding landscape. If the feeding or nesting sites, especially rare ones, are destroyed, the impact on birdlife is supposed to be high. Even construction activities which are not directly affecting any breeding or nesting sites, may prevent individual birds from coming to these places or cause other which are already there to leave the area, due to noise and other disturbances.

***The nature conservation function* -** Nature conservation function of forests must aim at warranting the dynamics of the forest as ecosystem with all its ecologically characteristic features and processes in all its stages in space and time. The nature conservation forest not only calls for the safeguard of particularly worthy areas (e.g. protected areas by law), but also for the forest management to be executed with such care that no species existence is jeopardised. Where applicable, research activities should be conducted in the nature conservation forest to improve the knowledge about the ecosystem that is worth to be protected.

The protection function - Protective functions of the forests shall prevent potentially dangerous impacts on the urban and suburban areas. Unmanaged forest would probably be able to sufficiently warrant the larger part of protective functions, in particular the regulation of water and local climate features, the prevention of erosion or protection from noise and immissions.

The recreation function – take into consideration that forests providing recreation services to the people which become increasingly popular. Such forests play an important role in increasing public awareness and appreciation of the multiple roles that forests offer to the society. In the eyes of most recreation-seekers, it is out of question that forests do contribute considerably to the favourable appearance of the landscape. Moreover, forests, or groups of trees, can act as screen, helping to offset visual nuisances or to organize the landscape.

***The utility function* -** of forests in a narrow sense of the word, implies economic utilization of natural resources. These resources are wood (fuel wood, timber, etc.) and other non-wood forest products such as medicinal plants etc. Usually, the local communities in Sabah take all these for economic and local consumption purposes. However this function may lead to conflicts with protection and nature conservation functions.

The functional zoning map was prepared to be used as a guideline for green management purposes and assist the government or other agencies to better address the most contentious or misunderstood issues concerning urban forest functions and management. The analysis shows which sites are possibly suitable for conservation, protection or for less intensive cultivation. As mentioned by Kiemstedt (1994), important green area functions should be safeguarded for public welfare and benefits, to keep the water and air clean, to protect the soil from erosion or to provide recreation opportunities. Significant areas should therefore be protected or conserved by safeguarding the greens; jungle, bush and shrub area and manage them according to their most important functions.

8.6 Conclusions and Recommendations

The gist of all the findings confirmed that the concept of sustainable management in tropical urban green areas requires appropriate measures to guarantee control of development. In order to cope with environmental problems and to prevent new ones, planning with foresight is essential. The overall goal is to safeguard the capacity of the ecosystem. That means that the complex interrelationships of all natural resources such as plant and animal species, soil and water with their vast physical, chemical and biological processes should be considered in the early planning process.

The success of biodiversity conservation in protected or unprotected areas will depend upon how well these individual areas are integrated into the wider landscape context. Through proper planning at a landscape level, natural and managed areas may both contribute to reconcile human activities with the goals of biodiversity conservation. Land managers need effective planning tools to properly manage multi-use areas for the benefit of all interests.

Landscape ecology and planning may be used at various scales. At a larger scale of analysis, landscape planning may be used to determine the most appropriated placement of agriculture and other land-use activities when attempting to reconcile human livelihoods and habitat needs for biodiversity conservation. By looking at the landscape of which the individual green ecosystems are a part, key ecological features (e.g. surrounding plant associations/vegetation patterns) need to be identified to determine appropriate urbanized habitat restoration efforts that may serve to re-establish continuity of habitat types and thereby reduce habitat fragmentation.

With respect to the results of the study, it seem to be necessary that the strengthening of the environmental policy from the State Government through the Environmental Protection Department Sabah is an important prerequisite for all further actions. As prescribed by the Environmental Quality Act 1974 (Amendment in 2005) any activity which may damage or have an adverse impact on the quality of the environment requires some mitigation measure as stipulated through Environmental Impact

Assessment. The following principles are hereby recommended to be highlighted in any development activities in Kota Kinabalu:

Provision of Hilly/steep Land Reserves

Areas of high erosion risk (e.g. steep slopes, lateritic soils and watershed areas) need to be either exempted from development or developed only under the stipulations of an Environmental Impact Assessment (EIA). Intensive conversion should ideally be restricted to low risk and more gentle terrain, generally in the lower parts of catchments. No trees are to be felled within the hilly reserves and risk areas should be identified and mapped with the help of Global Position System (GPS). High hills or steep slopes areas over 25 degrees should become totally protected from any commercial activity.

Provision of River Reserves

In accordance with the Water Resources Enactment (1998), all permanent watercourses more than 3 meters wide should maintain a river reserve. No trees should be felled within the river reserve and if does, then the vegetated areas along both sides of river should be maintained at least 30 m width. Reforesting the watersheds is important for the socio-economic improvement of the people in the hills, and community forestry incorporating agri-silvo-pastoral systems the most appropriate options to be applied when watershed plantations are established.

Preservation for Recreation

Nature and landscape need to be protected, maintained and developed in a way that the capacity of the ecosystems, the availability of natural resources, plant and animal species, and the entire biodiversity which are the basis for living and recreation are preserved sustainably. This goal does not only apply to natural, more or less unpopulated areas but likewise to cultural landscapes in rural areas and even to densely populated urbanised areas. Recreation areas can be provided and preserved as "protected recreation areas" in order to safeguard scenic or valuable landscape features e.g. waterfalls, rocky streams, flat riverbanks for picnic, hills with views, plateaus with hills, scenic lookouts, wildlife, rare plants, geological formation and cultural heritage etc. Development in these areas should be carefully watched and controlled to prevent undesirable disturbances and depreciation.

Wildlife Management

Strict implementation of existing wildlife law and policies is essential. The provision of escape routes and corridors to adjacent habitat systems has to be enforced. Conservation of adequate, contiguous and suitable habitats may provide a sanctuary for animals that are forced to temporarily leave their territory. Ecological improvements of parks and other urban green areas could be of immediate benefit to the bird population. This concerns public parks where the existing habitat is not particularly suitable for birds, as well as vegetated corridors along which birds may move between more adequate habitats. These corridors can be areas of low density housing, with tree-lined avenues and large gardens, or carefully planted green spaces alongside roads, railways, rivers, electricity lines, etc.

Public Awareness and Education Program

It is a great concern to motivate people in all aspects of the management of natural resources. Local communities play an essential role in achieving the success of conservation efforts. It is important to help the local people to get aware of the environmental influence and vital role of the tree stands and forests. They should also understand the reasons why to safeguard ecosystems, habitats and species of both flora and fauna is necessary. Public support and involvement of the local people should be sought through all available media and it should reach rural and urban people, decision makers, school teachers and kids.

Alternative Livelihood Programs

Prominent instruments to create incentives as well as to generate financial resources for biodiversity conservation are user charges, nature-based tourism, trust funds and endowments, tradable forest obligations, and transferable development right. The success of these instruments depends critically on how well they manage to reconcile the needs and aspirations of the local people with the need to protect biodiversity. The

United Nations (2001) in a report on the State of the Environment in Bhutan recommended the important themes below in order to find a balance between the needs of the people and the overall aim of safeguarding the environment.

- Build on existing structures, utilise them, and if required, assist the policy-makers in formulating and implementing new reforms.
- Establish a policy and legislative framework in order to ensure that land use plans and recommendations actually are implemented.
- Raise awareness among the decision-maker and the farmers that soil erosion is a problem of great consequences and that it will escalate in future if nothing is done today.
- A natural watershed would represent an ideal unit for most effective management of land, soil, water and vegetation and would allow sustained production of food, fuel, fiber, forage and water, and reduce the occurrence of floods and droughts. This would influence land use positively, protecting land against all forms of degradation. However, this should enlist people's participation at all stages of development.
- The failure of land users and community leaders to recognize or be educated about the causes, urgency, seriousness and full consequences of degradation often work against any measures to counter degradation. In this context, the negotiated participatory approach should mitigate some of these adverse effects.
- Ensure that people's needs are the driving force in the planning process at different levels, suggest alternatives which can relieve the pressure on the most affected areas

To deminish the negative impacts of further developments, the following mitigation measures should be considered:

a) Several totally protected areas should be identified that will not be touched by road construction or human activities. This includes rare and unique habitats. These areas could be designated as conservation areas and should be linked by natural forest corridors to give the animals the opportunity to stay mobile.

b) A farsighted limitation of roads to the essential demand/ need reduces the disturbances of the life cycle of animals and decreases the risk of road kills. Wherever possible, no nesting or breeding sites should be destroyed.

c) Trees which provide seed for birds or attract insects should be conserved or enriched. In Sabah the *Ficus* sp. tree is a crucial food for many bird species as rare as hornbills and other animal like monkey. Large *Ficus* trees should always remain.

d) Trees below 60 cm dbh and above 120 cm dbh as well as species/fruit trees (*Mangrove, Enkabang, Mangga, Durian, Kedondong, Senkuang, Langsat, Belimbing, Terap, Maeritam, Mata Kuching*), and trees within riparian reserves should not be felled.

e) Enrichment planting, silvicultural treatment and plantation establishment should be conducted to improve the quality of urban forests and green areas (maintenance plan needed).

f) Environmental Impact Assessment (EIA) should become obligatory for any development activities within the study area.

g) Areas with high erosion risk activities require additional attention and care. Consideration of the topography application of mitigation measures such as zoning and limitations against development, as well as stream buffer zones are necessary to mitigate soil erosion and subsequent stream sedimentation.

h) Harvesting or clearing activities should not be carried out at slopes steeper that 35°, since they cause enormous soil disturbance, landslides and high erosion rates. This limitation should be drawn in the map.

9.0 Summary

Malaysia has been identified as one of the world's mega diverse countries being extremely rich in biodiversity. Tropical rainforests, the oldest and most diverse ecosystems on earth, still cover an average 60 % of the country (Soepadmo, 1998). The rainforests are estimated to contain about 12,500 species of flowering plants, and more than 1,100 species of ferns and fern allies (MSET, 1998). The dominating plant family is dipterocarp trees many of which produce commercial timber being native to Borneo as well as to Peninsular Malaysia, Indonesia, Philippine, Thailand etc. Large portions of these species are endemic and unique to the Malaysian archipelago.

There is also great diversity in fauna, including about 300 species of wild mammals, 700-750 species of birds, 350 species of reptiles, 165 species of amphibians and more than 300 species of freshwater fish. Endemism in flora and fauna is high. As with other cultures, it is assumed that much of the traditional knowledge about these flora and fauna are heritage of the many traditional societies and communities that are dependent on them for their livelihood (Soepadmo, 1998).

Unfortunately, much of Sabah's natural vegetation has been altered and degraded due to unsustainable and destructive human practices. Their existence continues to be threatened. Certain forest types are in danger of being totally eradicated from Sabah, while many plant species will likely disappear before they have ever been described. The fragmentation of natural forests also threatens the viability of various wildlife populations. The State is undergoing rapid development and the transformation of rural areas into urban is also accelerating. Many green areas are lost which causes serious threats to biodiversity in the country, because green areas play a very important role in buffering negative impacts on conservation areas.

The objective of this study is to provide the information for developing a concept for sustainable urban green management in Kota Kinabalu district as well as to judge the ecological sustainability and to describe the importance of urban green area for the public. A focus is placed on the terrestrial and aerial inventory of the natural resources, including trees, birds, and biotopes. Furthermore, the study tries to explore the perception and attitude of local people, concerning urban forests and green areas. It also explores and investigates the possibilities for implementing an urban green management concept.

The terrestrial data collection accordingly comprises of four fields: (1) tree inventory/ survey, (2) bird survey/ observation, (3) public perception survey, and (4) the mapping and classifying of urban forest functions.

i) For the purpose of *tree inventory*, four common vegetation stands have been analysed for comparison. The stands included: secondary re-growth area, mixed-horticulture area, mangroves area and town tree stands. 32 sampling plots of 2048 m^2 each have been established for vegetation recording data. A complete inventory of tree vegetation (dbh $\geq$ 10 cm) was carried out and the following parameters were assessed: tree species, dbh (diameter at breast height, 1.3 m above the ground), tree height, stand density, floristic composition and regeneration potential. The data was analysed using Statistica 6.0 and Microsoft Office Excel 2003 to get the descriptive and frequency table.

ii) The data for *bird analysis* were gathered from literatures, reports and survey plots. For the survey plots, the same 32 sampling points were used as for the preceding tree inventory. At each sample point, every bird species observed was recorded with a distance of 10 meter to 100 meters. The bird abundance was analysed using distance sampling software (*Distance sampling 3.5*) to estimate the density and population size. Additionally, when moving between points on a grid line, the characterization of birdlife habitat types were recorded and located by Global Position System (GPS). Potentially rich birdlife habitat areas and bird risk areas were then mapped all over the district.

iii) The *public perception survey* was conducted by distributing questionnaires and conducting interviews to the town public and village community randomly. A total of 450 questionnaires have been distributed and important issues were evaluated: (1) the demographic characteristics, (2) the perception of people concerning the importance and benefits of urban green areas (3) the opinion concerning conservation issues, (4) perceptions and opinions concerning tree management, and (5) perception of problems that threaten the forest today. The questionnaires were analysed using Statistical Package for Social Sciences (SPSS) software in a descriptive analysis, frequency table, and percentage.

iv) *Biotope mapping and classification of urban forest functions* – Aerial photographs (2000) and SPOT satellite images (2002) have been used to classify the type of biotopes and land covers in Kota Kinabalu district. A set of biotope mapping classification was produced and on-site ground truthing was performed with the help of topographic map and geographic position system (GPS) to distinguish the land cover. The information gathered from the field then was analysed and cross-checked to perform the 'functional value' of urban forests in Kota Kinabalu. The information includes terrain data, slope data, soil erosion risk, flow of rivers, creeks and streams, land use conflicts, and other potential areas. For the purpose of future management, a set of criteria has been developed to map and classify each function of urban forests. The mapping analysis was done using Geographic Information System (GIS) software e.g. ArcView GIS Version 3.1, Erdas Imagine 8.6 and ArcInfo.

From the research, the following results were obtained:
The tree species diversity and stand structure of urban forest, as a two criteria for stability and sustainability of the land use system. Overall species diversity found, in secondary re-growth stand as indicated by the Shannon index of diversity (*E*) recorded that a value of 0.87, in mixed horticulture stand recorded with 0.83, in mangrove stand 0.74 and in vegetated town stand recorded with 0.73. The primary conclusion from this study is that Kota Kinabalu has a relatively rich diversity of tree flora above 10 cm DBH. With up to 88 tree species in secondary re-growth area, 95 species in mixed horticulture and 23 species in mangrove with dbh $\geq$ 10 cm per ha, biodiversity is much higher than in the natural forests.

The total basal area of secondary re-growth was 28.4 m^2 ha^{-1}. In comparison to similar studies in Sabah (26 - 43 m^2 ha^{-1}) it is almost as good as in the natural forests which indicates a forest-like character of the stands. While in mixed horticulture, mangrove and town stands, the basal area was measured in with 14.5 m^2 ha^{-1}, 11.6 m^2 ha^{-1} and 1.5 m^2 ha^{-1} respectively, a value that underlines the optical impression of a sparsely stocked stand. Diameter distribution in secondary re-growth stands follows the ideal inverse J-shape function, which indicates a good form of forest structural stability. The distribution of natural regeneration shows the abundance of 260 species per ha, ensuring a sustainable use of the stands for the future.

In secondary re-growth stands, *Hevea brasiliensis* form the abundant species with the highest Important Value Index (IVI) of (20.9) followed by *Acacia mangium* (17.2), *Macaranga tanarius* (13.2), *Artocarpus anisophyllus* (13.2) and *Alstonia angustilobia* (12.5). While in mixed-horticulture stands, *Acacia mangium* form the highest IVI value of (33.8) followed by *Acacia auriculiformis* (20.1), *Hevea brasiliensis* (14.3), *Mangifera indica* (11.6) and *Cocos nucifera* (10.7). In mangrove stands, *Rhizophora apiculata* is the dominant species with the highest IVI value of (63.8), followed by other most common species which are *Rhizophora mucronata* (45.3), *Acacia mangium* (40.1), *Nypa fruticans* (26.3) and *Bruguiera parviflora* (15.7). While in town stand, most of the trees are planted tree, specially for ornamentals, highways and greening purposes. The dominant species with highest value of IVI ranked with *Pterocarpus indicus* (87.2) followed by *Veitchia merillii* (15.2), *Delonix regia* (14.5), *Roystonea regia* (9.9) and *Tabebuia rosea* (8.7).

For bird results and analysis, the most bird category was found in Kota Kinabalu is *Waders* (14.07%); secondly are *Herons, Storks and Bitterns,* (12.59%); thirdly are *Raptors* (8.15%) and *Bulbuls* (7.41%) respectively. The high presence of Waders and Herons category suitable to most of the area in Kota Kinabalu is because the Kota Kinabalu district is intact with coastal sea and also some areas with swamps or mudflats which are associated with mangrove area. Most of the birds observed in Kota Kinabalu are resident birds with 66% of the total overall birds survey; whereas migratory bird consists of 32% and 2% for both resident and migratory bird.

The analysis of bird abundance using distance sampling estimated a population density of 14 birds per km^2. Its density lies between a range of 11.53 – 17.25 birds per km^2 within 95% confidence interval. Results show that a total population of 3526 individuals covered an area of about 280 km^2.

Potential birdlife habitats were classified into classes of rich birdlife areas which including: secondary re-growth areas; coastal mangroves; coastal areas; rice fields; swamp areas; grasslands & scrub; riverside areas; plantations; hill vegetation; and pond, lakes & pools. The potential birdlife habitats then were derived and mapped using GIS software.

The presence of birdlife in the urban environment is a testimony to the quality of the environment. It is an indicator that some balance between the natural and the built environment could be achieved. To enhance the birdlife, it would be necessary to consider of three particular types of bird areas, namely:

a) Natural areas which are currently rich in birdlife and may act as “reservoirs” for populating urban parks. These reservoirs do not necessarily need to be situated in the urban areas but it must be possible to connect them to urban parks via vegetated corridors through which the birds can move safely.
b) Parks and green spaces where improvements would be of immediate benefit to the bird population. These include public parks where the present habitat is not particularly suitable for birds; and
c) To enhance vegetated corridors along which birds may move between the reservoirs and to other areas in between. These corridors can correspond to areas of low density housing, with tree-lined avenues and large gardens, or carefully-planted reserves alongside roads, railways, rivers, electricity lines, etc.

The public perception analysis indicates that the major ethnicity background of the respondents in Kota Kinabalu is Kadazandusun. They form the biggest community among others ethnic with a total population of 519,800 in 2005.

The town people appreciate the importance and benefits of trees to them for several reasons, which include: helping to reduce warmth and heat from the sunlight, beautification and aesthetic value, recreation opportunities, obstruction of rubbish and other annoyances (e.g. noise and dust pollution). The villagers gave additional views. They opined that trees provide clean and fresh air, provide clean water, food sources and important forest products.

The town community also indicated their reasons for visiting the forest, which are; *walking and sightseeing, jogging, hiking and walking for sports, picnicking and other informal outdoor recreation activities, and collecting plants.*

The village communities expressed, with 50%, that their usage of forest resources concentrated on non-wood forest products including *wild fruit, rubber, rattan, root tuber and dammar*. Another 32% mentioned use for medicinal purpose and 12% for poles, dyes and firewood, 4% sago, and 1% wildlife. Few respondents also expressed that they took several forest products to sell them in the open market to gain income e.g. *Garcinia hombroniana* (akob-akob), *Bambusa sp* (Bamboo tuber), *Parkia pinnata* (Petai-petai), *Zingiber sp* (Wild Ginger) and *Eurycoma longifolia* (Tonkat Ali) etc.

In line with the statement of nature protection and conservation, about 89.5% of the towns' respondents and 82% of the village respondents agree with this statement. They opined that the government should conserve and protect the remaining natural environment, and that there should be an educational and awareness program to educate people about the importance of forest to the environments. While some of the respondents also expressed their interest in helping the government, over third-forth explained that they were interested to be involved in decision making concerning conservation effort in their areas. The analysis further reveals that respondents with substantially higher levels of interest are female respondents.

The respondents also expressed that the problem threatening the forest today are unsustainable land use practices and expansion, with 38% opined these as the main threat. Unsustainable land use practices such as slash-and-burn agriculture has caused much of Kota Kinabalu surface and natural resources depleted. The second problem opined is river pollution. Most of the peoples in villages in Kota Kinabalu are river dependent, these includes Kg. Kitabu, Kg. Kokol, Kg. Kibambangan, Kg. Babagon and Kg. Kiansam. If forest areas were cleared, the silt or clay sediments from the bare surface will be washed into the river with heavy rainfall. They will directly pollute and increase the sediment in the river, thus making the water unsafe for drinking. Others view suggested that, cutting of trees in the hilly region will affect the physical structure of the soil, which in the end increases the susceptibility to landslide problem. Other minor problems expressed were the problems of deforestation, forest fire, and decreasing of wildlife through hunting activities.

The last chapter is dedicated to the analysis of biotope - land use types and mapping of urban forest functions. The result indicates that the land cover in Kota Kinabalu can be categorised into nine major important classes which include: settlements and associated non-agricultural areas; horticultural lands; improve permanent pasture; grasslands; croplands; tree, palm and other permanent crops; forest lands; swamps, marshlands and wetlands forests, and unused lands. Each class then subdivided into subclasses that together formed of 43 different land use type, and digitize and mapped using GIS software.

From the classifying of urban forest functions, the analysis reveals the important functions derived from urban forest in Kota Kinabalu. These include; bird habitat function; nature conservation function; protection function; recreation function and utility function. A set of criteria was produced for each function as a baseline for planning and management decisions. All the forest functions were mapped using GIS software, and later used as guidelines for management decisions concerning urban green of Kota Kinabalu.

Based on the overall results, the concept for sustainable management in tropical urban green areas requires appropriate measures to guarantee control of the development. In order to cope with environmental problems and to prevent new ones, planning with foresight is necessary. The overall goal is to safeguard the capacity of the ecosystem.

That means the complex interrelationship of all natural resources such as plants, animals species, human intervention, soil, water with their vast physical, chemical and biological processes should be considered in the early planning processes.

Regions of high risk will need to be excluded from development or to be developed with particular care and restrictions. These areas are: hilly land areas, streams and rivers, scenic landscape areas and potential wildlife areas. Moreover, the establishment of a policy and legislative framework is essential in order to ensure that land use plans and recommendations will be implemented.

It is a great concern to motivate people in all aspects of the management of natural resources. Local communities can play a critical role in achieving a success of conservation efforts. It is important to help the local people to put awareness on the environmental influence and vital role of the forests. They should understand the importance of safeguarding the ecosystems, habitats and species of both flora and fauna. Public support and involvement of the local people should be sought through all available media and include rural and urban people, decision makers, school teachers and kids.

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Appendices

Appendix 1: Sheet 1 - General Data Sheet

Plot Information : __________________

Date: __________________ *Begin hour:* ____________ *End hour:* _____________
Group / Name: _________________

Description of Forest area

Other References:
Previous record:
Growing area:
Others:

Location of Sample plot:
Transect Nr:
Point count Nr:
(if transect unsuitable):
GPS Coordinate:
Bearing/ Direction:
Size of plot: 0.25ha

Growing place:
Height above sea level:
Inclination/slope:
Geology (Rock type presence):
Soils texture: clay, sandy, silt @ fine, coarse, medium
Soil pH:

District Register:
Forest/ Urban District:
Location:

Descriptions of forest stand (composition of Species, Aspect, and Structure)
1 – Shrubs and grassland
2 – Bush and Small Jungle
3 – Secondary forest
4 - Swamp and peat
4 - Kerangas
5 – Coastal forest
6 - Riverine
7 – Mangrove
8 - Mix dipterocarp forest
9 – Others, *please specify:* ……………………

Presence influence / disturbance: (0 – 4)
0 – No influence (area more than 50 years)
1 – Disturb area with stand harvesting /secondary
2 – Disturb area with shifting cultivation/ left over area
3 – Plantation / single species / fruit species
4 – Degrade / clear cutting area
5 – Others, *Please specify:* …………………………

Additional Remarks:

Appendix 2: Sheet 2 - Natural Regeneration

Natural regeneration counting in clockwise direction (1m x 1m, per m²)

Direction		North					North-East					East					South-East				
No	**Species**	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
1																					
2																					
3																					
4																					
5																					
Direction		**South**					**South-West**					**West**					**North-West**				
No	**Species**	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
1																					
2																					
3																					
4																					
5																					

Appendix 3: Sheet 3 - Shrub, Herb and Bamboo

Layers	Height (cm)	Remarks
S (Shrub Layer) H (Herb Layer) M (Bamboo Layer)		

No.	Species List	Layer	Scale of Cover	Life from groups
1				
2				
3				
4				
5				

Appendix 4: Sheet 4 - Detail Tree Structure

Layers	DBH Class (cm)		Height Class (m)		Cover Class (%)	
T1 (Over layer) T2 (Middle layer) T3 (Under layer)	1 < 5 cm 2 = 6-25 3 = 26-50 4 = 51-75 5 = 76-100	6 = 101-125 7 = 126-150 8 = 151-175 9 > 175	1 < 0.5m 2 = 0.5-2m 3 = 2-5m 4 = 5-10m 5 = 10-15m	6 = 15-20m 7 = 20-35m 8 > 35m	1 = 0-1% 2 = 1-5% 3 = 5-25% 4 = 25-50% 5 = 50-75%	6 =75-100%

No	Species name	Distance (m)	α (°)	DBH (cm)	Height (m)	Cover (%)	Layer
1							
2							
3							
4							
5							

Appendix 5: Birdlife Collection Sheet - Point Transect Sampling, Kota Kinabalu, Malaysia

General description:-		
Point No:	Nearest location:	Date:
Observer Name :	Altitude:	Weather:
Start Time:	Finish Time:	Inclination/slope:
GPS Start:	Nearest location/road/village/	Latitude:
Aerial/ Satellite images:	or tie point in the map	Longitude:
GPS Point:	Distance to the point count	Latitude:
Habitat type:	Remarks:	Longitude:
Character:		
Flying: F, (Front/ Back)F/B	*Nesting: N*	*Calling: CL*
Flying: F, (Left/ Right)L/R	*Eating: E, Settling: ST*	*Singing: SG*

No	Species	Group size	P'endicular distance	Angle (ø)	Character	Habitat type/ remarks
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Appendix 6: Open-ended Questionnaire on tree managements

Kajian soal selidik ini bertujuan untuk mendapat input orang ramai tentang pokok dan pengurusannya di kawasan anda. *Please don't hesitate to give your opinion and idea regarding the subject above. Everything you write will be very valuable for this case study, thank you very much for your co-operation.*

Seksyen A (Maklumat Responden) General Information (Demographic Background)
Sila tandakan tanda (✓) di dalam petak yang berkenaan:- (Please tick (✓) inside the small box your answer)

1) Jantina / Gender ;-
   a) Lelaki/ male ☐ b) Perempuan/ female ☐

2) Lingkungan Umur / Age;-
   a) Under 20 tahun/ years ☐ d) 40-49 tahun / years ☐
   b) 20-29 tahun/ years ☐ e) 50-59 tahun / years ☐
   c) 30-39 tahun/ years ☐ f) 60 or older ☐

3) Agama / Religion :-
   a) Islam ☐ d) Buddist ☐
   b) Christians ☐ e) others ☐
   c) Hindus ☐

4) Bangsa / Ethnicity :-
   a) Melayu ☐ d) Kadazandusun ☐
   b) Cina ☐ e) others: ……………… ☐
   c) India ☐

5) Taraf Pendidikan / Education :-
   a) Primary 6 (UPSR) ☐ d) STPM or Diploma ☐
   b) SRP/ PMR (Middle Secondary School) ☐ e) Bachelor or Master ☐
   c) SPM (Upper Secondary School) ☐ f) Ph.D ☐

6) Pekerjaan / Profession ;-
   a) Kerajaan/ Public services ☐ d) Pelajar / Student ☐
   b) Swasta/ Non Government ☐ e) Tidak berkerja / unemployed: …………… ☐
   c) Berniaga / Business ☐

7) Pendapatan setahun / Income in year (RM) :-
   a) 15,000 – 20,000 ☐ e) 36,000 – 40,000 ☐
   b) 21,000 –25,000 ☐ f) 41,000 & ke atas ☐
   c) 26,000 – 30,000 ☐ g) Tiada berkaitan / not available: …………… ☐
   d) 31,000 – 35,000 ☐

8) Tempoh Berkhidmat / Years of service:-
   a) Kurang 10 tahun /years ☐ d) 21 – 25 tahun /years ☐
   b) 10 – 15 tahun /years ☐ e) 26 ke atas / above ☐
   c) 16 – 20 tahun / years ☐ f) Tiada berkaitan / not available: ……………… ☐

Appendix 6: Open-ended Questionnaire on tree managements (Contd.)

Seksyen B (maklumat berkenaan kawasan hijau):
Sila Tandakan (✓) di dalam petak yang disediakan dan sila isikan ruangan dengan pendapat dan idea anda.
Please tick (✓) inside the small box your desired answer and please fill the column with your idea's and opinions.

Everything you write will be very valuable for the study, Thank you!

1) Sila berikan jarak dari tempat tinggal anda sekarang ke satu kawasan hijau atau berpokok yang terhampir?
(Please indicate the distance (km) from your house to the nearby green areas inside your area?)

a) Kurang 5 km / *Less than 5 km* ☐ c) 10 to 25 km ☐
b) 5 to 15 km ☐ d) Lebih 25 km/ *more than 25 km* ☐

Jawapan lain sekiranya ada / *(Other answers)*..... ……………………………….………………………

2) Aktiviti yang sering saya lakukan ketika melawat satu-satu kawasan hijau atau taman?
(Please indicate the usual or most common activity you do in green areas?)

a) Berjalan menikmati keindahan taman/ *Walking for admiring the scenery* ☐ c) Mengutip tumbu tumbuhan dan bunga/ *Collect plants and flowers* ☐
b) Bersukan, berjogging dan berjalan kaki *Sports, jogging and walking* d) Berkelah / *picnic or informal outdoor*

Jawapan lain sekiranya ada / *(Other answers)*: ……………………………………….…………………

3) Pada pendapat saya, pokok-pokok yg ada di sini memainkan peranan yang amat penting seperti yang berikut: *(In my opinion, trees in my areas play a great important role, such as below :)*

a) Kecantikan / Beautification ☐ c) Mengurangkan panas /reduce warmth ☐
b) Rekreasi luar/ Outdoor recreation ☐ d) Menutup sampah/ obstruct rubbish ☐

Jawapan lain anda sekiranya ada / *(Other answers)*: …………………………………………………
……………………………………………………………………………………………………..

4) Sebagai pengguna, kehadiran pokok-pokok di sini memberikan faedah kepada saya.
(As a users, the presence of trees is intensely valuable to me… and why?)

☐ Sangat setuju/ Strongly agree ☐ Setuju / Partly agree ☐ Tidak Tahu / Ambivalent ☐ Tidak setuju / Partly disagree ☐ Sangat tidak setuju / Strongly disagree

Kalau setuju, mengapa? *(If yes, why?)* ………………………………………………………………
……………………………………………………………………………………………………..
Kalau tidak, mengapa? *(If no, why?)* ………………………………………………………………
……………………………………………………………………………………………………..

5) Saya berpendapat, pihak perancang bandaraya harus memulihara kawasan hijau yang sedia ada di kawasan ini. *(In my opinion, the town hall planning authorities should conserve all the green spaces in my area)*

☐ Sangat setuju/ Strongly agree ☐ Setuju / Partly agree ☐ Tidak Tahu / Ambivalent ☐ Tidak setuju / Partly disagree ☐ Sangat tidak setuju / Strongly disagree

Kalau setuju, mengapa? *(If yes, why?)* ………………………………………………………………
……………………………………………………………………………………………………..
Kalau tidak, mengapa? *(If no, why?)* ………………………………………………………………
……………………………………………………………………………………………………..

Appendix 6: Open-ended Questionnaire on tree managements (Contd.)

6) Pada pendapat saya, kehadiran pokok-pokok memberikan habitat bagi hidupan liar, burung burung dan serangga.
(*In my opinion, the presence of trees can provide habitat for wildlife to live such as birds and insects)*

☐ Sangat setuju/ Strongly agree ☐ Setuju / Partly agree ☐ Tidak Tahu / Ambivalent ☐ Tidak setuju / Partly disagree ☐ Sangat tidak setuju / Strongly disagree

Kalau setuju, mengapa? *(If yes, why?)*………………………………………………………………
……..
Kalau tidak, mengapa? *(If no, why?)* ………………………………………………………………
……..

7) Saya berpendapat, program kesedaran alam sekitar dan kempen penghijauan bandar diperlukan di kawasan ini.
(In my opinion, an environmental awareness program and green campaign is necessary in my area)

☐ Sangat setuju/ Strongly agree ☐ Setuju / Partly agree ☐ Tidak Tahu / Ambivalent ☐ Tidak setuju / Partly disagree ☐ Sangat tidak setuju / Strongly disagree

Kalau setuju, program yang bagaimana anda perlukan? (*If yes, which kind of program or in which way should be realised?*) ………………………..………………………………………………………
……..

8) Pada pendapat saya, penduduk di sini mempunyai kesedaran terhadap penghijauan dan selalu ingin berpartisipasi.
(I think the peoples here have awareness towards greenery and like to participate as much)

☐ Sangat setuju/ Strongly agree ☐ Setuju / Partly agree ☐ Tidak Tahu / Ambivalent ☐ Tidak setuju / Partly disagree ☐ Sangat tidak setuju / Strongly disagree

Kalau setuju, mengapa? *(If yes, why?)*………………………………………………………………
……..
Kalau tidak, mengapa? *(If no, why?)* ………………………………………………………………
……..

9) Saya tahu ada beberapa kawasan hijau (*taman, kawasan lapang, berpokok & rekreasi*) di kawasan ini.
(I know there are few green spaces, tree areas & parks nearby/close to my areas)

☐ Sangat setuju/ Strongly agree ☐ Setuju / Partly agree ☐ Tidak Tahu / Ambivalent ☐ Tidak setuju / Partly disagree ☐ Sangat tidak setuju / Strongly disagree

Kalau setuju, sila namakan dan nyatakan berapa kali seminggu/sebulan anda datang melawat ?
(If yes, please state the name? & how many times in a weeks/ month do you come to visit the gren areas)
……………………………………..…………………………………………..……….…………..…

10) Sekiranya saya berasa tertekan atau bosan, saya akan pergi ke kawasan hijau untuk melapangkan fikiran. *(When I feel bored or sometimes stressed, I will go to the parks to release my mind)*

☐ Sangat setuju/ Strongly agree ☐ Setuju / Partly agree ☐ Tidak Tahu / Ambivalent ☐ Tidak setuju / Partly disagree ☐ Sangat tidak setuju / Strongly disagree

Kalau setuju, mengapa? *(If yes, why?)*……………………………..…………………………………….
……..
Kalau tidak, mengapa? *(If no, why?)* ………………………………………………………………
……..

Appendix 6: Open-ended Questionnaire on tree managements (Contd.)

<u>Seksyen C (Aspek pengurusan pokok di kawasan bandar):</u>

11) Pada pendapat saya, pengurusan pokok yang diperlukan di bandar adalah seperti berikut:
(In my opinion, trees management in town should be needed as follows)
   a) Pemilihan pokok yang sesuai dan kesesuaian tapak kawasan ☐
      (Tree species selection and suitability of site)
   b) Pencantasan pokok dari semasa ke semasa untuk mengelakkan bahaya ☐
      (Pruning or pollarding of trees from time to time to prevent from hazards)
   c) Menjaga pokok-pokok yang telah tua di bandar sebagai warisan alam ☐
      (To take care of old trees in town as a heritage trees and to conserve)
   d) Mengawal serangan serangga perosak dan penyakit pokok ☐
      (To control insect, pest and diseases from affecting trees)

   Jawaban lain saya / *(my other answers)*: ……………………………………………………………………

12) Saya berpendapat, pekerja yg menyelenggara dan mengurus pokok-pokok bandar adalah terlatih dan berkemahiran.
(In my opinion, the peoples who maintain and manage the trees in town are experienced and skillful)

☐ Sangat setuju/ Strongly agree ☐ Setuju / Partly agree ☐ Tidak Tahu / Ambivalent ☐ Tidak setuju / Partly disagree ☐ Sangat tidak setuju / Strongly disagree

Kalau setuju, mengapa? *(If yes, why?)*……………………………………………………………………
………
Kalau tidak, mengapa? *(If no, why?)* ……………………………………………………………………
………

13) Saya berpendapat, pengurusan bg pokok yg boleh mendatangkan bahaya kpd keselamatan orang awam adalah perlu.
(In my opinion, tree hazard management or tree safety is necessary for the public safety)

☐ Sangat setuju/ Strongly agree ☐ Setuju / Partly agree ☐ Tidak Tahu / Ambivalent ☐ Tidak setuju / Partly disagree ☐ Sangat tidak setuju / Strongly disagree

Kalau setuju, mengapa? *(If yes, why?)*……………………………………………………………………
………..
Kalau tidak, mengapa? *(If no, why?)* ……………………………………………………………………
………..

14) Pada pendapat saya, pokok-pokok yang telah tua harus ditebang dan diganti dengan pokok-pokok yang baru. *(In my opinion, old trees that are found in town should be cut and changed with ones)*

☐ Sangat setuju/ Strongly agree ☐ Setuju / Partly agree ☐ Tidak Tahu / Ambivalent ☐ Tidak setuju / Partly disagree ☐ Sangat tidak setuju / Strongly disagree

Kalau setuju, mengapa? *(If yes, why?)*……………………………………………………………………
………..
Kalau tidak, mengapa? *(If no, why?)* ……………………………………………………………………
………..

15) Pada pendapat saya, kebanyakkan pokok-pokok di bandar kurang menarik dan menyebabkan kekotoran. *(In my opinion, most of the trees in town are not beautiful and effectuate dirtiness)*

☐ Sangat setuju/ Strongly agree ☐ Setuju / Partly agree ☐ Tidak Tahu / Ambivalent ☐ Tidak setuju / Partly disagree ☐ Sangat tidak setuju / Strongly disagree

Kalau setuju, mengapa? *(If yes, why?)* ……………………………………………………………………
………..
Kalau tidak, mengapa? *(If no, why?)* ……………………………………………………………………

Appendix 6: Open-ended Questionnaire on tree managements (Contd.)

16) Vandalisma pokok atau gangguan kepada pokok adalah diakibatkan oleh pengguna bandar (orang awam) sendiri.
(Trees Vandalism or interruption happened because of the interference by humans and town users itself)

☐ Sangat setuju/ Strongly agree ☐ Setuju / Partly agree ☐ Tidak Tahu / Ambivalent ☐ Tidak setuju / Partly disagree ☐ Sangat tidak setuju / Strongly disagree

Kalau setuju, mengapa? *(If yes, why?)*……..……………………………………………………………
……
Kalau tidak, mengapa? *(If no, why?)* …………………………………………………………………
……

17) Secara keseluruhan, saya sangat berpuashati dengan pengurusan pokok yang di laksanakan di bandar sekarang. *(I am satisfied with the trees management activities in town at this moment)*

☐ Sangat setuju/ Strongly agree ☐ Setuju / Partly agree ☐ Tidak Tahu / Ambivalent ☐ Tidak setuju / Partly disagree ☐ Sangat tidak setuju / Strongly disagree

Kalau setuju, mengapa? *(If yes, why?)*…………………………………………………………………
………………………………………………………………………………………………………..
Kalau tidak, mengapa? *(If no, why?)* …………………………………………………………………
………………………………………………………………………………………………………..

18) Sebagai pengguna, berikan pendapat anda untuk meningkatkan lagi pengurusan pokok pada masa akan datang?
(In your opinion as a user, what should be done to increase the management of this area in future?)
Jawaban anda *(Your answer?)*…………………………………………………………………..…………

"Terima kasih atas kerjasama anda untuk mengisi borang soal selidik ini"

''Thank you very much for you cooperation''

Appendix 7: Semi-structured interview (in Malay only)

SOAL SELIDIK : PEMULIHARAAN KAWASAN HIJAU DAN HUTAN - KOTA KINABALU

Tujuan kajian soal selidik ini adalah untuk mengetahui pendapat orang kampung tentang fungsi pemuliharaan (konservasi) hutan.

Tarikh: ______________________________
Nama kampung: ______________________
GPS: _________________________________
Diskripsi kampung: ______________________
Latar belakang kampung: ____

Sila isi jawapan anda pada ruangan yang disediakan:

a) Demografi seksyen:

1. Jantina: Lelaki Perempuan
2. Status: Bujang Berkahwin
3. Jika berkeluarga, sila nyatakan bilangan ahli keluarga: ____________________________
4. Umur: ____
5. Agama: ____
6. Bangsa: ____
7. Taraf Pendidikan / education: ____________________________
8. Pekerjaan / profession: _________________________________
9. Pendapatan setahun / income in year (RM): __________________
10. Jika anda bekerja dengan kerajaan atau swasta, sila nyatakan tempoh berkhidmat: ______________
11. Jika anda berkerja sendiri, apakah pekerjaan anda? Contohnya; bertani, nelayan, berniaga atau sbgnya sila nyatakan : ____
12. Sudah berapa lama anda menetap di sini: ______________________________________

b) Perhutanan seksyen:

1. Adakah anda pernah mengikuti ceramah berkaitan dengan perhutanan di tempat ini? ____________
2. Adakah anda bersedia mengikuti ceramah berkaitan tentang pemuliharaan /penjagaan hutan? _____
3. Adakah anda pernah menerima subsidi daripada mana-mana pihak? Contohnya; benih pokok, padi, ikan, getah, bunga, perahu, atau sila nyatakan ________________________________
4. Adakah anda bersetuju jika kawasan hutan ini dipulihara? __________________________
5. Adakah anda bergantung kepada sumber-sumber hutan sebagai kegunaan ubat-ubatan dan lain-lain kegunaan? ____
6. Apakah jenis pokok yang banyak terdapat di kampung ini? Contohnya; paya bakau, belukar, rumbia, pokok pantai atau lain lain sila nyatakan ______________________________
7. Adakah terdapat kawasan yang menarik di tempat ini (pemandangan yang menarik bagi anda)? Contohnya; a) air terjun b) bunga c) pokok besar d) hidupan liar @ burung-burung dan nyatakan __
8. Apakah binatang liar yang masih terdapat di kampung ini; contohnya burung, tupai, atau namakan yang anda tahu ____
9. Apakah pendapat anda tentang sumber-sumber hutan yang terdapat di sini? Contohnya; a) menghasilkan cuaca baik b) sumber bekalan air c) sumber makanan d) produk hutan atau lain lain sila nyatakan ____
10. Pada pandapat anda, apakah masalah yang terdapat di hutan ini? Contohnya; a) berbahaya b) pembiakan nyamuk c) jenayah d) berpenunggu e) binatang buas atau lain lain sila nyatakan _____
11. Sebagai penduduk di kampung ini apakah pendapat anda untuk meningkatkan lagi pemuliharaan hutan di kampung ini? ____
12. Pada pandangan anda adakah pokok-pokok hutan di sini membantu mengurangkan pemanasan / udara yang bersih? ____

Catatan :

Appendix 8: List of tree species surveyed in secondary re-growth plots in Kota Kinabalu

Family	Scientific name	Local Name
Leguminosae	*Acacia auriculiformis**	Akasia kuning
Leguminosae	*Acacia mangium**	Mangium
Lauraceae	*Actinodaphne glomerata*	Medang serai
Lauraceae	*Actinodaphne sesquipedalis*	Kayu Medang
Leguminosae	*Adenanthera pavonina*	Saga
Meliaceae	*Aglaia squamulosa*	Langsat-langsat
Apocynaceae	*Alstonia angustiloba*	Pulai bukit
Apocynaceae	*Alstonia macrophylla*	Pulai daun besar
Anacardiaceae	*Anacardium accidentale*	Jagus
Palmae	*Areca catechu*	Pinang
Moraceae	*Artocarpus anisophyllus*	Terap ikal
Moraceae	*Artocarpus artilis*	Sukun
Moraceae	*Artocarpus elasticus*	Terap togop
Moraceae	*Artocarpus scortechinii*	Terap hutan
Moraceae	*Artocarpus sp*	Timadang
Oxalidaceae	*Averrhoa bilimbi*	Belimbing pipit
Meliaceae	*Azadirachta excelsa*	Limpaga
Euphorbiaceae	*Baccaurea angulata*	Belimbing hutan
Guttiferae	*Callophylum innophylum*	Penaga laut
Anacardiaceae	*Campnosperma auriculatum*	Terentang
Leguminosae	*Cassia fistula*	Golden shower
Bombacaceae	*Ceiba pentandra*	Kapok
Lauraceae	*Cinamommum sp*	Kayu Manis
Lauraceae	*Cinnamommum camphora*	Champor
Lauraceae	*Cinnamomum iners*	Kayu Manis
Palmae	*Cocos nucifera*	Kelapa
Dilleniaceae	*Decaspermum fruticosum*	Obah merah
Dilleniaceae	*Dillenia borneensis*	Simpoh gajah
Dilleniaceae	*Dillenia suffruticosa*	Simpor
Dipterocarpaceae	*Dipterocarpus applanatus*	Keruing daun besar
Dipterocarpaceae	*Dipterocarpus sp.*	Keruing
Dipterocarpaceae	*Dryobalanops acromatica*	Kapur barus
Bombacaceae	*Durio acutifolius*	Durian daun runcing
Bombacaceae	*Durio lowianus*	Durian sukang
Bombacaceae	*Durio zibethinus*	Durian putih
Palmae	*Elaeis guineensis**	Sawit
Myrtaceae	*Eugenia sp.*	Kelat
Myrtaceae	*Eugenia claviflora*	Kelat merah
Myrtaceae	*Eugenia jambos*	Kelat jambu
Simaroubaceae	*Eurycoma longifolia*	Pahit pahit
Lauraceae	*Eusideroxylon melagangai*	Melagangai
Loganiaceae	*Fagraea volubilis*	Todopon puok
Moraceae	*Ficus aurata*	Ara bulu kuning
Moraceae	*Ficus benjamina*	Beringin
Moraceae	*Ficus sp.*	Ara
Rubiaceae	*Gardenia sp.*	Champaka tanjong
Euphorbiaceae	*Glochidion littorale*	Saka-saka
Anacardiaceae	*Gluta renghas*	Rengas
Euphorbiaceae	*Hevea brasiliensis**	Getah
Leguminosae	*Koompassia excelsa*	Mengaris

(contd.)

Appendix 8: List of tree species surveyed in secondary re-growth plots in Kota Kinabalu (contd.)

Family	Scientific name	Local Name
Meliaceae	*Lansium domesticum*	Langsat
Lauraceae	*Litsea sp*	Medang kuning
Fagaceae	*Lithocarpus sp*	Mempening
Lauraceae	*Litsea odorifera*	Medang pawas
Euphorbiaceae	*Macaranga tanarius*	Linkabong
Euphorbiaceae	*Macaranga triloba*	Sedaman
Anacardiaceae	*Mangifera caesia*	Beluno
Anacardiaceae	*Mangifera indica*	Mangga
Anacardiaceae	*Mangifera pajang*	Bambangan
Anacardiaceae	*Melanochyla fasciculiflora*	Rengas lupi
Meliaceae	*Melia indica*	Nim
Melostomataceae	*Memecylon laevigatum*	Nipis kulit
Rubiaceae	*Morinda citrifolia*	Bengkudu
Elaeocarpaceae	*Muntingia calabura*	Kerukup siam
Mucaceae	*Musa violascens*	Pisang
Bombacaceae	*Neesia sp*	Durian monyet
Sapindaceae	*Nephelium lappaceum*	Rambutan
Sapindaceae	*Nephelium maingayi*	Kelamondoi
Palmae	*Nypa fruticans*	Nipah
Datiscaceae	*Octomeles sumatrana*	Binuang
Palmae	*Oncosperma horridum*	Bayas
Palmae	*Oncosperma tigillarium*	Nibong
Leguminosae	*Parkia sp*	Kupang
Leguminosae	*Parkia sumatrana*	Petai
Pinaceae	*Pinus sp*	Pinus
Leguminosae	*Pithecellobium ellipticum*	Saga gajah
Leguminosae	*Pithecellobium sp*	Jiring tupai
Lauraceae	*Eusideroxylon zwageri*	Belian
Myrtaceae	*Psidium guajava*	Jambu Batu
Meliaceae	*Sandoricum koetjape*	Sentul hutan
Oxalidaceae	*Sarcotheca diversifolia*	Tabarus
Dipterocarpaceae	*Shorea flaviflora*	Seraya daun besar
Dipterocarpaceae	*Shorea parvifolia*	Seraya punai
Dipterocarpaceae	*Shorea sp.*	Seraya tembaga
Dipterocarpaceae	*Sindora beccariana*	Sepetir
Combretaceae	*Terminalia subspathulata*	Talisai
Sterculiaceae	*Theobroma cacao*	Koko
Burceraceae	*Triomma malaccensis*	Kedondong asam
Verbenaceae	*Vitex pubescens*	Kulimpapa

*Note: Exotic tree species marked with **

Appendix 9: List of tree species surveyed in mixed-horticulture plots in Kota Kinabalu

Family	Scientific name	Local Name
Leguminosae	*Acacia auriculiformis**	Akasia kuning
Leguminosae	*Acacia mangium**	Mangium
Araucariaceae	*Agathis borneensis*	Mengilan
Leguminosae	*Albizia chinensis**	Albizia
Lauraceae	*Alseodaphne bancana*	Medang payung
Apocynaceae	*Alstonia angustiloba*	Pulai bukit
Apocynaceae	*Alstonia spatulata*	Pulai basung
Anacardiaceae	*Anacardium accidentale*	Jagus
Myrsinaceae	*Ardisia elliptica*	Surusop
Palmae	*Areca catechu*	Pinang
Moraceae	*Artocarpus artilis*	Sukun
Moraceae	*Artocarpus anisophyllus*	Terap ikal
Moraceae	*Artocarpus elasticus*	Terap togop
Moraceae	*Artocarpus integer*	Pulutan
Moraceae	*Artocarpus sp*	Timadang
Meliaceae	*Azadirachta excelsa*	Limpaga
Euphorbiaceae	*Baccaurea angulata*	Belimbing hutan
Euphorbiaceae	*Baccaurea motleyana*	Rambai
Leguminosae	*Bauhinia blakeana*	Tapak kuda
Guttiferae	*Callophylum innophylum*	Penaga laut
Burseraceae	*Canarium sp*	Kedondong
Caricaceae	*Carica papaya**	Papaya
Leguminosae	*Cassia alata*	Gelengang
Leguminosae	*Cassia fistula*	Golden shower
Casuarinaceae	*Casuarina equisetifolia*	Aru
Bombacaceae	*Ceiba pentandra*	Kapok
Apocynaceae	*Cerbera odollam*	Pong-pong
Lauraceae	*Cinnamomum zeylanicum*	Cinamom
Rutaceae	*Citrus microcarpa*	Kalomondin
Palmae	*Cocos nucifera*	Kelapa
Fabaceae	*Dalbergia sissoo*	Siso
Leguminosae	*Delonix regia**	Semarak api
Dilleniaceae	*Dillenia suffruticosa*	Simpor
Bombacaceae	*Durio acutifolius*	Durian daun runcing
Bombacaceae	*Durio zibethinus*	Durian putih
Elaeocarpaceae	*Elaeocarpus stipularis*	Kungkurad
Leguminosae	*Erythrina sp*	Dadap
Leguminosae	*Erythrina variegata*	Dadap
Myrtaceae	*Eugenia cerasiformis*	Obah merah
Myrtaceae	*Eugenia grandis*	Kelat jambu
Myrtaceae	*Eugenia malaccensis*	Kelat malaya
Myrtaceae	*Eugenia papillosa*	Kelat paya
Myrtaceae	*Eugenia sp.*	Obah
Loganiaceae	*Fagraea gigantea*	Tembusu hutan
Loganiaceae	*Fagraea fragrans*	Tembusu
Loganiaceae	*Fagraea volubilis*	Todopon puok
Moraceae	*Ficus benjamina*	Beringin
Moraceae	*Ficus elastica**	Indian rubber
Moraceae	*Ficus microcarpa*	Banyan tree
Moraceae	*Ficus sp.*	Ara

(contd.)

Appendix 9: List of tree species surveyed in mixed-horticulture plots in Kota Kinabalu (contd.)

Family	Scientific name	Local Name
Sapindaceae	*Filicium dicipiens**	Fern tree
Guttiferae	*Garcinia malaccensis*	Asam-asam
Guttiferae	*Garcinia mangostana*	Manggis
Euphorbiaceae	*Hevea brasiliensis**	Getah
Lythraceae	*Lagerstroemia speciosa*	Bungur
Meliaceae	*Lansium domesticum*	Langsat
Leguminosae	*Leucaena glauca*	Petai-petai
Leguminosae	*Leucaena leucocephala**	Ipil-ipil
Combretaceae	*Lumnitzera sp*	Geriting
Euphorbiaceae	*Macaranga gigantean*	Merkubong
Euphorbiaceae	*Macaranga sp*	Mahang
Euphorbiaceae	*Macaranga tanarius*	Linkabong
Euphorbiaceae	*Macaranga trichocarpa*	Sedaman
Euphorbiaceae	*Macaranga triloba*	Sedaman
Anacardiaceae	*Mangifera caesia*	Beluno
Anacardiaceae	*Mangifera indica*	Mangga
Anacardiaceae	*Mangifera pajang*	Bambangan
Meliaceae	*Melia indica*	Nim
Sapotaceae	*Mimusops elengi*	Tanjong
Rubiaceae	*Morinda citrifolia*	Bengkudu
Elaeocarpaceae	*Muntingia calabura*	Kerukup siam
Mucaceae	*Musa violascens*	Pisang
Sapindaceae	*Nephelium lappaceum*	Rambutan
Palmae	*Nypa fruticans*	Nipah
Datiscaceae	*Octomeles sumatrana*	Binuang
Palmae	*Oncosperma tigillarium*	Nibong
Leguminosae	*Paraserianthes falcataria*	Batai
Leguminosae	*Peltophorum pterocarpum*	Batai laut
Pinaceae	*Pinus sp**	Pinus
Rubiaceae	*Pleiocarpidia sandakanica*	Buluh-buluh
Myrtaceae	*Psidium guajava*	Jambu Batu
Leguminosae	*Pterocarpus indicus*	Angsana
Palmae	*Roystonea regia*	Royal palm
Leguminosae	*Samanea saman**	Hujan hujan
Oxalidaceae	*Sarcotheca diversifolia*	Tabarus
Oxalidaceae	*Sarcotheca glauca*	Arak-arak
Sonneratiaceae	*Sonneratia sp*	Pedada
Bignoniaceae	*Spathodea campanulata*	Pancut-pancut
Myrtaceae	*Syzygium cumini*	Jambolan
Bignoniaceae	*Tabebuia rosea**	Poui
Leguminosae	*Tamarindus indica*	Asam jawa
Combretaceae	*Terminalia catappa*	Talisai Ketapang
Combretaceae	*Terminalia subspathulata*	Talisai
Verbenaceae	*Vitex pubescens*	Kulimpapa
Euphorbiaceae	*Wetria insignis*	Rambai hutan

*Note: Exotic tree species marked with **

Appendix 10: List of tree species surveyed in mangrove plots in Kota Kinabalu

Family	Scientific name	Local Name
Leguminosae	*Acacia auriculiformis**	Akasia kuning
Leguminosae	*Acacia mangium**	Mangium
Verbenaceae	*Avicennia sp*	Api-api
Meliaceae	*Azadirachta sp*	Limpaga
Rhizophoraceae	*Bruguiera cylindrica*	Beus
Rhizophoraceae	*Bruguiera parviflora*	Lenggadai
Burseraceae	*Canarium dacryodes*	Kodondong
Casuarinaceae	*Casuarina equisetifolia*	Aru
Palmae	*Cocos nucifera*	Kelapa
Moraceae	*Ficus benjamina*	Beringin
Malvaceae	*Hibiscus tiliaceus*	Baru
Euphorbiaceae	*Hura creptans**	Payung indonesia
Leguminosae	*Leucaena leucocephala**	Ipil-ipil
Euphorbiaceae	*Macaranga sp*	Mahang
Elaeocarpaceae	*Muntingia calabura*	Kerukup siam
Palmae	*Nypa fruticans*	Nipah
Rhizophoraceae	*Rhizophora apiculata*	Bakau minyak
Rhizophoraceae	*Rhizophora mucronata*	Bakau kurap
Leguminosae	*Samanea saman**	Hujan-hujan
Verbenaceae	*Tectona grandis**	Jati
Combretaceae	*Terminalia catappa*	Talisai Ketapang
Malvaceae	*Thespesia populnea*	Baru laut
Meliaceae	*Xylocarpus granatum*	Nyirih

*Note: Exotic tree species marked with **

Appendix 11: List of tree species surveyed in town plantation in Kota Kinabalu

Family	Scientific name	Local Name
Leguminosae	*Acacia auriculiformis**	Akasia kuning
Leguminosae	*Acacia mangium**	Mangium
Leguminosae	*Andira surinamensis**	Kedondong
Leguminosae	*Bauhinia blakeanna*	Tapak kuda
Leguminosae	*Bauhinia purpurea*	Tapak kuda
Guttiferae	*Callophylum innophylum*	Penaga laut
Leguminosae	*Cassia biflora**	Twin flowered cassia
Leguminosae	*Cassia fistula*	Golden shower
Leguminosae	*Cassia siamea**	Kassod tree
Leguminosae	*Cassia spectabilis*	Sena
Casuarinaceae	*Casuarina equisetifolia*	Aru
Apocynaceae	*Cerbera manghas*	Pong-pong
Apocynaceae	*Cerbera odollam*	Pong-pong
Palmae	*Cocos nucifera*	Kelapa
Palmae	*Cryfostachys lakka*	Pinang raja
Leguminosae	*Delonix regia**	Semarak api
Dilleniaceae	*Dillenia suffruticosa*	Simpor
Fabaceae	*Erythrina crista-galli**	Coral tree
Myrtaceae	*Eugenia grandis*	Kelat jambu
Moraceae	*Ficus elastica**	Indian rubber
Moraceae	*Ficus speciosa*	Ara
Euphorbiaceae	*Hura creptans**	Payung indonesia
Lythraceae	*Lagerstroemia speciosa*	Bungur
Sapotaceae	*Mimusops elengi*	Tanjong
Musaceae	*Musa speciosa*	Pisang
Leguminosae	*Peltophorum pterocarpum*	Batai laut
Fabaceae	*Pithecellobium dulce**	Manila tamarind
Annonaceae	*Polyalthia longifolia**	Cemetery tree
Leguminosae	*Pongamia pinnata*	Marabahai
Leguminosae	*Pterocarpus indicus*	Angsana
Palmae	*Ptychosperma macarthurii*	Macartur palm
Palmae	*Roystonea regia*	Royal palm
Leguminosae	*Samanea saman**	Hujan hujan
Bignoniaceae	*Tabebuia pallida**	Pink trumpet tree
Bignoniaceae	*Tabebuia rosea**	Poui
Ulamaceae	*Trema virgata*	Randangong
Combretaceae	*Terminalia catappa*	Talisai Ketapang
Palmae	*Veitchia merrillii*	Christmas palm

*Note: Exotic tree species marked with **

Appendix 12: List of the common regeneration species in secondary re-growth plots in Kota Kinabalu

Family	Scientific name	Local name
Leguminosae	*Acacia auriculiformis**	Akasia Kuning
Leguminosae	*Acacia mangium**	Mangium
Myrsinaceae	*Aegiceras corniculatum*	Kacang-kacang
Apocynaceae	*Alstonia angustiloba*	Pulai Bukit
Apocynaceae	*Alstonia macrophylla*	Pulai daun besar
Moraceae	*Artocarpus anisophyllus*	Terap ikal
Oxalidaceae	*Averrhoa bilimbi*	Belimbing Pipit
Meliaceae	*Azadirachta excelsa*	Limpaga
Burseraceae	*Canarium sp*	Kedondong
Palmae	*Cocos nucifera*	Kelapa
Dilleniaceae	*Dillenia suffroticosa*	Simpor
Dipterocarpaceae	*Dipterocarpus sp*	Keruing
Dipterocarpaceae	*Dryobalanops aromatica*	Kapur barus
Palmae	*Elaeis guineensis**	Sawit
Myrtaceae	*Eugenia jambos*	Kelat jambu
Myrtaceae	*Eugenia oliena*	Kelat merah
Myrtaceae	*Eugenia sp*	Kelat
Lauraceae	*Eusideroxylon melagangai*	Melagangai
Moraceae	*Ficus aurata*	Ara bulu kuning
Euphorbiaceae	*Glochidion littorale*	Jambu Kera
Anacardiaceae	*Gluta sp*	Rengas
Euphorbiaceae	*Hevea brasiliensis**	Getah
Euphorbiaceae	*Macaranga sp*	Mahang
Euphorbiaceae	*Macaranga tanarius*	Linkabong
Euphorbiaceae	*Macaranga triloba*	Sedaman
Euphorbiaceae	*Manihot esculenta*	Tapioca
Anacardiaceae	*Melanochyla fasciculiflora*	Rengas Padi
Melastomataceae	*Melastoma malabathricum*	Senduduk
Elaeocarpaceae	*Muntingia calabura*	Kerukup siam
Dipterocarpaceae	*Shorea sp.*	Seraya
Combretaceae	*Terminalia subspathulata*	Talisai
Verbenaceae	*Vitex peubescens*	Kulimpapa

*Note: Exotic tree species marked with **

Appendix 13: List of the common regeneration species in mixed horticulture plots in Kota Kinabalu

Family	Scientific name	Local name
Leguminosae	*Acacia auriculiformis**	Akasia Kuning
Leguminosae	*Acacia mangium**	Mangium
Apocynaceae	*Alstonia macrophylla*	Pulai Daun Besar
Myrsinaceae	*Ardisia elliptica*	Surusop
Moraceae	*Artocarpus anisophyllus*	Terap ikal
Moraceae	*Artocarpus heterophyllus*	Terap
Palmae	*Calamus subinermis*	Rotan batu
Guttiferae	*Calophyllum inophyllum*	Penaga Laut
Annonaceae	*Canangium sp*	Kenanga
Caricaceae	*Carica papaya**	Papaya
Asteraceae	*Chromolaena odorata*	Rumput Malaysia
Lauraceae	*Cinnamommum sp*	Kayu Manis
Lauraceae	*Cinnamomum camphora*	Camphor
Sterculiaceae	*Commersonia bartramia*	Kurajong
Fabaceae	*Dalbergia sissoo*	Siso
Dilleniaceae	*Dillenia excelsa*	Simpoh Laki
Dilleniaceae	*Dillenia suffruticosa*	Simpor
Dryopteridaceae	*Dryopteris thelypteris*	Paku pakis
Myrtaceae	*Eugenia cerasiformis*	Obah Merah
Myrtaceae	*Eugenia jambos*	Kelat jambu
Myrtaceae	*Eugenia olieana*	Kelat daun merah
Myrtaceae	*Eugenia sp*	Kelat
Sapindaceae	*Guioa pleuroptris*	Senyamuk
Euphorbiaceae	*Hevea brasiliensis**	Getah
Euphorbiaceae	*Macaranga triloba*	Sedaman
Anacardiaceae	*Mangifera indica*	Mangga
Melastomataceae	*Melastoma malabathricum*	Senduduk
Elaeocarpaceae	*Muntingia calabura*	Kerukup siam
Sapindaceae	*Nephelium lappaceum*	Rambutan
Sapotaceae	*Palaquium gutta*	Nyatoh Taban Merah
Moraceae	*Paratocarpus sp*	Terap
Phyllanthaceae	*Phyllanthus urinaria*	Meniran
Oxalidaceae	*Sarcotheca diversifolia*	Tabarus
Sonneratiaceae	*Sonneratia sp*	Pedada
Myrtaceae	*Syzygium cumini*	Jambolan

*Note: Exotic tree species marked with **

Appendix 14: List of the common regeneration species in mangrove plots in Kota Kinabalu

Family	Scientific name	Local name
Leguminosae	*Acacia auriculiformis**	Akasia Kuning
Leguminosae	*Acacia mangium**	Mangium
Rhizophoraceae	*Bruguiera parviflora*	Lenggadai
Anisophylleaceae	*Combretocarpus rotundatus*	Perepat Paya
Melastomataceae	*Melastoma malabathricum*	Senduduk
Palmae	*Nypa fruticans*	Nipah
Rhizophoraceae	*Rhizophora apiculata*	Bakau minyak
Rhizophoraceae	*Rhizophora mucronata*	Bakau Kurap

*Note: Exotic tree species marked with **

Appendix 15: List of traditional forest products among village communities in Kota Kinabalu.

Identification		Plant and Products
Species / Family	:	*Alstonia* sp. (Apocynaceae)
Local name	:	Pulai
Products (Uses)	:	Treating Malaria, medical – skin disease, Rubber latex
Species / Family	:	*Anacardium occidentale* (Anacardiaceae)
Local name	:	Gajus
Products (Uses)	:	Nut for food, fruits, medical (diarrhoea)
Species / Family	:	*Ananas comosus* (Bromeliaceae)
Local name	:	Nanas
Products (Uses)	:	Fruit, food, medical (diphtheria)
Species / Family	:	*Averrhoa bilimbi* (Geraniaceae)
Local name	:	Belimbing
Products (Uses)	:	Fruit, food, medical (fever, itching and cough)
Species / Family	:	*Avicennia* sp. (Verbenaceae)
Local name	:	Api Api
Products (Uses)	:	Tanning, Medical (tooth-ache)
Species / Family	:	*Bauhinia purpurea* (Leguminosae)
Local name	:	Tapak kuda
Products (Uses)	:	Medical (cough)
Species / Family	:	*Colocasia esculentum* (Araceae)
Local name	:	Keladi hutan
Products (Uses)	:	Food, Liquid - Treating bites by poisonous animals
Species / Family	:	*Carica papaya* (Caricaceae)
Local name	:	Betik
Products (Uses)	:	Medical, Food, and fruit

(contd.)

Appendix 15: List of traditional forest products among village communities in Kota Kinabalu (contd.)

Identification		Plant and Products
Species / Family	:	*Canangium odoratum* (Annonaceae)
Local name	:	Kenanga
Products (Uses)	:	Perfume, Medical (fever)
Species / Family	:	*Calophyllum inophyllum* (Guttiferae)
Local name	:	Bintangor
Products (Uses)	:	Medical (wounds), Resin, Oil-illuminant
Species / Family	:	*Ceiba pentandra* (Bombacaceae)
Local name	:	Kapok
Products (Uses)	:	Floss, fibre to make pillow, tanning
Species / Family	:	*Durio zibethinus* (Malvaceae)
Local name	:	Durian
Products (Uses)	:	Fruit, food, medical (tonic, fever)
Species / Family	:	*Scleria* sp. (Cyperaceae)
Local name	:	Rumput pisau
Products (Uses)	:	Young leaves as bandage for treating headache
Species / Family	:	*Dillenia* sp (Dilleniaceae)
Local name	:	Simpor
Products (Uses)	:	Leaves use for wraping food
Species / Family	:	*Bambusa* sp. (Gramineae)
Local name	:	Buluh, Poring
Products (Uses)	:	Food, general uses for house construction
Species / Family	:	*Imperata cylindrical* (Grimineae)
Local name	:	Lalang, Sakot
Products (Uses)	:	Medical – roots treating chest pain
Species / Family	:	*Garcinia* sp (Guttiferae)
Local name	:	Gelugur, Asam asam
Products (Uses)	:	Medical – treating throat irritation and cough
Species / Family	:	*Cinnamomum* sp. (Lauraceae)
Local name	:	Kayu manis
Products (Uses)	:	Medical – liquid treating stomach-ache
Species / Family	:	*Parkia* sp. (Leguminosae)
Local name	:	Petai
Products (Uses)	:	Food, medical – treating malaria
Species / Family	:	*Hibiscus rosa-sinensis* (Malvaceae)
Local name	:	Bunga raya
Products (Uses)	:	Medical – leaves for stomach-ache
Species / Family	:	*Melastoma malabatrichum* (Melastomataceae)
Local name	:	Senduduk
Products (Uses)	:	Medical – liquid stopping bleeding from cut

(contd.)

Appendix 15: List of traditional forest products among village communities in Kota Kinabalu (contd.)

Identification		Plant and Products
Species / Family	:	*Morinda citrifolia* (Rubiaceae)
Local name	:	Bengkudu
Products (Uses)	:	Medical (High-blood, diabetes, small-pox, cough)
Species / Family	:	*Musa* sp. (Musaceae)
Local name	:	Pisang
Products (Uses)	:	Fruit, fibre
Species / Family	:	*Nypa fruticans* (Palmae)
Local name	:	Nipah
Products (Uses)	:	Sugar, handicraft, vinegar food
Species / Family	:	*Lansium domesticum* (Meliaceae)
Local name	:	Langsat
Products (Uses)	:	Medical, fruits
Species / Family	:	*Eugenia* sp. (Myrsinaceae)
Local name	:	Obah
Products (Uses)	:	Medical – leaves uses for treating stomach-ache
Species / Family	:	*Psidium guajava* (Myrtaceae)
Local name	:	Jambu
Products (Uses)	:	Fruit, Medical – leaves use for treating stomach-ache/ diarrhea
Species / Family	:	*Areca catechu* (Palmae)
Local name	:	Pinang
Products (Uses)	:	Medical – seed treating cough and throat irritation, tanning
Species / Family	:	*Calamus* sp. (Palmae)
Local name	:	Rotan
Products (Uses)	:	Furniture, handicraft, Medical – young fruits treating cough and stomach-ache
Species / Family	:	*Eurocoma longifolia* (Simaroubaceae)
Local name	:	Tongkat Ali
Products (Uses)	:	Medical – treting malaria and scabies scars
Species / Family	:	*Zingiber* sp. (Zingiberaceae)
Local name	:	Halia
Products (Uses)	:	Medical – treating stomach-ache and head ache
Species / Family	:	*Costus* sp. (Zingiberaceae)
Local name	:	Setawar
Products (Uses)	:	Medical – leaves treating fever
Species / Family	:	*Rhizophora* sp. (Rhizophoraceae)
Local name	:	Bakau, Vakau
Products (Uses)	:	Charcoal, thanning, dye, for house construction

Note: Based on interviews, observations and personal experiences

Appendix 16: Systematic list of bird recorded at Kota Kinabalu (August – December 2005), Trip report by Andy Russel Mojiol, Hii Siew Mee and Renie Linjabat (UMS)

Vernacular name	Scientific name
White-vented Myna	*Acridotheres javanicus*
Common Sandpiper	*Actitis hypoleucos*
Crimson Sunbird	*Aethopyga siparaja*
Common Kingfisher	*Alcedo atthis*
White-breasted Water-hen	*Amaurornis phoenicurus*
Brown-throated Sunbird	*Anthreptes malacensis*
Phillippine Glossy Starling	*Aplonis panayensis*
Yellow-eared Spiderhunter	*Arachnothera chrysogenys*
Spectacled Spiderhunter	*Arachnothera flavigaster*
Little Spiderhunter	*Arachnothera longirostra*
Purple Heron	*Ardea purpurea*
Little Heron	*Butorides striatus*
Lesser Coucal	*Centropus bengalensis*
Greater Coucal	*Centropus sinensis*
Sunda Bush Warbler	*Cettia vulcania*
Green-winged Pigeon	*Chalcophaps indica*
Little Ringed Plover	*Charadrius dubius*
Marsh harrier	*Circus aeroginosus*
White-bellied Swiftlet	*Collocalia esculenta*
Magpie Robin	*Copsychus saularis*
Yellow-bellied Bulbul	*Criniger phaeocephalus*
Flower pecker	*Dicaeum celebicum*
Orange-bellied Flowerpecker	*Dicaeum trigonostigma*
Green Imperial Pigeon	*Ducula aenea*
Little Egret	*Egretta garzetta*
Plumed Egret	*Egretta intermedia*
Great Egret	*Egretta alba*
Little Pied Flycatcher	*Ficedula wetermanni*
Common Moorhen	*Gallinula chloropus*
Peacful Dove	*Geopelia striata*
Flyeater	*Gerygone sulphurea*
White-collared Kingfisher	*Halcyon chloris*
Black-capped Kingfisher	*Halcyon pileata*
White-bellied Sea-eagle	*Haliaeetus leucogaster*
Brahminy Kite	*Haliastur indus*
Red-rumped Swallow	*Hirundo daurica*
Pacific Swallow	*Hirundo tahitica*
Purple-naped Sunbird	*Hypogramma hypogrammicum*
Hairy-backed Bulbul	*Hypsipetes criniger*
Ashy Bulbul	*Hypsipetes flavalus*
Cinnamon Bittern	*Ixobrychus cinnamomeus*
Schrenck's Bittern	*Ixobrychus eurhythmus*
Yellow Bittern	*Ixobrychus sinensis*
Brown Shrike	*Lanius cristatus*
Lesser Adjutant	*Leptoptilos javanicus*
Dusky munia	*Lonchura fuscans*
Chestnut Munia	*Lonchura malacca*
Javanese munia	*Lonchura leucogastroides*

(contd.)

Appendix 16: Systematic list of bird recorded at Kota Kinabalu (August – December 2005), Trip report by Andy Russel Mojiol, Hii Siew Mee and Renie Linjabat (UMS) (contd.)

Vernacular name	Scientific name
Blue-crowned Hanging Parrot	*Loriculus galgulus*
Blue-tailed Bee-eater	*Merops philippinus*
Sunda Whistling Thrush	*Myiophoneus glaucinus*
Olive-backed Sunbird	*Nectarinia jugularis*
Black-crowned Night-heron	*Nycticorax nycticorax*
Dark-necked Tailor Bird	*Orthotomus atrogularis*
Ashy Tailor Bird	*Orthotomus ruficeps*
Collared Scops-owl	*Otus bakkamoena*
Osprey	*Pandion haliaetus*
Eurasian Tree Sparrow	*Passer montanus*
Stork-billed Kingfisher	*Pelargopsis capensis*
Chestnut-breasted Malkoha	*Phaenicophaeus curvirostris*
Yellow-breasted flowerpecker	*Prionochilus percussus*
Red-eyed Brown Bulbul	*Pycnonotus brunneus*
Spectacled Bulbul	*Pycnonotus erythrophthalmos*
Puff-backed Bulbul	*Pycnonotus eutilotus*
Flavescent Bulbul	*Pycnonotus flavescens*
Yellow-vented Bulbul	*Pycnonotus goiavier*
Olive-winged Bulbul	*Pycnonotus plumosus*
Straw-crowned Bulbul	*Pycnonotus zeylanicus*
Pied Fantail	*Rhipidura javanica*
Crested Serpent eagle	*Spilornis cheela*
Changeable Hawk Eagle	*Spizaetus cirrhatus*
Spotted dove	*Streptopelia chinensis*
Spotted-necked Dove	*Streptopelia chinensis*
Thick-billed Green Pigeon	*Treron curvirostra*
Pink-necked Green Pigeon	*Treron vermans*
Common Redshank	*Tringa tetanus*

Appendix 17: Systematic list of birds species recorded at Kota Kinabalu (March – April, 2002). Surveyed report by Rick Addison, Norfolk, UK available online from http://www.surfbirds.com/mb/trips/borneo-rad-0902.html (accessed at 2/3/2006)

Vernacular name	Scientific name
Ashy Tailorbird	*Orthotontus ruficeps*
Barn Swallow	*Hirundo rustica*
Black-crowned Night-heron	*Nvcticorax nycticorax*
Black-headed Munia	*Lonchura Malacca*
Brahimny Kite	*Halistur Indus*
Brown-backed Needletail	*Hirundapus giganteus*
Cattle Egret	*Bubulcus ibis*
Chinese Crested Myna	*Acridotheres cristatellus*
Collared Kingfisher	*Halcyon chloris*
Common Sandpiper	*Actitis hypoleucos*
Crimson Sunbird	*Aerhopyga siparaja*
Dusky Munia	*Lonchura fuscans*
Eurasian Tree Sparrow	*Passer montanus*
Glossy Swiftlet	*Collocalia esculenta*
Great Egret	*Egretta alba*
Greater Coucal	*Centropus sinensis*
Greater Sandplover	*Charadrius leschenaultia*
Green Imperial Pigeon	*Ducula aenea*
Greenshank	*Tringa nebularia*
Grey Heron	*Ardea cinerea*
Gull-billed Tern	*Gelochelidon nilotica*
House Swift	*Apus affinis*
Intermediate Egret	*Egretta intermedia*
Lesser Fish-Eagle	*Ichthyophaga humilis*
Little Egret	*Egretta garzetta*
Little heron	*Butorides striatus*
Magpie Robin	*Copsychits saularis*
Moorhen	*Gallinula chloropus*
Olive-backed Sunbird	*Nectarinia jugularis*
Pacific Golden Plover	*Pluvialis fulva*
Pacific Swallow	*Hirundo tahitica*
Paddyfield Pipit	*Atithus rufulus*
Phillipine Glossy Starling	*Aplonis panayensis*
Purple Heron	*Ardea purpurea*
Purple Swamphen	*Porphyrio porphyrio*
Redshank	*Tringa tetanus*
Spotted Dove	*Streptopelia chinensis*
Striated Grassbird	*Megalurus striatus*
Whiskered Tern	*Childonias hybridus*
White-bellied Sea Eagle	*Haliaeetus leucogaster*
White-breasted Waterhen	*Amaurornis phoenicurus*
White-breasted Woodswallow	*Artamus leucorhynchus*
White-browed Crake	*Porzatia cinerea*
Wood Sandpiper	*Tringa glareola*
Yellow Bittern	*Ixobrychiis sinensis*
Yellow-vented Bulbul	*Pycnonotus goiavier*

Appendix 18: List of bird species recorded at Kota Kinabalu* (August, 2001) by WWF, 2001

Vernacular name	Scientific names
Purple Heron	*Ardea purpurea*
Grey Heron	*Ardea cinerea*
Lesser Adjutant	*Leptoptilos javanius*
Rufous Night-heron	*Nycticorax caledonius*
Black-crowned	*Nycticarax nycticorax*
Intermediate Egret	*Egretta intermedia*
Chinese Egret	*Egretta eulophotes*
Pacific Reef Egret	*Egretta sacra*
Great Egret	*Egretta alba*
Little Egret	*Egretta garzetta*
Little Heron	*Butorides striatus*
Yellow Bittern	*Lxobrychus sinensis*
Cinnamon Bittern	*Lxobrychus cinnamomeus*
Tiger Bittern	*Gorsachius melanolophus*
Lesser Golden Plover	*Pluvialis fulva*
Little Ringed Plover	*Charadrius dubius*
Common Redshank	*Tringa tetanus*
Marsh Sandpiper	*Tringa stagnatilis*
Common Greenshank	*Tringa nebularia*
Wood Sandpiper	*Tringa glareola*
Common Sandpiper	*Actitis hypoleucos*
Terek Sandpiper	*Xenus cinereus*
Grey-tailed Tattler	*Tringa brevipes*
Snipe sp.	*Gallinago sp.*
Swinhoe´s Snipe	*Gallinago megala*
Black-winged Stilt	*Himantopus himantopus*
Common Kingfisher	*Alcedo atthis*
Blue-eared Kingfisher	*Alcedo meninting*
Stork-billed Kingfisher	*Pelargopsis capensis*
Black-capped Kingfisher	*Halcyon pileata*
Collared Kingfisher	*Halcyon chloris*
Blue-throated Bee-Eater	*Merops viridis*
Osprey	*Pandion haliaetus*
Brahminy Kite	*Haliastur Indus*
White-bellied Fish-eagle	*Haliaeetus leucogaster*
Grested Serpent Eagle	*Spilornis cheela*
Slaty-breasted Rail	*Rallus striatus*
White-breasted Waterhen	*Amauronis phoenicurus*
Common Moorhen	*Gallinula chloropus*
Little Green-Pigeon	*Treron olax*
Pink-necked Green- Pigeon	*Treron vernans*
Green Imperial- Pigeon	*Ducula aenea*
Feral Pigeon	*Columbia livia*
Spotted-necked Dove	*Streptopelia chinensis*
Peaceful Dove	*Geopelia striata*
Emerald Dove	*Chalcophaps indica*
Plaintive Cuckoo	*Cacomantis merulinus*
Lesser Coucal	*Centropus bengalensis*
Greater Coucal	*Centropus sinensis*

(contd.)

Appendix 18: List of bird species recorded at Kota Kinabalu* (August, 2001) by WWF, 2001 (contd.)

Vernacular name	Scientific names
Large-tailed Nightjar	*Caprimulgus macrurus*
White-bellied Swiftlet	*Collocalia esculenta*
House Swift	*Apus affinis*
Sunda Woodpecker	*Picoides moluccensis*
Barn Swallow	*Hirundo rustica*
Pacific Swallow	*Hirundo tahitica*
White-breasted Wood Swallow	*Artamus leucorhynchus*
Pied Triller	*Lalage nigra*
Green lora	*Aegithina viridissima*
Common lora	*Aegithina tiphia*
Greater Green Leafbird	*Chloropsis sonnerati*
Yellow-vented Bulbul	*Pycnonotus goiavier*
Olive-winged Bulbul	*Pycnonotus plumosus*
Red Eyed Brown Bulbul	*Pycnonotus brunneus*
Straw Headed Bulbul	*Pycnonotus zeylanicus*
Magpie Robin	*Copsychus saularis*
Ferruginous Babbler	*Trichatoma bicolor*
Striated Grassbird	*Megalurus palustris*
Ashy Tailorbird	*Orthotomus ruficeps*
Rufous-tailed Tailorbird	*Orthotomus sericeus*
Yellow-belied Prinia	*Prinia flaviventris*
Pied Fantail	*Rhipdura javanica*
Brown Shrike	*Lanius cristatus*
Paddyfield Pipit	*Anthus rufulus*
Philippine Glossy Starling	*Aplonis panayensis*
White-shouldered Starling	*Sturnus sinensis*
Plain-throated Sundbird	*Anthreptes malacensis*
Purple Naped Sundbird	*Hypogramma hypogrammicum*
Oliver-backed Sundbird	*Nectarinia jugularis*
Little Spider Hunter	*Arachnothera longirostra*
Yellow-breasted Flowerpecker	*Prionochilus maculates*
Dusky Munia	*Lonchura fuscans*
Chestnut Munia	*Lonchura Malacca*
Eurasian Tree-sparrow	*Passer montanus*

*Note: * Including oobservations at KKCB, city area and surroundings urban green areas.*

Appendix 19: Systematic list of birds species recorded at Kota Kinabalu (December 1996). Sources: ICZM Sabah, 1998

Vernacular name	Scientific name
Ashly Tailorbird	*Orthotontus ruficeps*
Barn Swallow	*Hirundo rustica*
Black-crowned Night-heron	*Nvcticorax nycticorax*
Brahminy Kite	*Halistur Indus*
Brown Shrike	*Lanius cristatus*
Cattle Egret	*Bubulcus ibis*
Chestnut Munia	*Lonchura Malacca*
Chinese Crested Myna	*Acridotheres cristatellus*
Cinnamon Bittern	*lxobrychus cinnamomeus*
Collared Kingfisher	*Halcyon chloris*
Common Sandpiper	*Actitis hypoleucos*
Dusky Munia	*Lonchura fuscans*
Eastern Great Reed-warbler	*Acrocephalus orientalis*
Eurasian Tree Sparrow	*Passer montanus*
Feral Pigeon	*Columba livia*
Garganey	*Anas querquedula*
Great Egret	*Egretta alba*
Greater Coucal	*Centropus sinensis*
Green Imperial Pigeon	*Ducula aenea*
Grey Heron	*Ardea cinerea*
House Swift	*Apus affinis*
Intermediate Egret	Egretta *intermedia*
Japanese Sparrowhawk	*Accipiter gularis*
Lesser Coucal	*Centropus bengalensis*
Lesser Golden Plover	*Pluvialis fulva*
Little Egret	*Egretta garzetta*
Little Heron	*Butorides striatus*
Marsh Sandpiper	*Tringa stagnatilis*
Moorhen	*Gallinula chloropus*
Olive-backed Sunbird	*Nectarinia jugularis*
Osprey	*Patidion haliaetus*
Pacific Reef-egret	*Egretta sacra*
Pacific Swallow	*Hirundo tahitica*
Peaceful Dove	*Geopelia striata*
Peregrine Falcon	Fal*co peregrinus*
Philippine Glossy Starling	*Aplonis panayensis*
Pied Triller	*Lalage nigra*
Plaintive Cuckoo	*Cacomantis menilinus*
Purple Heron	Ardea purpurea
Red Avadavat	*Amandava amandava*
Rufous-tailed Tailorbird	*Orthotomus sericeus*
Scaly-breasted Munia	*Lonchura punctulata*
Slaty-breasted Rail	*Rail Rallus striatus*
Snipe sp.	*Gallinago sp.*
Spotted-necked Dove	*Streptopelia chinensis*
Stork-billed Kingfisher	*Pelargopsis capensis*
Striated Grassbird	*Megalurus striatus*
Tufted Duck	*Aythya fuligula*
White-bellied Swiftlet	*Collocalia esculenta*

(contd.)

Appendix 19: Systematic list of birds species recorded at Kota Kinabalu (December 1996). Sources: ICZM Sabah, 1998 (Contd.)

Vernacular name	Scientific name
White-breasted Waterhen	*Amaurornis phoenicurus*
White-browed Crake	*Porzatia cinerea*
White-winged Tern	*Chlidonias leucopterus*
White-breasted Wood- swallow	*Artamus leucorhynchus*
Yellow Bittern	*Ixobrychiis sinensis*
Yellow-bellied Prinia	*Prinia flaviventris*
Yellow-vented Bulbul	*Pycnonotus goiavier*

Appendix 20: Systematic list of bird's species recorded at Kota Kinabalu (1986). Sources: ICZM Sabah, 1998*

Vernacular name	Scientific name
Ashy Tailorbird	*Orthotontus ruficeps*
Barn Swallow	*Hirundo rustica*
Black Bittern	*Dupetor flavicollis*
Black-capped Kingfisher	*Halcyon pileata*
Black-crowned Night-heron	*Nvcticorax nycticorax*
Black-headed Gull	*Larus ridibundus*
Black-winged Stilt	*Himantopus himantopus*
Brahminy Kite	*Halistur Indus*
Brown Shrike	*Lanius cristatus*
Cattle Egret	*Bubulcus ibis*
Chestnut Munia	*Lonchura Malacca*
Chinese Crested Myna	*Acridotheres cristatellus*
Chinese Painted Quail	*Coturix chinensis*
Cinnamon Bittern	*lxobrychus cinnamomeus*
Collared Kingfisher	*Halcyon chloris*
Common Iora	*Aegithina tiphia*
Common Kingfisher	*Alcedo atthis*
Common Redshank	*Tringa tetanus*
Common Sandpiper	*Actitis hypoleucos*
Crested Honey-buzzard	*Pernis plilorynchus*
Crimson Sunbird	*Aerhopyga siparaja*
Dusky Munia	*Lonchura fuscans*
Eastern Great Reed-warbler	*Acrocephalus orientalis*
Eurasian Tree-sparrow	*Passer montanus*
Feral Pigeon	*Columba livia*
Flowerpecker	*Dicaeum quadricolor*
Gargaiiey	*Anas querquedula*
Great Egret	*Egretta alba*
Green Imperial Pigeon	*Ducula aenea*
Green Iora	*Aegithina viridissiptia*
Grey Heron	*Ardea cinerea*
Grey Wagtail	*Motacilla cinerea*
Grey-faced Buzzard	*Butashur indcus*

(contd.)

Appendix 20: Systematic list of bird's species recorded at Kota Kinabalu (1986). Sources: ICZM Sabah, 1998* (contd.)

Vernacular name	*Scientific name*
House Swift	*Apus affinis*
Intermediate Egret	Egretta intermedia
Japanese Sparrowhawk	*Accipiter gularis*
Lesser Coucal	*Centropus bengalensis*
Lesser Golden Plover	*Pluvialis fulva*
Little Egret	*Egretta garzetta*
Little Green Pigeon	*Treron olax*
Little Heron	*Butorides striatus*
Little Ringed Plover	*Charadrius dubius*
Magpie Robin	*Copsychits saularis*
Marsh Sandpiper	*Tringa stagnatilis*
Moorhen	*Gallinula chloropus*
Olive-backed Suiibird	*Nectarinia jugularis*
Olive-winged Bulbul	*Pycnonolus plumosus*
Oriental Darter	*Anhinga melanogaster*
Osprey	*Patidion haliaetus*
Pacific Reef-egret	*Egretta sacra*
Pacific Swallow	*Hirundo tahitica*
Paddy field Pipit	*Anthus rufulus*
Peaceful Dove	*Geopelia striata*
Peregrine Falcon	Fa*lco peregrinus*
Philippine Glossy Starling	*Aplonis panayensis*
Pied Fantail	*Rhipidura javanica*
Pied Triller	*Lalage nigra*
Plaintive Cuckoo	*Cacomantis menilinus*
Purple Heron	Ardea purpurea
Red Avadavat	*Amandava amandava*
Rufous Night-heron	*Nycticorax caledonicus*
Rufous-tailed Tailorbird	*Orthotomus sericeus*
Scaly-breasted Munia	*Lonchura punctulata*
Slaty-breasted	*Rail Rallus striatus*
Snipe sp.	*Gallinago sp.*
Spotted-necked Dove	*Streptopelia chinensis*
Stork-billed Kingfisher	*Pelargopsis capensis*
Striated Grassbird	*Megalurus striatus*
Terek Sandpiper	*Xenus cinereus*
Tufted Duck	*Aythya fuligula*
White-bellied Swiftlet	*Collocalia esculenta*
White-breasted Waterhen	*Amaurornis phoenicurus*
White-breasted Wood-swallow	*Artamus leucorhynchus*
White-browed Crake	*Porzatia cinerea*
White-winged Tern	*Chlidonias leucopterus*
Wood Sandpiper	*Tringa glareola*
Yellow Bittern	*Ixobrychiis sinensis*
Yellow-bellied Prinia	*Prinia flaviventris*
Yellow-breasted Flowerpecker	*Priotiochilus percussus*
Yellow-vented Bulbul	*Pycnonotus goiavier*

* *Including observations at KKCB, city area and urban green surroundings.*

Appendix 21: List of bird species recorded at Kota Kinabalu from 1986 - 2005

Vernacular name	Scientific name	Category Class	M/R	Famili
Yellow-bellied Prinia	*Prinia flaviventris*	Babblers & relatives	R	Cisticolidae
Ferruginous Babbler	*Trichastoma bicolor*	Babblers & relatives	R	Timaliidae
Blue-tailed Bee-eater	*Merops philippinus*	Bee-eaters	R	Meropidae
Blue-throated Bee-Eater	*Merops viridis*	Bee-eaters	R	Meropidae
Yellow-bellied Bulbul	*Criniger phaeocephalus*	Bulbuls	R	Pycnonotidae
Hairy-backed Bulbul	*Hypsipetes criniger*	Bulbuls	R	Pycnonotidae
Ashy Bulbul	*Hypsipetes flavalus*	Bulbuls	R	Pycnonotidae
Olive-winged Bulbul	*Pycnonotus plumosus*	Bulbuls	R	Pycnonotidae
Red-eyed Brown Bulbul	*Pycnonotus brunneus*	Bulbuls	R	Pycnonotidae
Spectacled Bulbul	*Pycnonotus erythrophthalmos*	Bulbuls	R	Pycnonotidae
Puff-backed Bulbul	*Pycnonotus eutilotus*	Bulbuls	R	Pycnonotidae
Flavescent Bulbul	*Pycnonotus flavescens*	Bulbuls	R	Pycnonotidae
Yellow-vented Bulbul	*Pycnonotus goiavier*	Bulbuls	R	Pycnonotidae
Straw Headed Bulbul	*Pycnonotus zeylanicus*	Bulbuls	R	Pycnonotidae
Plaintive Cuckoo	*Cacomantis merulinus*	Cuckoos & Coucals	R	Cuculidae
Lesser Coucal	*Centropus bengalensis*	Cuckoos & coucals	R	Cuculidae
Greater Coucal	*Centropus sinensis*	Cuckoos & Coucals	R	Cuculidae
Chestnut-breasted Malkoha	*Phaenicophaeus curvirostris*	Cuckoos & Coucals	R	Cuculidae
Oriental Darter	*Anhinga melanogaster*	Darter & frigatebirds	R	Anhingidae
Tufted Duck	*Aythya fuligula*	Ducks	M	Anatidae
Garganey	*Anas querquedula*	Ducks	M	Anatidae
Back-sided Flowerpecker	*Dicaeum celebicum*	Flowerpeckers	R	Nectariniidae
Flowerpecker2	*Dicaeum cruentatum*	Flowerpeckers	R	Nectariniidae
Orange-bellied Flowerpecker	*Dicaeum trigonostigma*	Flowerpeckers	R	Nectariniidae
Yellow-breasted flowerpecker	*Prionochilus percussus*	Flowerpeckers	R	Nectariniidae
Little Pied Flycatcher	*Ficedula westermanni*	Flycatchers & whistlers	R	Muscicapidae
Flyeater	*Gerygone sulphurea*	Flycatchers & whistlers	R	Pardalotidae
Pied Fantail	*Rhipidura javanica*	Flycatchers & whistlers	R	Corvidae
Large-tailed Nightjar	*Caprimulgus macrurus*	Frogmouth & Swifts	R	Caprimulgidae
House Swift	*Apus affinis*	Frogmouths & swifts	R	Apodidae
White-bellied Swiftlet *(Glossy Swiftlet)*	*Collocalia esculenta*	Frogmouths & swifts	R	Apodidae
Whiskered Tern	*Chlidonias hybridus*	Gulls & terns	M	Laridae
White-winged Tern	*Chlidonias leucopterus*	Gulls & terns	M	Laridae
Gull-billed Tern	*Gelochelidon nilotica*	Gulls & terns	M	Sternidae
Black-headed Gull	*Larus ridibundus*	Gulls & terns	M	Laridae
Grey Heron	*Ardea cinerea*	Herons, Storks and Bitterns	M	Ardeidae
Purple Heron	*Ardea purpurea*	Herons, Storks and Bitterns	R	Ardeidae
Cattle Egret	*Bubulcus ibis*	Herons, Storks and Bitterns	M	Ardeidae
Little Heron	*Butorides striatus*	Herons, Storks and Bitterns	R	Ardeidae
Black Bittern	*Dupetor flavicollis*	Herons, Storks and Bitterns	M	Ardeidae
Great Egret	*Egretta alba*	Herons, Storks and Bitterns	R, M	Ardeidae
Chinese Egret	*Egretta eulophotes*	Herons, Storks and Bitterns	R, M	Ardeidae
Tiger Bittern	*Gorsachius melanolophus*	Herons, Storks and Bitterns	M	Ardeidae
Yellow Bittern	*Ixobrychus sinensis*	Herons, Storks and Bitterns	R	Ardeidae
Little Egret	*Egretta garzetta*	Herons, Storks and Bitterns	R, M	Ardeidae
Intermediate Egret *(Plumed Egret)*	*Egretta intermedia*	Herons, Storks and Bitterns	M	Ardeidae

(contd.)

Appendix 21: List of bird species recorded at Kota Kinabalu from 1986 - 2005 (contd.)

Vernacular name	Scientific name	Category Class	M/R	Famili
Pacific Reef-egret	*Egretta sacra*	Herons, Storks and Bitterns	R	Ardeidae
Cinnamon Bittern	*Ixobrychus cinnamomeus*	Herons, Storks and Bitterns	R	Ardeidae
Schrenck's Bittern	*Ixobrychus eurhythmus*	Herons, Storks and Bitterns	R	Ardeidae
Lesser Adjutant	*Leptoptilos javanicus*	Herons, Storks and Bitterns	R	Ciconiidae
Black-crowned Night-heron	*Nycticorax nycticorax*	Herons, Storks and Bitterns	R	Ardeidae
Rufous Night-heron	*Nycticorax caledonicus*	Herons, Storks and Bitterns	R	Ardeidae
Common Kingfisher	*Alcedo atthis*	Kingfishers	M	Alcedinidae
Blue-eared Kingfisher	*Alcedo meninting*	Kingfishers	R	Alcedinidae
White-collared Kingfisher	*Halcyon chloris*	Kingfishers	R	Alcedinidae
Black-capped Kingfisher	*Halcyon pileata*	Kingfishers	M	Alcedinidae
Stork-billed Kingfisher	*Pelargopsis capensis*	Kingfishers	R	Alcedinidae
Common Iora	*Aegithina tiphia*	Leafbirds & allies	R	Aegithinidae
Green lora	*Aegithina viridissima*	Leafbirds & allies	R	Aegithinidae
Greater Green Leafbird	*Chloropsis sonnerati*	Leafbirds & allies	R	Irenidae
Collared Scops-owl	*Otus bakkamoena*	Owls	R	Strigidae
Chinese Painted Quail	*Coturnix chinensis*	Pheasant	R	Phasianidae
Green-winged Pigeon *(Emerald dove)*	*Chalcophaps indica*	Pigeons, doves & parrots	R	Columbidae
Feral Pigeon	*Columba livia*	Pigeons, doves & parrots	R	Columbidae
Green Imperial Pigeon	*Ducula aenea*	Pigeons, doves & parrots	R	Columbidae
Peaceful Dove	*Geopelia striata*	Pigeons, Doves & Parrots	R	Columbidae
Blue-crowned Hanging Parrot	*Loriculus galgulus*	Pigeons, doves & parrots	R	Psittacidae
Spotted-necked Dove	*Streptopelia chinensis*	Pigeons, doves & parrots	R	Columbidae
Thick-billed Green Pigeon	*Treron curvirostra*	Pigeons, doves & parrots	R	Columbidae
Little Green Pigeon	*Treron olax*	Pigeons, doves & parrots	R	Columbidae
Pink-necked Green Pigeon	*Treron vernans*	Pigeons, doves & parrots	R	Columbidae
White-breasted Water-hen	*Amaurornis phoenicurus*	Rails & allies	R	Rallidae
Common Moorhen	*Gallinula chloropus*	Rails & allies	R	Rallidae
Purple Swamphen	*Porphyrio porphyrio*	Rails & allies	M	Rallidae
White-browed Crake	*Porzana cinerea*	Rails & allies	M	Rallidae
Slaty-breasted Rail	*Rallus striatus*	Rails & allies	R	Rallidae
Japanese Sparrowhawk	*Accipiter gularis*	Raptors	M	Accipitridae
Grey-faced Buzzard	*Butastur indicus*	Raptors	M	Accipitridae
Marsh harrier	*Circus aeruginosus*	Raptors	M	Accipitridae
Peregrine Falcon	*Falco peregrinus*	Raptors	M	Falconidae
White-bellied Sea-eagle	*Haliaeetus leucogaster*	Raptors	R	Accipitridae
Brahimny Kite	*Haliastur indus*	Raptors	R	Accipitridae
Lesser Fish-Eagle	*Ichthyophaga humilis*	Raptors	M	Accipitridae
Osprey	*Pandion haliaetus*	Raptors	M	Pandionidae
Crested Honey-buzzard	*Pernis ptilorhynchus*	Raptors	M	Accipitridae
Grested Serpent Eagle	*Spilornis cheela*	Raptors	R	Accipitridae
Changeable Hawk Eagle	*Spizaetus cirrhatus*	Raptors	R	Accipitridae
Brown Shrike	*Lanius cristatus*	Shrikes	M	Laniidae
Red Avadavat	*Amandava amandava*	Sparrows & munia	R	Estrildidae
Dusky Munia	*Lonchura fuscans*	Sparrows & munia	R	Estrildidae

(contd.)

Appendix 21: List of bird species recorded at Kota Kinabalu from 1986 - 2005 (contd.)

Vernacular name	Scientific name	Category Class	M/R	Famili
Javanese munia	*Lonchura leucogastroides*	Sparrows & munia	M	Estrildidae
Black-headed Munia *(Chestnut Munia)*	*Lonchura malacca*	Sparrows & munia	R	Estrildidae
Scaly-breasted Munia	*Lonchura punctulata*	Sparrows & munia	M	Estrildidae
Eurasian Tree-sparrow	*Passer montanus*	Sparrows & munia	R	Passeridae
Philippine Glossy Starling	*Aplonis panayensis*	Starling & Mynas	R	Sturnidae
White-shouldered Starling	*Sturnus sinensis*	Starling & Mynas	M	Sturnidae
Chinese Crested Myna	*Acridotheres cristatellus*	Starlings & mynas	R	Sturnidae
White-vented Myna	*Acridotheres javanicus*	Starlings & mynas	R	Sturnidae
Brown-throated Sundbird	*Anthreptes malacensis*	Sunbirds & Spiderhunters	R	Nectariniidae
Purple Naped Sundbird	*Hypogramma hypogrammicum*	Sunbirds & Spiderhunters	R	Nectariniidae
Crimson Sunbird	*Aethopyga siparaja*	Sunbirds& spiderhunters	R	Nectariniidae
Yellow-eared Spiderhunter	*Arachnothera chrysogenys*	Sunbirds& spiderhunters	R	Nectariniidae
Spectacled Spiderhunter	*Arachnothera flavigaster*	Sunbirds& spiderhunters	R	Nectariniidae
Little Spiderhunter	*Arachnothera longirostra*	Sunbirds& spiderhunters	R	Nectariniidae
Olive-backed Sunbird	*Nectarinia jugularis*	Sunbirds& spiderhunters	R	Nectariniidae
White-breasted Wood-swallow	*Artamus leucorhynchus*	Swallows	R	Artamidae
Brown-backed Needletail	*Hirundapus giganteus*	Swallows	M	Apodidae
Red-rumped Swallow	*Hirundo daurica*	Swallows	M	Hirundinidae
Barn Swallow	*Hirundo rustica*	Swallows	M	Hirundinidae
Pacific Swallow	*Hirundo tahitica*	Swallows	R	Hirundinidae
Pied Triller	*Lalage nigra*	Thrillers & minivels	R	Campephagidae
Magpie Robin	*Copsychus saularis*	Thrushes & relatives	R	Muscicapidae
Sunda Whistling Thrush	*Myophonus glaucinus*	Thrushes & relatives	R	Turdidae
Eastern Great Reed-warbler	*Acrocephalus orientalis*	Wablers	M	Sylviidae
Sunda Bush Warbler	*Cettia vulcania*	Wablers	R	Sylviidae
Striated Grassbird	*Megalurus palustris*	Wablers	R	Sylviidae
Dark-necked Tailor Bird	*Orthotomus atrogularis*	Wablers	R	Sylviidae
Rufous-tailed Tailorbird	*Orthotomus sericeus*	Wablers	R	Sylviidae
Ashy Tailorbird	*Orthotomus ruficeps*	Wablers	R	Sylviidae
Common Sandpiper	*Actitis hypoleucos*	Waders	M	Scolopacidae
Little Ringed Plover	*Charadrius dubius*	Waders	M	Charadriidae
Greater Sandplover	*Charadrius leschenaultii*	Waders	M	Charadriidae
Swinhoe´s Snipe	*Gallinago megala*	Waders	R	Scolopacidae
Snipe sp.	*Gallinago sp.*	Waders	M	Scolopacidae
Black-winged Stilt	*Himantopus himantopus*	Waders	M	Recurvirostridae
Pacific Golden Plover	*Pluvialis fulva*	Waders	M	Charadriidae
Grey-tailed Tattler	*Tringa brevipes*	Waders	M	Scolopacidae
Wood Sandpiper	*Tringa glareola*	Waders	M	Scolopacidae
Common Greenshank	*Tringa nebularia*	Waders	M	Scolopacidae
Marsh Sandpiper	*Tringa stagnatilis*	Waders	M	Scolopacidae
Common Redshank	*Tringa totanus*	Waders	M	Scolopacidae
Terek Sandpiper	*Xenus cinereus*	Waders	M	Scolopacidae
Paddy field Pipit	*Anthus rufulus*	Wagtails & pipits	R	Motacillidae
Grey Wagtail	*Motacilla cinerea*	Wagtails & pipits	M	Motacillidae
Sunda Woodpecker	*Picoides moluccensis*	Woodpeckers	R	Picidae

Appendix 22: List of recorded bird species in 2005 (own survey) and their usual habitat in Kota Kinabalu

Family and species	Habitat conservation	Habitat categories											
		S	*CM*	*CS*	*RF*	*SW*	*G*	*RV*	*PT*	*T*	*HV*	*PD*	*R*
CISTICOLIDAE													
Prinia flaviventris Yellow-bellied Prinia	Pt,G						1		1				
TIMALIIDAE													
Trichastoma bicolor Ferruginous Babbler	S,Hv	1									1		
MEROPIDAE													
Merops philippinus Blue-tailed Bee-eater	S,Cm,Pt, G	1	1				1		1				
Merops viridis Blue-throated Bee-Eater	S,Cm,Pt, G	1	1				1		1				
PYCNONOTIDAE													
*Criniger phaeocephalus*Yellow-bellied Bulbul	S,Hv,Pt	1							1		1		
Hypsipetes criniger Hairy-backed Bulbul	Hv, S,Pt	1							1		1		
Hypsipetes flavalus Ashy Bulbul	Hv,S,Pt	1							1		1		
Pycnonotus plumosus Olive-winged Bulbul	S,G, Pt	1					1		1				
Pycnonotus brunneus Red-eyed Brown Bulbul	Hv;S,Pt	1							1		1		
Pycnonotus erythrophthalmos Spectacled Bulbul	S;Sw,Pt	1				1			1				
Pycnonotus eutilotus Puff-backed Bulbul	S,Pt	1							1				
Pycnonotus flavescens Flavescent Bulbul	S;Hv,Pt	1							1		1		
Pycnonotus goiavier Yellow-vented Bulbul	Pt,T,Cm		1						1	1			1
Pycnonotus zeylanicus Straw Headed Bulbul	S;Rv; Pt	1						1	1				
CUCULIDAE													
Cacomantis merulinus Plaintive Cuckoo	G;S	1					1						
Centropus bengalensis Lesser Coucal	Sw;S;G,Pt	1				1	1		1				
Centropus sinensis Greater Coucal	S;G;CM; Rv,Pt	1	1				1	1	1				
Phaenicophaeus curvirostris Chestnut-breasted Malkoha	Pt,S	1							1				
ANHINGIDAE													
Anhinga melanogaster Oriental Darter	Rv							1					
RECURVIROSTRIDAE													
Himantopus himantopus Black-winged Stilt	Sw,Cs			1		1							

(contd.)

Appendix 22: List of recorded bird species in 2005 (own survey) and their usual habitat in Kota Kinabalu

Family and species	Habitat conserva-tion	Habitat categories											
		S	*CM*	*CS*	*RF*	*SW*	*G*	*RV*	*PT*	*T*	*HV*	*PD*	*R*
ANATIDAE													
Aythya fuligula Tufted Duck	Sw,Rv,Pd					1		1				1	
Anas querquedula Garganey	Sw,Rv,Pd					1		1				1	
NECTARINIIDAE													
Dicaeum celebicum Back-sided Flowerpecker	S,Hv,Pt	1							1		1		
Dicaeum cruentatum Flowerpecker2	T,S,Pt	1							1	1			
Dicaeum trigonostigma Orange-bellied Flowerpecker	S,Hv,Pt	1							1		1		
Prionochilus percussus Yellow-breasted flowerpecker	S	1											
Anthreptes malacensis Plain-throated Sundbird	Pt,S,G,Cm	1	1				1		1				
Hypogramma hypogrammicum Purple Naped Sundbird	Hv										1		
Aethopyga siparaja Crimson Sunbird	S,Pt	1							1				
Arachnothera chrysogenys Yellow-eared Spiderhunter	S	1											
Arachnothera flavigaster Spectacled Spiderhunter	S,Pt	1							1				
Arachnothera longirostra Little Spiderhunter	S,Hv	1									1		
Nectarinia jugularis Olive-backed Sunbird	S,Cm	1	1										
MUSCICAPIDAE													
Ficedula westermanni Little Pied Flycatcher	Hv,S	1									1		
PARDALOTIDAE													
Gerygone sulphurea Flyeater	Hv,Cm,G,Pt		1				1		1		1		
CORVIDAE													
Rhipidura javanica Pied Fantail	Cm,Pt,G		1				1		1				
APODIDAE													
Apus affinis House Swift	T									1			
Collocalia esculenta White-bellied Swiftlet	T,S	1								1			1
LARIDAE													
Chlidonias hybridus Whiskered Tern	Cs			1									
Chlidonias leucopterus White-winged Tern	Cs,Rv			1				1					
Larus ridibundus Black-headed Gull	Cs,Rv			1				1					
MOTACILLIDAE													
Anthus rufulus Paddy field Pipit	G,Pt						1		1				
Motacilla cinerea Grey Wagtail	G,Rf				1		1						
MUSCICAPIDAE													
Copsychus saularis Magpie Robin	Pt,S,G	1					1		1				1

(contd.)

Appendix 22: List of recorded bird species in 2005 (own survey) and their usual habitat in Kota Kinabalu (contd.)

Family and species	Habitat conservation	Habitat categories											
		S	*CM*	*CS*	*RF*	*SW*	*G*	*RV*	*PT*	*T*	*HV*	*PD*	*R*
STERNIDAE													
Gelochelidon nilotica Gull-billed Tern	Cs			1									
ARDEIDAE													
Ardea cinerea Grey Heron	CM,Cs		1	1									
Ardea purpurea Purple Heron	Sw,CM,		1			1							
Bubulcus ibis Cattle Egret	Pd,Rf,G				1		1					1	
Butorides striatus Little Heron	Rv,Pd,Cm,Cs		1	1				1				1	
Dupetor flavicollis Black Bittern	Sw,Rf,Pd				1	1						1	
Egretta alba Great Egret	CM; Rf;Sw			1	1	1							
Egretta eulophotes Chinese Egret	Cm,Rv			1				1					
Egretta garzetta Little Egret	Cs,Rv			1				1					
Egretta intermedia Intermediate Egret	Cm,Rf,Sw,Cs		1	1	1	1							
Egretta sacra Pacific Reef-egret	Cm,Cs		1	1									
Gorsachius melanolophus Tiger Bittern	Sw,Rv					1		1					
Ixobrychus sinensis Yellow Bittern	Sw,Rf,Pd				1	1						1	
Ixobrychus cinnamomeus Cinnamon Bittern	Sw					1							
Ixobrychus eurhythmus Schrenck's Bittern	Sw,Rf,Pd				1	1						1	
Nycticorax nycticorax Black-crowned Night-heron	Cm,Sw		1			1							
Nycticorax caledonicus Rufous Night-heron	Cm,Rv,Cs		1	1				1					
CICONIIDAE													
Leptoptilos javanicus Lesser Adjutant	Rf,Cs			1	1								
ALCEDINIDAE													
Alcedo atthis Common Kingfisher	Sw,Pd,Cm		1			1						1	
Alcedo meninting Blue-eared Kingfisher	Pt,Hv,S	1									1	1	
Halcyon chloris White-collared Kingfisher	Cm,Cs		1	1									
Halcyon pileata Black-capped Kingfisher	Rv,Sw,Cm		1			1		1					
Pelargopsis capensis Stork-billed Kingfisher	Cm,Pt,Rf,Rv		1		1			1	1				
PICIDAE													
Picoides moluccensis Sunda Woodpecker	Pt,S	1							1				

(contd.)

Appendix 22: List of recorded bird species in 2005 (own survey) and their usual habitat in Kota Kinabalu

Family and species	Habitat conserva-tion	Habitat categories											
		S	*CM*	*CS*	*RF*	*SW*	*G*	*RV*	*PT*	*T*	*HV*	*PD*	*R*
AEGITHINIDAE													
Aegithina tiphia Common Iora	S,Pt,Rv,Cm	1	1					1	1				
Aegithina viridissima Green lora	S,Pt	1							1				
IRENIDAE													
Chloropsis sonnerati Greater Green Leafbird	S,Pt	1							1				
STRIGIDAE													
Otus bakkamoena Collared Scops-owl	S,Pt	1							1				
PHASIANIDAE													
Coturnix chinensis Chinese Painted Quail	G,S	1					1						
COLUMBIDAE													
Chalcophaps indica Green-winged Pigeon	Pt;Hv								1		1		
Columba livia Feral Pigeon	G,S	1					1						
Ducula aenea Green Imperial Pigeon	Rv,Cm,Cs,Pt		1	1				1	1				
Geopelia striata Peaceful Dove *(Zebra Dove)*	Pt,G,T,Cs			1			1		1	1			
Streptopelia chinensis Spotted-necked Dove	Pt,G,S	1					1		1				1
Treron curvirostra Thick-billed Green Pigeon	Cm,Hv,Pt		1						1		1		
Treron olax Little Green Pigeon	S,Pt	1							1				
Treron vernans Pink-necked Green Pigeon	Cm,G,S,Pt	1	1				1		1				
LANIIDAE													
Lanius cristatus Brown Shrike	S,G	1					1						
RALLIDAE													
Amaurornis phoenicurus White-breasted Water-hen	S,Rf,Sw,Pd	1			1	1						1	
Gallinula chloropus Common Moorhen	Rf,Sw,Pd				1	1						1	
Porphyrio porphyrio Purple Swamphen	Rf,Sw,Pd				1	1						1	
Porzana cinerea White-browed Crake	Sw,Rf				1	1							
Rallus striatus Slaty-breasted Rail	Cm,Pd		1									1	
CHARADRIIDAE													
Charadrius dubius Little Ringed Plover	Cs,RV			1				1					
Charadrius leschenaultii Greater Sandplover	Cs			1									
Pluvialis fulva Lesser Golden Plover	Cs			1									

(contd.)

Appendix 22: List of recorded bird species in 2005 (own survey) and their usual habitat in Kota Kinabalu

Family and species	Habitat conserva-tion	Habitat categories											
		S	*CM*	*CS*	*RF*	*SW*	*G*	*RV*	*PT*	*T*	*HV*	*PD*	*R*
ACCIPITRIDAE													
Accipiter gularis Japanese Sparrowhawk	Pt								1				
Butastur indicus Grey-faced Buzzard	Pt								1				
Circus aeruginosus Marsh harrier	Hv,Rf				1						1		
Haliaeetus leucogaster White-bellied Sea-eagle	Cs,Cm		1	1									
Haliastur indus Brahimny Kite	Cs,Cm		1	1									
Ichthyophaga humilis Lesser Fish-Eagle	Rv,Cm		1					1					
Pernis ptilorhynchus Crested Honey-buzzard	S	1											
Spilornis cheela Grested Serpent Eagle	Hv,S	1									1		
Spizaetus cirrhatus Changeable Hawk Eagle	Pt,S	1							1				
PANDIONIDAE													
Pandion haliaetus Osprey	Cs,Rv,Pd			1				1				1	
FALCONIDAE													
Falco peregrinus Peregrine Falcon	S	1											
ESTRILDIDAE													
Amandava amandava Red Avadavat	S,G	1					1						
Lonchura fuscans Dusky Munia	G,Rf;E,Pt				1		1		1				1
Lonchura leucogastroides Javanese munia	G,Rf				1		1						
Lonchura malacca Black-headed Munia *(Chestnut Munia)*	S,Rf,Pt,S w	1			1	1			1				
Lonchura punctulata Scaly-breasted Munia	S,Rf	1			1								
PASSERIDAE													
Passer montanus Eurasian Tree-sparrow	Cs,T			1						1			
STURNIDAE													
Aplonis panayensis Philippine Glossy Starling	S,T,Cs,Pt	1		1					1	1			1
Sturnus sinensis White-shouldered Starling	S	1											
Acridotheres cristatellus Chinese Crested Myna	T									1			1
Acridotheres javanicus White-vented Myna	T									1			1
CAPRIMULGIDAE													
Caprimulgus macrurus Large-tailed Nightjar	G,Pt						1		1				
PSITTACIDAE													
Loriculus galgulus Blue-crowned Hanging Parrot	Cs,Hv			1							1		

(contd.)

Appendix 22: List of recorded bird species in 2005 (own survey) and their usual habitat in Kota Kinabalu

Family and species	Habitat conservation	Habitat categories											
		S	*CM*	*CS*	*RF*	*SW*	*G*	*RV*	*PT*	*T*	*HV*	*PD*	*R*
ARTAMIDAE													
Artamus leucorhynchus White-breasted Wood-swallow	S	1											
APODIDAE													
Hirundapus giganteus Brown-backed Needletail	S	1											
HIRUNDINIDAE													
Hirundo daurica Red-rumped Swallow	Pt,S	1							1				
Hirundo rustica Barn Swallow	S	1											
Hirundo tahitica Pacific Swallow	Cm,G		1				1						
CAMPEPHAGIDAE													
Lalage nigra Pied Triller	Pt,S,Cm	1	1						1				
TURDIDAE													
Myophonus glaucinus Sunda Whistling Thrush	Hv										1		
SYLVIIDAE													
Acrocephalus orientalis Eastern Great Reed-warbler	G,Pd,Rv, Pt						1	1	1			1	
Cettia vulcania Sunda Bush Warbler	Hv,Pt								1		1		
Megalurus palustris Striated Grassbird	S,Pt	1							1				
Orthotomus atrogularis Dark-necked Tailor Bird	S,Pt	1							1				
Orthotomus sericeus Rufous-tailed Tailorbird	S;Pt	1							1				
Orthotomus ruficeps Ashy Tailorbird	Cm,Rv,Pt		1					1	1				
SCOLOPACIDAE													
Actitis hypoleucos Common Sandpiper	Rv,Rf,Sw ,Cm		1		1	1		1					
Gallinago megala Swinhoe´s Snipe	Sw					1							
Gallinago sp. Snipe sp.	Sw					1							
Tringa brevipes Grey-tailed Tattler	Cs		1										
Tringa glareola Wood Sandpiper	Sw,Rf,C m		1		1	1							
Tringa nebularia Common Greenshank	Cs,Rf,Sw			1	1	1							
Tringa stagnatilis Marsh Sandpiper	Sw,Rf,C m		1		1	1							
Tringa totanus Common Redshank	Sw,Cs			1		1							
Xenus cinereus Terek Sandpiper	Cs,Rv			1				1					
TOTAL		*56*	*34*	*29*	*22*	*28*	*26*	*23*	*54*	*9*	*20*	*15*	*8*

Notes: S = Secondary growth area; CM = Coastal mangrove; Cs = Coastal area, RF = Rice field; Sw = Swamp; G = Grassland & scrub; RV = Riverside area; PT = Plantation; T = Town; Hv = Hill vegetation; Pd = Pond & pools; R = Residential area

Appendix 23: Wildlife Conservation Enactment 1997, Sabah Wildlife Department Sabah, Malaysia

SCHEDULES
Schedule 1 Totally protected species of animals and plants.
Schedule 2 Protected species of animals and plantsn - limited hunting and collection under licence.
Schedule 3 Protected species of animals for which hunting licence required.

SCHEDULE 1 (Section 2) TOTALLY PROTECTED SPECIES OF ANIMALS AND PLANTS
PART I (Section 25(1)) TOTALLY PROTECTED ANIMALS

1. Sumatra Rhinoceros (Dicerorhinus sumatrensis) Badak Sumatra
2. Orang Utan (Pongo pygmaeus) Orang Utan
3. Sun Bear (Helarctos malayanus) Beruang Madu
4. Dugong (Dugong dugon) Duyung
5. Proboscis Monkey (Nasalis larvatus) Monyet Bangkatan
6. Clouded Leopard (Neofelis nebulosa) Harimau Dahan
7. Gharial (Tomistoma schlegeli) Buaya Julung-julung
8. Green Turtle (Chelonia mydas) Penyu Hijau
9. Hawksbill Turtle (Eretmochelys imbricata) Penyu Sisik

PART II (Section 54(1)(a)) TOTALLY PROTECTED PLANTS

1. Nepenthes Rajah spp - Periuk Kera
2. Paphiopedilum spp - Orkid Selipar
3. Rafflesia spp - Rafflesia
4. Tetrastigma spp - Pokok Perumah Rafflesia

SCHEDULE 2 (Section 2) PROTECTED SPECIES OF ANIMALS AND PLANTS-LIMITED HUNTING AND COLLECTION UNDER LICENCE
PART I (Section 25(2) PROTECTED ANIMALS

<u>**MAMMALS**</u>

1. Kinabalu Shrew (Crocidura baluensis) Cencurut Kinabalu
2. Dayak Roundleaf Bat (Hipposideros dyacorum) Kelawar Ladam-bulat Dayak
3. Coppery Pipistrelle (Pipistrellus cuprosus) Kelawar Hidung Pendek Tembaga
4. Gilded Tube-nosed Bat (Murina rozendaali) Kelawar Hidung Laras Emas
5. Flying Lemur (Cynocephalus variegatus) Kubung
6. Slow Loris (Nycticebus coucang) Kongkang
7. Tarsier (Tarsius bancanus) Kera Hantu
8. Maroon Leaf Monkey (Presbytis rubicunda) Monyet Merah
9. Grey Leaf Monkey (Presbytis hosei) Monyet Kikok
10. Silver Leaf Monkey (Presbytis cristata) Monyet Kelabu
11. Long-tailed Macaque (Macaca fascicularis) Kera
12. Pig-tailed Macaque (Macaca nemestrina) Beruk
13. Gibbon (Hylobates muelleri) Kelawat
14. Pangolin (Manis javanica) Tenggiling
15. Giant Squirrel (Ratufa affinis) Tupai Kerawak Putih-kuning
16. Kinabalu Squirrel (Callosciurus baluensis) Tupai Kinabalu
17. Giant Tufted Ground Squirrel (Rheithrosciurus macrotis) Babut
18. Hose's Pigmy Flying Squirrel (Petaurillus hosei) Tupai Terbang Kecil
19. Temminck's Flying Squirrel (Petinomys setosus) Tupai Terbang Dada Putih
20. Horsfield's Flying Squirrel (Iomys horsfieldi) Tupai Terbang Ekor Merah
21. Grey-cheeked Flying Squirrel (Hylopetes lepidus) Tupai Terbang Pipi Kelabu
22. Black Flying Squirrel (Aeromys tephromelas) Tupai Terbang Hitam
23. Smoky Flying Squirrel (Pteromyscus pulverulentus) Tupai Terbang Kotor
24. Whiskered Flying Squirrel (Petinomys genibarbis) Tupai Terbang Berjambang

(contd.)

Appendix 23: Wildlife Conservation Enactment 1997, Sabah Wildlife Department Sabah, Malaysia (contd.)

25. Spotted Giant Flying Squirrel (Petaurista elegans) Tupai Terbang Bintang
26. Red Giant Flying Squirrel (Petaurista petaurista) Tupai Terbang Merah
27. Thomas's Flying Squirrel (Aeromys thomasi) Tupai Terbang Merah
28. Long-tailed Porcupine (Trichys fasciculata) Landak Padi
29. Thick-spined Porcupine (Thecurus crassispinis) Landak Borneo
30. Yellow-throated Marten (Martes flavigula) Mengkira
31. Malay Weasel (Mustela nudipes) Pulasan Tanah
32. Ferret-Badger (Melogale personata) Pulasan Lamri
33. Malay Badger (Mydaus javanensis) Teledu
34. Hairy-nosed Otter (Lutra sumatrana) Memerang Kumis
35. Smooth Otter (Lutra perspicillata) Memerrang Licin
36. Oriental Small-clawed Otter (Aonyx cinerea) Memerang Kecil
37. Malay Civet (Viverra tangalunga) Musang Tanggalong
38. Otter-Civet (Cynogale bennettii) Musang Memerang
39. Binturong (Arctictis binturong) Musang Binturong
40. Small-toothed Palm Civet (Arctogalidia trivirgata) Musang Akar
41. Masked Palm Civet (Paguma larvata) Musang Lamri
42. Common Palm Civet (Paradoxurus hermaphroditus) Musang Pulut
43. Hose's Civet (Hemigalus hosei) Musang Hitam Pudar
44. Banded Palm Civet (Hemigalus derbyanus) Musang Belang
45. Banded Linsang (Prionodon linsang) Musang Linsang
46. Collared Mongoose (Herpestes semitorquatus) Bambun Ekor Panjang
47. Short-tailed Mongoose (Herpestes brachyurus) Bambun Ekor Pendek
48. Leopard Cat (Felis bengalensis) Kucing Batu
49. Marbled Cat (Felis marmorata) Kucing Dahan
50. Flat Headed Cat (Felis planiceps) Kucing Hutan
51. Bay Cat (Felis badia) Kucing Merah
52. Asian Elephant (Elephas maximus) Gajah
53. Banteng (Bos javanicus) Tembadau
54. Sei Whale (Balanoptera borealis) Ikan Paus Sei
55. Bryde's Whale (Balanoptera edent) Ikan Paus Bryde
56. Killer Whale (Orcinus orca) Ikan Paus Buding
57. Short-finned Pilot Whale (Globicephala macrohynchus) Ikan Paus Pendek Sirip
58. Pigmy Sperm Whale (Kogia breviceps) Ikan Paus Nayan
59. Grey Dolphin (Grampus griseus) Dolfin Kelabu
60. Bottlenose Dolphin (Tursiops truncatus) Dolfin Hidung Botol
61. Indo-Pacific Hump-backed Dolphin (Sousa chinensis) Dolfin Bongkok Bernie
62. Irrawaddy Dolphin (Orcaella brevirostris) Dolfin Empesut
63. Finless Porpoise (Neophocaena phocaenides) Ikan Lumba-lumba Ambu
64. Fraser's Dolphin (Lagenodelhis hosei) Dolfin Fraser
65. Long Snouted Spinner Dolphin (Stenella longirostra) Dolfin Hidung Mancung

REPTILES

66. Estuarine Crocodile (Crocodylus porosus) Buaya
67. False Gharial (Tomistoma schlegeli) Buaya Julung-julung
68. Monitor Lizard (All varanus species) Biawak
69. Reticulated Python (Python reticulatus) Ular Sawa Panjang
70. Blood Python (Python curtus) Ular Sawa Darah
71. King Cobra (Ophiophagus hannah) Ular Tedung Selar
72. Forest Tortoise (Tetsudo emys) Kura-kura Bukit
73. Asian Giant Turtle (Orlitia borneonsis) Juku-Juku Besar

(contd.)

Appendix 23: Wildlife Conservation Enactment 1997, Sabah Wildlife Department Sabah, Malaysia (contd.)

FRIGATEBIRDS
74. Christimas Island Frigatebird (Fregata andrewsi) Simbang Pulau Christmas
75. Lesser Frigatebird (Fregata ariel) Simbang Kecil

CORMORANTS AND DARTERS
76. Great Cormorant (Phalacrocorax carbo) Dendang Air
77. Oriental Darter (Anhinga melanogaster) Kosa

HERONS AND BITTERNS
78. Great-billed Heron (Ardea sumatrana) Bangau Bakau
79. Purple Heron (Ardea purpurea) Bangau Paya
80. Grey Heron (Ardea cinerea) Seriap
81. Reef Egret (Egretta sacra) Bangau Laut
82. Little Egret (Egretta garzetta) Bangau Kecil
83. Chinese Egret (Egretta eulophotes) Bangau Cina
84. Intermediate Egret (Egretta intermedia) Bangau Kerbau
85. Little Heron (Butorides striatus) Pucong Keladi
86. Black-crowned Night-Heron (Nycticorax nycticorax) Pucong Kuak
87. Rufous Night Heron (Nycticorax caledonicus) Pucong Malam
88. Malayan Night Heron (Gorsachius melanolophus) Pucong Rimau
89. Yellow Bittern (Ixobrychus sinensis) Pucong Merah
90. Schrenck's Bittern (Ixobrychus eurhythmus) Pucong Gelam
91. Black Bittern (Ixobrychus flavicollis) Pucong Hitam
92. Cinnamon Bittern (Ixobrychus cinnamomeus) Pucong Bendang

STORKS
93. Storm's Stork (Cicona stormi) Botak Storm
94. Lessers Adjutant Stork (Leptoptilos javanicus) Botak Kecil

IBISES
95. Black-headed Ibis (Threskiornis melanocephalus) Sekendi Kepala Hitam

HAWKS AND EAGLES
96. Bat Hawk (Machaeramphus alcinus) Helang Malam
97. Jerdon Baza (Avicedo jerdoni) Helang Baza
98. Crested Honey-Buzzard (Pernis ptilorhynchus) Helang Lebah
99. Brahminy Kite (Haliastur indus) Helang Merah
100. Black Kite (Milvus migrans) Helang Kembara Hitam
101. Black Eagle (Ictinaetus malayensis) Helang Hitam
102. Lesser Fish-Eagle (Ichthyophaga humilis) Helang Kangok
103. Grey-headed Fish-Eagle (Ichthyophaga ichtyaetus) Helang Kepala Kelabu
104. Kinabalu Serpent-Eagle (Spilornis kinabaluensis) Helang Kinabalu
105. Crested Serpent-Eagle (Spilornis cheela) Helang Berjambul
106. Besra (Accipiter virgatus) Helang Pipit
107. Crested Goshawk (Accipiter trivirgatus) Helang Putih
108. Wallace's Hawk-Eagle (Spizaetus nanus) Helang Selat

OSPREYS
109. Osprey (Pandion haliacetus) Helang Tiram

FALCONS
110. White-fronted Falconet (Microhierax latifros) Falko Dahi Putih
111. Peregrine Falcon (Falcon peregrinus) Falko Belalang

(contd.)

Appendix 23: Wildlife Conservation Enactment 1997, Sabah Wildlife Department Sabah, Malaysia (contd.)

112. Common Falconet (Microhierax caerulescens) Falko Biasa
113. Oriental hobby (Falco severus) Falko Timor
114. Eurasian Kestrel (Falco tinnunculus) Falko Serani

MEGAPODES
115. Tabon Scrubfowl (Megapodius cumingii) Tambun

PARTRIDGES AND PHEASANT
116. Blue-breasted Quail (Coturnix chinensis) Pikau
117. Long-billed Partridge (Rhizothera longirostris) Siul Selanting
118. Ferruginous Partridge (Caloperdix oculea) Sang Seruk Rimba
119. Red-breasted Partridge (Arborophila hyperythra) Siul Dada Merah
120. Chestnus-necklaced Partridge (Arborophilla charltonii) Sang Serok
121. Black Wood-Partridge (Melanoperdix nigra) Siul Bertam
122. Crested Partridge (Rollulus rouloul) Siul Berjambul
123. Crimson-headed Partridge (Haematortyx sanguiniceps) Siul Kepala Merah
124. Crested Fireback (Lophura ignita) Ayam Pegar
125. Crestless Fireback (Lophura erythopthalma) Merah Mata
126. Bulwer's Pheasant (Lophura bulweri) Pakiak
127. Bornean Peacock-Pheasant (Polyplectron schleiermacheri) Merak Pongsu
128. Great Argus (Argusianus argus) Kuang Raya

PLOVERS
129. Malaysian Plover (Charadrius peronii) Rapang Pasir

SANDPIPERS AND SNIPES
130. Far Eastern Curlew (Numenius madagascariensis) Kedidi Timor
131. Nordmann's Greenshank (Tringa guttifer) Kedidi Kaki Hijau Berbintik
132. Asian Dowitcher (Limnodromus semipalmatus) Kedidi Dada Merah

THICK-KNEES
133. Beach Thick-knee (Esacus magnirostris) Burung Lutut Tebal

SKUAS, GULLS AND TURNS
134. Black-naped Tern (Sterna sumatrana) Camar Tengkuk Hitam
135. Bridled Tern (Sterna anaethetus) Camar Batu
136. Chinese-crested Tern (Sterna bernsteini) Camar Cina Berjambul

PIGEONS AND DOVES
137. Large-Green Pigeon (Treron capellei) Lengguak
138. Cinnamon-headed Green-Pigeon (Treron fulvicollis) Punai Bakau
139. Black-naped Fruit-Dove (Ptilinopus melanospila) Punai Tengkuk Hitam
140. Grey Imperial Pigeon (Ducula pickeringi) Merpati Raja Kelabu
141. Metalic Wood-Pigeon (Columbia vitiensis) Merpati Kayu
142. Emerald Dove (Chalcophaps indica) Punai Tanah
143. Nicobar Pigeon (Caloenas nicobarica) Punai Emas

PARROTS
144. Blue-naped Parrot (Tanygnathus lucionensis) Bayan Tengkuk Biru
145. Blue-rumped Parrot (Psittinus cyanurus) Bayan Puling
146. Long-tailed Parakeet (psittacula longicauda) Bayan Nuri
147. Blue-crowned Hanging-Parrot (Loriculus galgulus) Bayan Kecil/Serindit

(contd.)

Appendix 23: Wildlife Conservation Enactment 1997, Sabah Wildlife Department Sabah, Malaysia (contd.)

CUCKOOS, MALKOHAS AND COUCALS
148. Violet Cuckoo (Chrysococcyx xanthorhynchus) Sewah Rembah
149. Short-toed Coucal (Centropus rectunguis) But-But Jari Pendek
150. Sunda Ground-Cuckoo (Carpococcyx radiceus) Sewah Tanah

OWLS
151. Bay Owl (Phodilus badius) Jampuk Pantai
152. Reddish Scops-Owl (Otus rufescens) Hantu Merah
153. Mountain Scops-Owl (Otus spilocephalus) Hantu Gunung
154. Collared Scops-Owl (Otus lempiji) Hantu Reban
155. Mantanani Scops-Owl (Otus mantananensis) Hantu Mantanani
156. Barred Eagle-Owl (Bubo sumatrana) Hantu Bubu
157. Buffy Fish-Owl (Ketupa ketupu) Hantu Kuning
158. Collared Owlet (Glaucidium brodiei) Hantu Kecil
159. Brown Boobook (Ninox scutulata) Hantu Betemak
160. Brown Wood-Owl (Strix leptogrammica) Hantu Punggor

FROGMOUTHS
161. Large Frogmouth (Batrachostomus auritus) Segan Besar

NIGHTJARS
162. Bonaparte's Nightjar (Caprimulgus concretus) Tukang Bonarparte

SWIFTS
163. Waterfall Swifts (Hydrochous gigas) Layang-Layang Hantu
164. Edible-nest Swiftlet (Aerodramus fuciphagus) Layang-Layang Gua
165. Black-nest Swiftlet (Aerodramus maximus) Layang-Layang Padi
166. Brown-backed Needletail (Hirundapus giganteus) Layang-Layang Besar

HORNBILLS
167. Wrinkled Hornbill (Rhyticeros corrugatus) Enggang Berkedut
168. Wreathed Hornbill (Rhyticeros undulatus) Enggang Gunung
169. White-crowned Hornbill (Berenicornis comatus) Enggang Jambul Putih
170. Bushy-crested Hornbill (Annorrhinus galeritus) Enggang Belukar
171. Black Hornbill (Anthracoceros malayanus) Enggang Gatal Birah
172. Pied Hornbill (Anthracoceros coronatus) Enggang Tangling
173. Rhinoceros Hornbill (Buceros rhinoceros) Enggang Badak
174. Helmeted Hornbill (Rhinoplax vigil) Enggang Terbang Mentua

HONEYGUIDES
175. Malaysian Honeyguide (Indicator archipelagicus) Gembala Lebah

WOODPECKERS
176. Speckled Piculet (Picumnus innominatus) Belatok Belang
177. Rufous Woodpecker (Celeus brachyurus) Belatok Kecil
178. White-bellied Woodpecker (Dryocopus javensis) Belatok Gajah

PITTAS
179. Giant Pitta (Pitta caerulea) Pacat Besar
180. Fairy Pitta (Pitta nympha) Pacat
181. Blue-headed Pitta (Pitta baudi) Pacat Kepala Merah
182. Blue-banded Pitta (Pitta arquata) Pacat
183. Banded Pitta (Pitta guajana) Pacat Bukit
184. Blue-winged Pitta (Pitta moluccensis) Pacat Sayap Biru
185. Hooded Pitta (Pitta sordida) Pacat Gembala Pelandok

Appendix 23: Wildlife Conservation Enactment 1997, Sabah Wildlife Department Sabah, Malaysia (contd.)

BULBULS
186. Straw-headed Bulbul (Pycnonotus zeylanicus) Barau-barau
187. Hook-billed Bulbul (Setornis criniger) Merbah

THRUSHES
188. Everett's Trush (Zoothera everetti) Murai Everett
189. White-crowned Forktail (Enicurus leschenaulti) Murai Cegar Belukar
190. White-rumped Shama (Copsychus malabaricus) Murai Rimba
191. Magpie Robin (Copsychus saulari) Murai Kampung

BABBLERS
192. White-chested Babbler (Trichastoma rostratum) Burung Telanjuk
193. Ferruginous Babbler (Trcihastoma bicolor) Rimba Sampah
194. Grey-breasted Babbler (Malacopteron albogulare) Rimba Dahan
195. Bornean Wren-Babbler (Ptilocichla leucogrammica) Rimba Borneo

FLYCATCHERS
196. Sunda Blue Flycather (Cyornis caerulata) Sambar Biru Sunda
197. Malaysian Blue Flycatcher (Cyornis turcosa) Sambar Biru Malaysia
198. Asian Paradise Flycather (Terpsiphone paradisi) Sambar Ekor Panjang

WHISTLERS
199. Mangrove Whistler (Pachycephala cinerea) Sambar Siul Belukar

FLOWERPECKERS
200. Brown-backed Flowerpecker (Dicaeum everetti) Sepah Puteri Gunung

STARLING AND MYNAS
201. Hill Myna (Gracula religiosa) Tiong Mas

BRISTLEHEADS
202. Bornean Bristlehead (Pityriasis gymnocephala) Burung Jambul

JAYS AND CROWS
203. Black Magpie (Platysmurus leucopterus) Murai Hitam
204. Short-tailed Green Magpie (Cissa thalassina) Murai Hijau

INSECTS
205. Rajah Brooke's Birdwing (Trogonoptera brookiana) Kupu-Kupu Rajah
206. Common Birdwing (All Troides species) Kupu-kupu (semua spesis Troides)

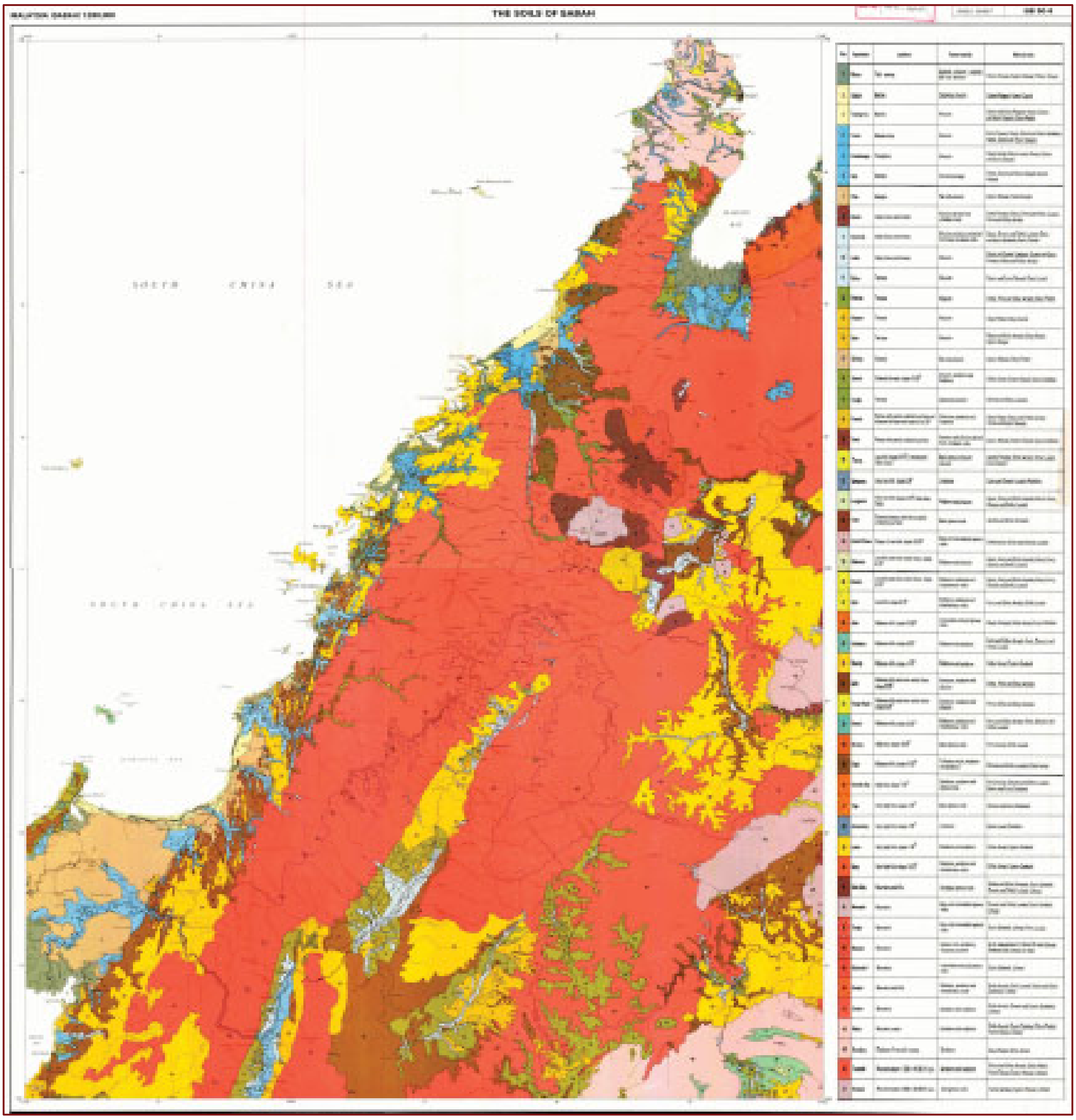
PART II (Section 54(1)(b)) PROTECTED PLANTS

1.	Caryota spp	- Botu
2.	Ceratolobus spp	- Rotan
3.	Corypha spp	- Gabang
4.	Cycadaceae	- Paku Laut
5.	Cytoceae	- Paku
6.	Zingiberaceae	- Halia Hutan
7.	Nenga spp	- Pinang Hutan
8.	Nepenthaceae	- Periuk Kera
9.	Orchidaceae	- Anggerek Hutan
10.	Podocarpus spp (Commercial spp)	- Lampias
11.	Rhododendron spp	- Mawar Hutan
12.	Livistonia sp	- Silad
13.	Arenga sp	- Polod

SCHEDULE 3 (Sections 2, 25(2)) PROTECTED SPECIES OF ANIMALS FOR WHICH HUNTNG LICENCE IS REQUIRED

1. Large Flying Fox (Pteropus vampyrus) Keluang Bakau
2. Island Flying Fox (Pteropus hypomelanus) Keluang Pulau
3. Common Porcupine (Hystrix brachyura) Landak Raya
4. Bearded Pig (Sus barbatus) Babi Hutan
5. Lesser Mousedeer (Tragulus javanicus) Pelandok
6. Greater Mousedeer (Tragulus napu) Napoh
7. Common Barking Deer (Muntiacus muntjac) Kijang
8. Borneon Yellow Muntjac (Muntiacus atherodes) Kijang
9. Sambar Deer (Cervus unicolor) Rusa

Appendix 24: Soil map of Sabah, scale of 1:250,000



Source: Agriculture Department of Sabah (2003)

Appendix 25: Soil associations of Sabah

Key	Association	Landform	Parent Material	Main Soil Units
1	Weston	Tidal swamps	Sulphidic alluvium, sulphidic peat and alluvium	Thionic Fluvisols: Dystric Histosols: Thionic Gleysol
2	Usukan	Beaches	Calcareous alluvium	Calcaric Regosol: Humic Gleysol
3	Tanjong Aru	Beaches	Alluvium	Dystric and Eutric Regosol: Humic, Dystric and Eutric Gleysols: Gleyic Podzol
4	Tuaran	Meander belts	Alluvium	Eutric Fluvisol; Gleyic, Dystric and Eutric Cambisols; Humic, Dystric and Eutric Gleysols
5	Kinabatangan	Foodplains	Alluvium	Gleyie Acrisol, Gleyic Luvisol; Humic, Dystric and Eutric Gleysols
6	Sapi	Swamps	Alluvium and peat	Humic, Dystric and Eutric Gleysols, Dystric Histosol
7	Klias	Swamps	Peat and alluvium	Dystric Histosol; Humie Gleysol
8	Binalik	Valley floors and terraces	Alluvium derived from ultrabasic rocks	Orthic Farralsol; Gleyic, Farric and Orthic Luvisols; Ferric and Orthic Acrisols
9	Karamuak	Valley floors and terraces	Alluvium and alluvium derived from basic/ ultrabasic rocks	Gleyic, Chromic and Orthic Luvisols; Gleyic and Eutric Combisols; Eutric Fluvisol
10	Labau	Valley floors and terraces	Alluvium	Glevic and Dystric Cambisols; Dystric and Eutric Fluvisols; Gleyic and Orthic Acrisols
11	Binkor	Terraces	Alluvium	Dystric and Eutric Glaysols; Gieyic Luvisol
12	Brantian	Terraces	Alluvium	Orthic, Ferric and Gleyic Acrisols; Gleyic Podzol
13	Kepayan	Terraces	Alluvium	Gleyic podzol; Gleyic Acrisol
14	Sook	Terraces	Alluvium	Gleyic and Orthic Acrisols; Gleyic Podzol; Dystric Gleysol
15	Sipitang	Swamps	Peat and alluvium	Dystric Histosol; Gleyic Podzol
16	Sinarun	Dissected terraces: slopes 15-25°	Alluvium, sandstone and mudstone	Orthic Acrisol; Dystric Gleysol; Dystric Cambisol
17	Tungku	Terraces	Calcareous alluvium	Chromic and Gleyic Luvisols
18	Pinosuk	Plateau with gently undulating surface and dissected terraces with slopes up to 25°	Colluvium, sandstone and mudstone	Gleyic Podzol; Gleyic and Orthic Acrisols; Humic and Dystric Gleysols

(contd.)

Appendix 25: Soil associations of Sabah (contd.)

Key	Association	Landform	Parent Material	Main Soil Units
19	Tawai	Plateau with gently undulating surface	Ironstone, alluvium derived from ultrabasic rocks	Dystric Histosol; Dystric Gleysol; Dystric Cambisol
20	Tapang	Low hills (0-15°), terraces and valley floors	Basic igneous rocks and alluvium	Xanthic Ferralsol; Orthic Acrisol; Orthic Luvisol; Eutric Gleysol
21	Semporna	Very low hills: slopes 0-5°	Limestone	Calcic and Chromic Luvisols; Rendzina
22	Lungmanis	Very low hills (slopes 0-15°) and valley floors	Mudstone and alluvium	Gleyic, Ferric and Orthic Acrisols; Gleyic, Ferric, Chromic and Orthic Luvisols
23	Table	Dissected plateaus with flat to gently undulating surfaces	Basic igneous rocks	Xanthic and Orthic Ferralsols
24	Orchid plateau	Plateaus of low hills: slopes 15-25°	Basic and intermediate igneous rocks	Orthic Acrisol; Orthic and Chromic Luvisols
25	Silabukan	Low hills and minor valley floors: slopes 0-15°	Mudstone and alluvium	Gleyic, Ferric and Orthic Acrisols; Gleyic, Ferric, Chromic and Orthic Luvisols
26	Rumidi	Low hills and minor valley floors: slopes 0-15°	Mudstone, sandstone and miscellaneous, rocks	Gleyic, Ferric and Orthic Acrisols; Gleyic, Ferric, Chromic and Orthic Luvisols
27	Sipit	Low hills: slopes 0-15°	Mudstone, sandstone and miscellaneous, rocks	Ferric and Orthic Acrisols; Orthic Luvisol
28	Apas	Moderate hills: slopes 15-25°	Intermediate and acid igneous rocks	Rhodic Ferralsol; Orthic Acrisol; Eutric Cambisol
29	Kalabakan	Moderate hills: slopes 0-25°	Mudstone and sandstone	Ferric and Orthic Acrisols; Ferric, Chromic and Orthic Luvisols
30	Mawing	Moderate hills: slopes >25°	Mudstone and sandstone	Orthic Acrisol; Dystric Cambisol
31	Dalit	Moderate hills and minor valley floors: slopes 0-20°	Sandstone, mudstone and alluvium	Orthic, Ferric and Gleyic Acrisols
32	Tengah Nipah	Moderate hills and minor valley floors: slopes 0-20°	Sandstone, mudstone and alluvium	Ferric, Orthic and Gleyic Acrisols
33	Kretam	Moderate hills: slopes 0-20°	Mudstone, sandstone and miscellaneous rocks	Ferric and Orthic Acrisols; Ferric, Chromic and Orthic Luvisols
34	Beruang	High hills: slopes 15-25°	Basic igneous rocks	Ferric Acrisol; Orthic Luvisol
35	Dagat	Moderate hills: slopes 10-20°	Tuffaceous rocks, mudstone and sandstone	Chromic and Orthic Luvisols, Orthic Acrisol

(contd.)

Appendix 25: Soil associations of Sabah (contd.)

Key	Association	Landform	Parent Material	Main Soil Units
36	Kennedy Bay	High hills: slopes >25°	Sandstone, mudstone and igneous rocks	Ferric Acrisol; Chromic and Orthic Luvisols; Dystric and Eutric Cambisols
37	Tiger	Very high hills: slopes >25°	Basic igneous rocks	Chromic and Eutric Cambisols
38	Gomantong	Very high hills: slopes >25°	Limestone	Calcic Luvisol; Rendzina
39	Lokan	Very high hills: slopes >25°	Sandstone and mudstone	Orthic Acrisol, Dystric Cambisol
40	Beng	Very high hills: slopes 15-25°	Mudstone, sandstone and miscellaneous rocks	Orthic Acrisol, Dystric Cambisol
41	Bidu Bidu	Mountains and hills	Ultrabasic igneous rocks	Rhodic and Orthic Ferrelsols; Eutric Cambisol; Chromic and Orthic Luvisols; Lithosol
42	Mentapok	Mountains	Basic and intermediate igneous rocks	Chromic and Orthic Luvisols; Eutric Cambisol; Lithosol
43	Tinagat	Mountains	Basic and intermediate igneous rocks	Eutric Cambisol; Lithosol; Ferric Luvisol
44	Malubok	Mountains	Igneous rocks, sandstone, mudstone and chert	As for Associations 41, 42 and 47 with Chromic Cambisols and Lithosols on Chert
45	Wullersdorf	Mountains	Intermediate and acid igneous rocks	Eutric Cambisol; Lithosol
46	Gumpal	Mountains and hills	Mudstone, sandstone and miscellaneous rocks	Orthic Acrisol; Orthic Luvisol; Dystric and Eutric Cambisols; Lithosol
47	Crocker	Mountains	Sandstone and mudstone	Orthic Acrisol; Chromic and Dystric Cambisols; Lithosol
48	Meliau	Mountain cuestas	Sandstone and mudstone	Orthic Acrisol; Dystric Cambisol; Gleyic Podzol, Humic Gleysol; Lithosol
49	Serudong	Dipslopes of mountain cuestas	Sandstone	Gleyic Podzol; Orthic Acrisol
50	Trusmadi	Mountains above 1200 m (4000 ft) a.s.l	Sandstone and mudstone	Gleyic and Orthic Acrisols; Gleyic Podzol; Humic Gleysol; Dystric Histosol; Lithosol
51	Kinabalu	Mountains above 2400 m (8000 ft) a.s.l	Acid igneous rocks	Humic Cambisol: Dystric Histosol: Lithosol

Source: Agriculture Department Sabah (2003)

Appendix 26: Types and Characteristics of soil in Sabah

(Source: Sabah Town Planning, 1998)

1.0 Soils

The characteristic soils of the tropical shield areas are red or yellow in color, old and strongly leached. They are deep, finely textured, contain no more than traces of weatherable minerals, have low-activity clays, less than 5 percent recognizable rock structure and gradual soil boundaries. Typical Major soil groupings are the plinthite-containing Sesquisols, the deeply weathered and chemically poor Ferralsols, the richer Nitisols, strongly leached Acrisols with a clay illuviation horizon and Alisols with low base saturation and high activity clays. The differences among the soils of the wet tropics can be largely attributed to differences in lithology and (past) moisture regime (Sabah ICZM, 1999).

1.1 Sesquisols.

Soils either containing at shallow depth a layer indurated by iron or at some depth mottled material that irreversibly hardens after repeated drying and wetting are called Sequisols. They occur mainly in the tropics but examples can also be found in subtropical areas. They are found in extensive areas with poor external drainage such as late Pleistocene or early Holocene sedimentary plains of eastern and central Amazonia and the central Congo basin. They may also occur on straight slopes with an impermeable substratum and the feet of concave slopes in rolling or table landscapes. Sesquisols with an indurated iron layer occur in higher positions of the landscape, often as a result of landscape inversion due to lowering of the erosion base. They now form tablelands and have widespread occurrence in Western Africa. The imperfectly drained soils with a plinthic horizon have poorer natural vegetation than geographically associated well drained soils. Also the land use of such soils is often restricted to extensive grazing or fire wood collection because arable crops suffer from poor rooting conditions. Artificial drainage of the soils would cause serious hazard of irreversible hardening of the plinthite. Also, well drained soils with a shallow hardened petroplintic horizon have poorer natural vegetation than soils without such a hard pan. Arable cropping and tree planting is problematic because of the stoniness of the soils.

1.2 Ferralsols.

Weathering and soil genesis in the tropics leads to the formation of so-called Ferralsols which are characterized by a clay fraction dominated by low activity clays and sesquioxides which normally have a variable charge. Associated properties of Ferralsols include very low amounts of weatherable minerals which have the potential to release nutrient cations on weathering, a profile morphology characterized by its uniformity in terms of the lack of distinct horizonation; if there is sufficient iron in the parent material, the soils are reddish; a weak expression of structure and few marks of soil forming processes like clay translocation. Rock fragments with weatherable minerals are absent. Secondary accumulation of minerals such as gibbsite or iron hydroxides may be present in the form of concretions or as part of the fine earth fraction of the soils. Ferralsols tend to occupy similar geomorphic positions. The land form is generally flat to undulation with few or no rock outcrops. The typical soils are situated on geomorphically old surfaces which have been formed through erosion and deposition. Ferralsols cover world-wide about 750 million ha of which roughly 60 percent is found in South and Central America and the rest occurs in Africa.

1.3 Acrisols.

Acrisols are characterized by a subsurface accumulation of low activity clays, a distinct clay increase with depth and a base saturation of less than 50 percent. These soils are common in tropical, subtropical regions on Pleistocene and older surfaces. Acrisols cover an estimated 1000 million ha worldwide of which about one-third is found in Southern and Central America and about 25 percent in Southern and Southeastern Asia. Acrisols have poor chemical characteristics. Their nutritional limitations include widespread aluminum toxicity and strong P-sorption. As with other highly weathered tropical soils, preservation of the surface soil with its important organic matter is imperative. Mechanical clearing of the natural forest by extraction of roots and filling up the holes with surrounding surface soil produces land that is largely unproductive because toxic levels of aluminum (the former subsoil) kill off any seedling planted. The commonly used 'slash-and-burn' agriculture ('shifting cultivation') may seem primitive at first sight but is really a well adapted type of land use, developed during centuries of trial and error and makes probably the best use of the limited possibilities of Acrisols. Large areas of Acrisols are still under forest which is probably the best use of these soils.

1.4 Alisols.

Alisols comprise the acid soils with a dense layer of accumulated clay in the subsoil, occurring in the humid (sub-) tropical regions. The intense weathering process is in these soils at a stage where 2:1 clays are being degraded releasing large amounts of aluminum thus creating a very acid environment. These soils contain low levels of nutrients and free Al is present in toxic quantities. Liming (to depress free Al) and full fertilization are needed for permanent cropping but is not always economic. Alisols are traditionally used in shifting cultivation or for low volume production of Al tolerant crops. They have some potential for the production of plantation crops like e.g. oil palm. Alisols on steep slopes are best left under their natural vegetation cover.

1.5 Nitisols.

Throughout the tropics and subtropics well drained soils occur which consist of dusky red to dark brown clays with a strongly developed fine blocky structure with shiny ped faces: Nitisols. They have a high aggregate stability, friable consistence, high porosity, fair to good moisture storage capacity and easy rooting. They are predominantly composed of low activity clay minerals. Nitisols cover more than 200 million ha globally of which almost half is found in Eastern Africa. Other main regions with Nitisols are South Brazil, Central America and South East Asia (Java, Philippines). Nitisols are among the most productive soils of the humid tropics. The deep and porous solum permits deep rooting. This, and the stable soil structure, makes Nitisols less susceptible to erosion than many other soils. Their internal drainage, water holding capacity and workability are good. Their chemical fertility compares favorably to that of Ferralsols because of the moderate CEC, their relatively high organic matter content and the presence of (some) weatherable minerals. Nitisols are intensively used for plantation crops such as cocoa, coffee, rubber and pineapple, and for food crop production. They respond well to fertilizer applications.

1.6 Vertisols.

Clayey soils dominated by clay minerals such as smectites, that expand upon wetting and shrink upon drying are called Vertisols. They occur in tropical and subtropical regions with pronounced unior bi-modal rainfall regimes. Vertisols develop deep wide cracks during the dry season from the surface downwards. The upper part of the pedons commonly consist of prism-like blocks while deeper in the solum wedge-shaped structural aggregates with shiny and grooved surfaces dominate ('slickensides' or vertic structure). In the dry season the cracking of the topsoil can be so strong that a mulch is formed. Vertisols are difficult to work, being hard when dry and very sticky when wet. Frequently they are dark colored but have a low organic matter content. Areas occupied by Vertisols often show a linear frequency of microknolls and depressions, also known as 'gilgai' microrelief. Soil materials whose properties are dominated by an abundance of expanding 2:1 clays (smectite) can occur in (former) sedimentary lowlands, but also in denudational plains. These also occur in semidesertic climate zones but are restricted to areas where parent rock was rich enough in Ca, Mg and Na for smectites to form. These are essentially basic volcanic rocks such as the Deccan traps basalts in India and basic basement rocks. Vertisols are widespread; they cover an estimated area of about 335 million hectares. Dominant areas of occurrence are Sudan, India and the Sahel zone. Land use in Vertisol areas ranges from very extensive (grazing, fire wood production) through smallholder post-rainy season crop production (millet, sorghum, cotton) to small scale (rice) and large-scale irrigated crop production (cotton, wheat, sorghum). Management practices for crop production are primarily directed to the control of water dynamics. Beds, ridges and furrows are traditionally used to protect crops from water logging in the rooting zone. Vertisols are usually N-deficient due to the general low amounts of organic matter.

1.7 Solonchaks.

Solonchaks (salt affected soils) form where there is a considerable evapotranspiration surplus over precipitation (plus irrigation) at least during part of the years. Salts dissolved in the soil moisture remain behind after evaporation of the water and accumulate at the surface of the soil or at some depth. Solonchaks cover an estimated 260 million hectares worldwide, most of which are in the arid subtropics. They occur predominantly in inland river basins, (former) lake bottoms and depressed areas which collect seepage water from surrounding uplands. Much of the salt that accumulates in an area is imported from far away catchment areas by rivers or from nearby uplands with seepage water or surface runoff. Accumulated salts can often be traced to deeper geological strata or marine origin (chlorides) or of volcanic origin (sulfates). The most pronounced Solonchaks are found in regions that were once the bread basket of prosperous civilizations (Mesopotamia, Nile delta, Indus floodplain) but succumbed to overpopulation, and mismanagement, processes which are still going on today for the same reasons.

1.8 Solonetz.

Solonetz are salt affected soils, which have a ‘natric’ B-horizon with an ‘exchangeable Sodium Percentage (ESP) of 15 or higher. Where soils are affected by neutral sodium salts (NaCl or Na2SO4) Solonchaks are formed, while Solonetz are developed more under the influence of basic salts like Na- HCO3, Na2CO3, and MgCO3. Solonetz have a poor internal and external drainage and are impermeable under wet conditions and hard under dry conditions. The main chemical characteristics are the high amounts of sodium or sodium plus magnesium at the adsorption complex and the high pH(H2O) which is frequently more than 9.0. The measure for the amount of adsorbed sodium is expressed either as exchangeable sodium percentage (ESP) or as sodium adsorption ration (SAR). How detrimental sodium saturation is, is partly determined by soil parameters such as the depth of the natric B horizon. Soils with smectite clays show already serious structure deterioration when SAR>9; illitic soils degrade at SAR>16 and the most stable soils (kaolinitic soils and soils rich in sesquioxides deteriorate only if the SAR exceeds 26 in the absence of salinity. The traditional way of reclaiming Solonetz is by flushing with calcium rich water. Reclaimed Solonetz are intensively used for agriculture. In many parts of the world Solonetz are also in use for extensive grazing.

1.9 Leptosols

Soils overlying hard rock or highly calcareous material and soils which have less than 10 percent fine earth material are called Leptosols. They represent the initial phase of soil formation, which is normally limited to a thin A-horizon over a beginning B-Horizon or directly of the parent material. Leptosols according to the FAO definition are the most widespread major soil group, covering globally an area of approximately 1655 million ha. They occur in all parts of the world from the tropics to the cold polar tundra and from sea level to the highest mountains. Lithic Leptosols (with continuous hard rock within 10 cm of the soil surface) are the most extensive. Their greatest concentration in the tropics is in the mountainous areas of Asia and South America and in the Sahara. Leptosols may occur on rocks which are resistant to weathering or where erosion has kept pace with soil formation as on steep slopes, keeping soil depth to a minimum. Alternatively, Leptosols may be found on lands where erosion has removed the major part of the soil profile and soil formation has had to begin again. Highly calcareous parent materials such as limestone frequently have a weathering product in which the clay humus complex remains rich in base cations so movement of fine soil constituents is arrested by flocculation and profile development is retarded (these soils were formerly called Rendzinas. All Leptosols are freely drained. Their shallowness and/or stoniness associated with a low water holding capacity are serious limitations even in a humid climate. Most Leptosols are not cultivated. They have a resource potential for grazing and as forest land. Calcareous Leptosol in Southeast Asia are planted to teak and mahogany. Erosion is the greatest threat to Leptosol areas. Steep slopes with shallow and stony soils can be transformed into cultivable land through terracing.

2.0 Regosols

Very weakly developed mineral soils, or those that are so recent that they do not reflect an imprint of pedogenesis are called Regosols. They normally consist of unconsolidated material which also has been considered regolith which explains the name. There are examples of initial stages of soil development in all landscapes throughout the world. About 170 million ha in arid zone, 52 million ha in the tropics and 36 million in mountain areas comprise most of the Regosols. In the terrain, Regosols are mostly associated with degrading or eroding areas. As time passes and soil formation gets more grip on the soil, Regosols, may develop into many other soils depending on the most important soil forming factors. Regosol in tropical mountainous areas are mainly used for extensive grazing; many are not used at all.

2.1 Andosols

Andosols occur in volcanic regions all over the world. Important concentrations are in the Andes Mountains, Central America, Philippines, Indonesia and many islands in the Pacific. Andosol formation depends essentially on the rapid chemical weathering of porous 'volcanic glass' in the presence of organic matter. The liberated basic cations are washed out. The Fe- and especially the Al- ions are tied up in stable complexes with humus. The Al in the complexes protects the organic part against biodegradation (Al is toxic to micro-organisms) and the high Al/organic ratio make them only poorly soluble. The combination of low solubility and high resistance against biological attack promotes the accumulation of organic matter in the topsoil. By contrast, a similar combination in Podzols leads to metal-undersaturated complexes which are much more mobile. If not all Al is complexed by the organic matter, it may precipitate with the liberated silica to form 'allophane' of varying composition. Andosols are soils of which the properties are largely determined by the nature of their clay ('colloidal') fraction which is para-crystalline and has the properties of a gel. Characteristically Andosols have loamy, dark colored and often very humic surface horizons with a fine crumb structure. Andosols were first described in Japan (from Japanese: an = black and do = soil). The group of Andosols is large and very variable. They cover more than 100 million ha worldwide. They occur in a wide range of climates, landscapes, parent materials and may differ in age considerably. Andosols exhibit some unique chemical properties. They have a pH-dependent variable charge of the CEC. Phosphate retention is normally 85% of the phosphorus added to the solution. Also the physical properties are typical. They have a low bulk density, a high water retention capacity, a good stability of microaggregates, and a low susceptibility to erosion. Andosols are strongly related to volcanic formations, especially those with recent pyroclastic material. They occur less commonly on old and/or compact volcanic material. Andosols are most frequent and widespread in regions with humid and perhumid climates. They are less common in climates with a long dry season and are rare in arid climates. If Andosols continue to weather one may encounter the following sequences depending on the climate regime:

- Tropical humid climates: Andosols Cambisols/Umbrisols Ferralsols/Acrisols
- Tropical climates with a dry season: Andosols Cambisols Lixisols/Vertisols
- Mediterranean climates: Andosols Cambisols Luvisols/Calcicols.

Andosols are often considered to be very fertile, because of their recent age, the large amount of weatherable minerals and the high content of nitrogen and phosphorus in the organic matter. Deep cultivation can modify the physical properties of Andosols and may produce too drastic and irreversible soil dehydration. The soil then becomes a loose sandy loam which is easily erodable. Some Andosols have a rather poor fertility owing to their high phosphorus retention. This can be overcome by adding the phosphorus demand, which can vary from 1 g P2O5 / kg soil to >4 g P2O5 / kg soil. Some Andosols present severe constraints to mechanization because of their low carrying capacity and tendency to become fluid under pressure. A wide variety of crops is cultivated on Andosols: sugarcane, tobacco, sweet potato (tolerant to low phosphate levels), tea, vegetables, wheat, orchards crops and forest (on steep slopes). Paddy rice cultivation requires that drainage is impeded by high groundwater or a dense subsoil layer.

2.2 Fluvisols

Fluvisols is a group of soils developed from alluvial sediments. By definition, Fluvisols occur on materials deposited in aqueous sedimentary environments. There are three situations where fresh material is continually added by sedimentation from water. These are (1) the inland fluvial and lacustrine fresh-water environment, (2) the marine environments and (3) the coastal saltings or brackish marsh environments of which delta's are a special case. Fluvisols cover an estimated area of over 350 million hectares worldwide, more or less proportionally distributed over the continents. Vast areas are found in the large deltas (Ganges, Mekong, Niger) as well as along all major and minor rivers. In the upstream part of river systems, Fluvisols are normally confined to narrow strips alongside the actual river bed. In the middle and lower stretches, the flood plain is normally wider and has the classical arrangement of levees and backswamps with coarsely textured Fluvisols on the levees and more finely textured soils in the backswamps further away from the river. The stratified parent material is the major characteristic used to distinguish these soils from others. Generally, Fluvisols are so young that soil forming processes, other than the formation of a surface horizon through accumulation of organic matter have not left their marks. Most Fluvisols are wet in all or part of the profile due to stagnating groundwater from rivers or tides. Most Fluvisols are fertile; they have neutral to near neutral pH values which do not impair the availability of nutrients. The high natural fertility of most Fluvisols allows cultivation of a wide range of dryland crops on river levees and on higher parts in marine landscapes. In tropical lowlands with a year-round supply of fresh water, three crops per year are possible. Such places are among the most densely populated areas of the world and have been under intensive use since pre-historic times. Paddy rive cultivation is widespread on tropical Fluvisols with satisfactory irrigation and drainage. Paddy land should be dry for at least a few weeks per year to prevent the soil's redox potential from becoming so low that nutritional problems (Fe, H2S) develop. Furthermore, a dry period promotes mineralization of organic matter. Other suitable crops besides rice may be jute and various tuber crops. Coconut survives periodic flooding and some degree of salinity.

2.3 Gleysols

Soils which are permanently wet and reduced in the subsoil and periodically to permanently wet in the topsoil are called Gleysols. The upper part of the soil is therefore either mottled (in case of temporary aeration) or has colors reflecting reduction (reduced free iron, Fe2+, has gray colors oxidized iron, Fe3+ has brown/orange colors). These features are formed under the influence of groundwater. This is in contrast to so-called Stagnosols which have also a redoximorphic horizon that occurs on top of an oxidized subsurface horizon. Stagnosols normally have dense subsoil with low permeability. Gleysols are commonly found in valleys, depressions and coastal areas, while Stagnosols are commonly found in plateau positions. The main process in Gleysols is the transport of reduced Fe2+ and Mn2+ ions by capillary forces. On macroscale this takes place from the subsoil into the topsoil or from one pedon to the other. Gleysols are found in nearly all climates, from perhumid to arid conditions and cover and area of almost 720 million ha worldwide. In the humid tropics they are found in valleys associated with Acrisols, Lixisols, Nitisols, Alisols or Ferralsols occupying the better drained positions of the surrounding uplands. In arid regions they are also concentrated in valleys, sometimes together with Solonchaks and Solonetz. Higher landscape positions are normally occupied by Calcisols or Gypsisols besides Cambisols, Regosols, and Arenosols. The main obstacle to the utilization of Gleysols is the necessity to install a drainage system, either designed to lower the groundwater table or to intercept seepage of surface runoff water. Adequately drained Gleysols are widely used for arable cropping, dairy farming or horticulture. Where the surface soil is high in organic matter and pH values are low, liming creates a better habitat of micro-organisms and enhances the decomposition of soil organic matter. Gleysols can be put under tree crops only after the water table has been lowered with deep drainage ditches. Alternatively the trees are planted on ridges that alternate with shallow depressions in which rice is grown.

2.4 Cambisols.

Soils which are moderately developed characterized by slight or moderate weathering of the parent material are called Cambisols. Cambisols are generally considered as soils conditioned by a limited age. Erosion and deposition cycles are the main reason why Cambisols occur frequently in the footslopes of mountains. Most Cambisols are predominant in the temperate areas because of the moderate weathering and the absence of clay migration. Cambisols are relatively uncommon in the tropics and subtropics, where extensive weathering and old parent material are more common. The largest continuous area of Cambisols in the tropics is found in the alluvial plains and terraces of the Ganges-Brahmaputra system. They are further widespread in areas with active geologic erosion where they may occur in association with highly developed soils such as Acrisols and Ferralsols, e.g. in the mountains of Papua New Guinea. Cambisols are also quite frequent in arid climates where they are closely associated with Calcisols. Cambisols cover about 1500 million ha worldwide and form the second largest major soil grouping. In the humid tropics Cambisols can form in a few years time because of the intensities of chemical and biological transformations. In the humid tropics Cambisols are widespread in highland regions and in hilly terrain, mainly at medium altitudes. The steepest slopes have no soil at all, or only Leptosols. Cambisols occur on moderately steep hillsides and Acrisols or Ferralsols in more stable sites. In the drier subtropics Cambisols may form upon erosion of Luvisols. Cambisols with vertic properties occur in association with Vertisols on the Deccan Plateau in India, where long continued cultivation and soil erosion have produced shallow soils that do not qualify for Vertisols. On the whole, Cambisols make good agricultural land and are intensively used. The Vertic and Calcaric Cambisols in alluvial plains in the dry zone are intensively used for the production of food and oil crops. Cambisols in undulating or hilly (mainly colluvial) terrain are planted to a variety of annual and perennial crops and tree crops or are used for grazing. The Dystric and Ferralic Cambisols of the humid tropics are poor in nutrients but still richer than neighboring Acrisols or Ferralsols and they have a higher cation exchange capacity. The Gleyic Cambisols of the alluvial plains under paddy rice are highly productive soils.

Curriculum Vitae

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Selected Publications (Books)

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