LANDUSE CHANGE AND ENVIRONMENTAL DEGRADATION IN DHAKA CITY

Ph.D Thesis

By

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Institute of Environmental Science (IES)
University of Rajshahi
Rajshahi, Bangladesh

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Session: 2006-2007

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in

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University of Rajshahi
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Dedicated

To

My Parents

Declaration

I hereby declare that the thesis entitled **"Landuse Change and Environmental Degradation in Dhaka City"** is the result of my original research work and submitted to the Institute of Environmental Science, University of Rajshahi, Bangladesh for the degree of Doctor of Philosophy.

I further declare that this thesis has not been submitted in part or full previously for any degree.

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Certificate

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This thesis or any part of the thesis in any from has not been previously presented for any degree, honour or title except due references wherever needed. I gladly recommend the thesis to be submitted for the award of the degree of Doctor of Philosophy in Environmental Science.

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Author

June, 2011.

Abstract

The present research documents the extent and impact of land use change since 1960 to 2008. Topographical maps of 1960 and two images of different years (Landsat TM image, 1991 and Google image, 2008) were used and analyzed to accomplish the expected research outcomes. The study reveals that a large portion of land has been changed, and the rate of decrease of vegetation and wet/lowlands has appeared to be quite alarming. During 1960-2008, the Dhaka city lost 39.94% (5354 ha) of cultivated land, 66% (5026 ha) of vegetation, 44.48% (1657 ha) of water-bodies and 47.32% (42.50 ha) of wet/lowlands. During the period 1960-1991, the cultivated areas decreased to about 22.45% (97 ha/year), vegetation cover decreased to about 28.85% (71 ha/year), water-bodies to about 14.20% (17 ha/year) and wet/lowlands to about 35.10% (102 ha/year).

During 1991 to 2008 Dhaka lost 22.56% (138 ha/year) of cultivated land, 52.21% (166 ha/year) of vegetation, 35.29% (66 ha/year) of water-bodies and 18.82% (65 ha/year) of wet/lowlands. Maximum changes were found to be concentrated on certain land uses such as in cultivated land (about 112 hectares were under change per year) and vegetation (105 hectares were under change per year) during the study period 1960-2008. Rate of decrease in case of wet/lowlands 89 hectares per year during the same period. It has been observed that wet/lowlands were converted predominantly into built-up areas. The transformation of cultivated land, vegetated lands and wet/lowlands were strongly related with the high rate of growth of urban settlement.

Three areas to represent the research were selected viz. Ashulia, Uttara and Amin Bazar. These areas grew and developed mostly during 1960 to 2008. It is important to observe that the increase for Ashulia was 218.2% during 1960 to 1991. It was true also in case other two areas during 1960-2008. Growth of Uttara region was about 540.4% continuously almost steadily during the same period. It means, the rate of urbanization is much faster in Uttara than in Ashulia. It has been observed that a cultivated lands has been reduced due to urbanization in Uttara. It has also been observed that in Uttara vegetated lands increased for about (159.2%) during 1960-1991. But it has decreased in Ashulia and in Amin Bazar.

This research presents a dynamic change of land use in Dhaka city, based on selected physical and social factors. Land Change Modeler (LCM) was used to analyze the land use changes between various land use classes during the period 1960-1991 and 1991-2008. The land use change was assessed through evaluation of gains and losses by those classes. It was noted that most of the land use categories experienced loss and gain to some extent. But the pattern was different.

During 1960-1991, cultivated/agricultural land lost 76.51% and gained 68.45%, with a net loss of 8.06%. And in 1991-2008 it lost 78.31% and gained 63.72%, with a net loss of 14.59%. Vegetation lost 67.53% and gained 25.34 % in 1960-1991 with a net loss of 42.19 %. In 1991-2008 the loss was 36.28% and the gain was 19.36% with a net loss of 16.92%. Wet/lowlands lost 57.45% and gained 12.53 % in 1960-1991 with a net loss of 44.92 %. In 1991-2008 the loss was 23.57 % and the gain was 24.85% with a net gain of 1.28% and water-bodies neither gained nor lost and land (the loss of water bodies was already completed before that period).

Built-up area lost to about 27.61% and gained 93.58%, with a net gain of 65.97 % during 1960-1991. During 1991-2008 the loss was 56.42% and gain was 71.26% with a net gain of 14.84%. Net gain for bare soil/landfill was 10.58 % and in transport and communication it was 18.24% in 1960-1991. During 1991-2008 similar trends have been noticed for the rest of the classes, with the exception of bare soil/landfill, which seems to be stable. Transport, communication and others categories have gained to some extent.

But however, there are always some scopes of checking the result in GIS environment. The location accuracy in land use change model using Landsat TM image of 1991 and Google Earth image of 2008 was done using the clear and visible roads. In case of classifying bare soil/landfill, cultivated/agricultural land and vegetation, the user accuracy were 59%, 49% and 61% respectively. The prediction of land use change was done on Neural Network, a built-in module in the Andes version of IDRISI. Iterations considered were 5000, considered sufficient for running the data. The lowest accuracy obtained was 57.30 for all the conversion types.

The transition probability matrix records the probability of future changes in which each land use category indicates in relation to other category. This matrix was produced by the multiplication of each column in the transition probability matrix where the numbers of cells of corresponding land use showed the later scenario. Though this matrix can be used to predict future land use in any period, it was specially designed for the predictions for the years 2020 (short term) and 2050 (long term).

This research attempted to bring light to the perception of local people regarding change of land use through questionnaire survey. It is evident from the views and opinions of the local people that real estate companies, unplanned urbanization, industrialization and government organizations are responsible for the change of land use pattern. They also claimed that flooding and drainage congestion, air and water pollution, traffic congestion, water, sanitation and health problems are the main effect of unplanned land use.

The air and water pollution, traffic congestion and water-logging are becoming an acute problem for the inhabitants of Dhaka city and creating adverse physical and social environmental impact. Interruption of daily life, traffic congestion, scarcity of drinking

water, disruption of sanitation, unhygienic situation and the spread of air-and water-borne diseases are the outcomes of land use changes. The local people viewed that to address the socio-environmental problems, it is immediately necessary to control rapid population growth, control unplanned urbanization, control air and water polluting industries and to remove all illegal structures from the wet/lowlands and to raise environmental awareness programs widely.

The investigation undertook for this study reveals that the present land use management practices of government organizations are very weak and not systematic. The existing legal tools for different agencies are not exercised properly. Overlapping of functions among the agencies creates conflicts in land use management. The coordination among government organizations is poor, and there sincerely is questionable as well.

This study delivers the essence that combined effort is necessary from the part of involved stakeholders such as local people, NGOs, local government body, central government and civic organizations to implement the conservation strategies of land use. Political will and government commitments are also needed essentially.

In conclusion, suggestions have been made regarding proper demarcation of land use change, strengthening the relevant GOs, developing appropriate regulations and proper enforcement of laws towards sustainable land use.

Contents

Declaration i

Certificate ii

Acknowledgement iv

Abstract vi

Contents ix

List of Tables xv

List of Figures xix

List of Photographs xxii

List of Abbreviations xxiii

Chapter 1 Introduction

1.1 Background 1

1.2 Statement of the Problem 2

1.2.1 Population growth and urbanization 3

1.2.2 Land use change and suburban development 6

1.2.3 Destruction of agricultural land, vegetation and wetlands 7

1.2.4 Construction of haphazard infrastructure and industrial establishments 10

1.2.5 Deterioration of urban air and water quality 11

1.2.6 Depletion of ground water level 11

1.3 Rationale of the Study 12

1.4 Research Questions 13

1.5 Hypothesis 13

1.6 Aim and Objectives of the Study 14

1.7 Conceptual framework 14

1.8 Scope and Limitation 15

1.9 Structure of the Thesis 16

Chapter 2 Review of Literature

2.1 Issues Related to Land use Change 18

2.1.1 Land use in Global scenario 19

2.1.2 Land use in South Asia 21

2.1.3 Land use in Bangladesh 22

2.1.3.1 Physiography 22

2.1.4 Land use in Dhaka City 26

2.2 In Global Land Classification 27

2.3 Land use/cover Change 28

2.3.1 In Global Context 28

2.3.2 In Bangladesh Context 30

2.3.3 In Context of Dhaka 32

2.4 Land Transformation Model 35

2.5 Plans for the Development of Dhaka and Land use Change 37

2.5.1 The Dacca (Dhaka) city Master Plan, 1959 38

2.5.2 Dhaka Metropolitan Area Integrated Urban Development Plan (DMAIUDP), 1981 38

2.5.3 Dhaka Metropolitan Development Plan (1995-2015) 41

2.5.4 Integrated Transport Network Plan for Metropolitan Dhaka (1995-2015) 47

2.5.5 Land use Characteristics and Dynamics of the SPZs (DMDP) 51

2.6 Flood Protection, Drainage Master Plan and Land use 52

2.6.1 Flood Action Plan (FAP) Studies 52

2.6.2 The Dhaka Integrated Flood Protection Project (FAP-8B) 54

2.7 Urban Land use Management 55

2.8 Problems of Urban Environment 58

2.9 Urban Environment Management 62

2.10 Exiting Environmental Polices, Laws and Regulations 64

2.11 Summary of the Literature Review 67

Chapter 3 Research Methodology

3.1 Research Approach....68

3.2 Sources of Data....68

3.2.1. Primary data collection....68

3.2.1.1 Observations....69

3.2.1.2 Land use Survey....69

3.2.1.3 Questionnaire Survey....69

3.2.1.4 Photographs....70

3.2.2 Secondary Data Collection....70

3.2.2.1 Maps and Images....70

3.2.2.2 Other Secondary Data....70

3.3 Post Field Survey Work Phase....72

3.3.1 Maps and Images Interpretation....72

3.3.2. Classification....72

3.3.3 Preparation of Land use Map....73

3.4 Selection of the Study Area....74

3.5 Sample Size Determination and Selection of the Major LUC Area....75

3.6. Change Detection....79

3.6.1. Land Change Modeler....79

3.7 Quantities Questionnaire Survey....80

3.8 Diagram of Research Methodology....82

Chapter 4 Study Area Profile and Land use Change

4.1 Physical Conditions of the Study Area....83

4.1.1 Geographical Location....83

4.1.2 Area and Population....83

4.1.3 Climate....86

4.1.4 Topography....86

4.1.5 Geomorphology and Land use....87

4.2 Demographic Characteristics of the Study Area 88
4.2.1 Sex Composition 88
4.2.2 Age Structure 89
4.2.3 Occupation 90
4.2.4 Literacy and Education 90
4.2.5 Land Ownership 91
4.3 Physical and Demographic Growth 91
4.3.1 Pre-Mughal Period (before 1608) 92
4.3.2 Mughal Period (1608 -1764) 92
4.3.3 British Period (1764-1947) 93
4.3.4 Pakistan Period (1947-1971) 95
4.3.5 Bangladesh (1971 onward) 95
4.4 Urbanization in Bangladesh and Dhaka city 99
4.5 Causes and Effects of Land use Changes 103
4.5.1 Unplanned Urbanization 105
4.5.2 Population Growth 106
4.5.3 Industrialization 107
4.5.4 Land Value 109
4.5.5 Encroachment and Land filling 110
4.5.6 Public Awareness and Education 114
4.6 Pressure Levels in the Study Area 114
4.6.1 Governance for Dhaka City 118

Chapter 5 Land use Change Pattern and Trend

5.1 Pattern of Land use Change 120
5.1.1 Global Land use Change Pattern 120
5.1.2 Land use pattern in South East Asian Countries 122
5.1.3 Land use pattern in Bangladesh 125
5.1.4 Land use pattern in Dhaka City 126

5.2 Interpretation of Maps and Images 129
5.3 Land use Change Pattern in the Study Area 130
5.3.1 Land use Pattern in the Study Area in 1960 133
5.3.2 Land use Pattern in the Study Area in 1991 135
5.3.3 Land use Pattern in the Study Area in 2008 135
5.4 Major Land use Change Areas 138
5.4.1 Ashulia area 139
5.4.2 Uttara area 141
5.4.3 Amin Bazar area 142
5.5 Comparative Land use Change Pattern and Trend in Selected Three Areas 147

Chapter 6 Land use Change and Modeling

6.1 Land use Change in the Study Area, 1960 to 2008 152
6.1.1 Land use Change Analysis 152
6.2 Change Detection using LCM 153
6.3 Modeling 162
6.3.1 Land use Models 162
6.3.2 Transition Probability Matrix 165
6.4 Overall Matrix Land use Classification Between 1960-1991 and 1991-2008 170
6.5 Accuracy Assessment 171

Chapter 7 Land Transformation and Environmental Degradation

7.1 Problems of Urban Environment 173
7.1.1 Flash flood and Drainage Congestion 174
7.1.2 Traffic Congestion 177
7.1.3 Urban Pollution 178
7.1.3.1 Water Pollution 179
7.1.3.2 Air Pollution 180
7.1.4 Water and Sanitation 184

7.1.5 Decreasing Ground Water Level 186
7.1.6 Garbage Disposal System 188
7.1.7 Health Related Problems 189
7.1.8 Open Space 191
7.2 People's Perception about Urban Environment in the Study Area 192
7.2.1 Degradation of Urban Environment 193
7.2.2 Variation of Urban Environmental Degradation in Different Areas 195
7.3 Perception of Respondents to Diminish Problems 197
7.3.1 People's Responsibility 198
7.3.2 Perception of Local Communities Regarding Mitigation of the Problems... 199
7.3.3 Government Steps to Overcome the Environmental Degradation 200

Chapter 8 Findings, Suggestions and Conclusion

8.1 Findings of the Research 202
8.1.1 Unplanned growth of Dhaka city and land use change 202
8.1.2 Trend and pattern of land use change 204
8.1.3 Impact of land use change on environment 207
8.1.4 Land use management and government organizations 210
8.1.5 Environment management 212
8.2 Suggestions 213
8.3 Conclusion 218
8.3.1 Future Research 221
References 223
Appendices 241
Appendices A
Appendices B
Appendices C
Appendices D

List of Tables

Table 1.1 Population forecast 1991-2016 of DMDP areas 4

Table 1.2 Changing patterns of land use and agricultural development in Bangladesh 7

Table 1.3 Changing land-man relationships in Bangladesh 9

Table 2.1 Global and regional land use and population change in 1700-1980 20

Table 2.2 Land use and population in South Asia, 1990.....22

Table 2.3 Inundation land types in Bangladesh.....25

Table 2.4 Land use scenarios in Bangladesh, 1999.....26

Table 2.5 Land use distribution in greater Dhaka city, 1990 26

Table 2.6 Land use/cover classification system for use with remote sensor data 27

Table 2.7 Characteristics of land use SPZs of DMDP areas 51

Table 2.8 Key environmental issues in Bangladesh and impacts.....61

Table 3.1 Maps and images collected for this study 70

Table 3.2 Land use/cover classification scheme in the study area 73

Table 3.3 Average location quotient value in the study area grid A to K 76

Table 3.4 Sample areas, corresponding wards/union parishad and household number 76

Table 3.5 Cumulative totals of sizes and associated numbers.....77

Table 3.6 Major urban environmental variables.....80

Table 3.7 Index for spatial variation of urban environmental degradation in Dhaka city 81

Table 3.8 Neighborhoods of three survey areas 81

Table 4.1 Population projection in Dhaka Mega City Area and Dhaka City Corporation Area 84

Table 4.2 Climatic condition in Dhaka (1990-2003) 86

Table 4.3 Land elevation of Dhaka city (above mean sea level) 87

Table 4.4 Percentage of area occupied by different land use on geomorphic units 87

Table 4.5 Occupation of the respondents 90

Table 4.6 Area and population of Dhaka city (1600-2005) 97

Table 4.7 Level of urbanization and annual growth of some Asian countries 100

Table 4.8 Trend of urban population in Dhaka 101

Table 4.9 Population of four statistical metropolitan area and six city corporations .. 102

Table 4.10 Relationship between urbanization and geomorphology during 1955-1996 102

Table 4.11 Causes of land use change and people's perception 104

Table 4.12 Population changes in Dhaka metropolitan area and Dhaka city corporation area 106

Table 4.13 Land value change pattern in the study area Ashulia-Uttara-Amin Bazar during 1960-2010 110

Table 4.14 Level of pressure in the study area 115

Table 5.1 Global and regional land use change in the regional grouping area, 1700-1980 121

Table 5.2 Global land areas converted to regular cropping, 1960, 1920 and 1978 122

Table 5.3 Trends in land use pattern in South East Asian Countries (1972-1998) 123

Table 5.4 General land use pattern of Bangladesh, 1965-2005 125

Table 5.5 Land use distribution in DIT master plan, 1959 127

Table 5.6 Land use changes in Uttara, 1974 -'88 and Savar, 1974 -'90 128

Table 5.7 Land use distribution in greater Dhaka city, 1990 129

Table 5.8 Present land use/cover classification scheme in the study area..... 130

Table 5.9 Analysis of land use change trends in the study area, 1960-2008..... 131

Table 5.10 Trends of land use change pattern in the selected three areas, 1960-2008 147

Table 6.1 Summary of land use classification statistics between 1991 and 2008..... 163

Table 6.2 Markov prediction to 2020 based on land use maps of 1991 and 2008 164

Table 6.3 Transitional probability matrix derived from the land use map of 1991 and 2008 166

Table 6.4 Projected land use/cover map for the study area, 2020 167

Table 6.5 Transitional probability matrix derived from the land use map of 1991 and 2008 168

Table 6.6 Projected land use/cover for the study area, 2050 197

Table 6.7 Cross tabulation of land use/cover 1960 (columns) against land use/cover 1991 (rows) 170

Table 6.8 Cross tabulation of land use/ cover 1991 (columns) against land use/cover 2008 171

Table 7.1 Types of problems originated from environmental degradation 174

Table 7.2 Inundation area percentage in 1988, 1998 and 2004 floods..... 175

Table 7.3 Distribution of water logging affected areas per geomorphic unit..... 176

Table 7.4 Average concentration of water quality indicators DO, BOD, COD and pH of different location of Turag River from 2006 to 2009, and Lakes from Nov, 2008 179

Table 7.5 Heavy metal concentration in river water of Dhaka city..... 180

Table 7.6 Principal source of air pollution in Dhaka city, 2003 (in percentage) 181

Table 7.7 Vehicular emission in 2004 in Dhaka city 181

Table 7.8 Average values for criteria pollutants measured at CAMS, Dhaka with standard deviations during 2003 along with Bangladesh standards 182

Table 7.9 Previous types of land uses of the brickfields 183

Table 7.10 Status of urban water supply in Bangladesh, 1985 184

Table 7.11 Perception on getting drinking water problem 185

Table 7.12 Perception about suffering from diseases and Spend for treatment 190

Table 7.13 People's perception (level of satisfaction) of urban environmental variables in the study area 193

Table 7.14 Degradation of urban environment in Dhaka city 194

Table 7.15 Areas variation of neighborhood environmental degradation in Dhaka city 196

Table 7.16 Probable solutions to environmental problems by percentage of respondents 198

Table 7.17 People's responsibilities for environmental degradation 198

Table 7.18 Responsibilities to the local communities for better environment 199

Table 7.19 Opinion of the respondents regarding mitigation of the problems 200

Table 7.20 Government's steps to over come environmental degradation 200

List of Figures

Figure 1.1 Growth of population and forecast 1981-2016 of DMDP areas 5

Figure 1.2 Conceptual Frame work of the study 15

Figure 2.1 Global land use and population change (1700-1980) 20

Figure 2.2 Land use and population change in Asia (1700-1980) 21

Figure 2.3 Location of Bangladesh in the South Asia monsoon region 23

Figure 2.4 Physiographic units of Bangladesh, 1999 24

Figure 2.5 Characteristics zones of Dhaka city, 1981 40

Figure 2.6 Dhaka metropolitan development plans 1995-2015 42

Figure 2.7 Flood flow zones in Dhaka structure plan 44

Figure 2.8 Spatial planning zones of Dhaka city structure plan 46

Figure 2.9 Integrated Transport Network Plan 49

Figure 2.10 Commuter Railway Development Plan 50

Figure 2.11 Drainage zones proposed in FAP 8A study cited in IWM, 2006 53

Figure 2.12 Changing geomorphic environment through land use change 57

Figure 2.13 Relationship between urban expansion and environmental problems 60

Figure 3.1 Flow chart preparation of land use change map 74

Figure 3.2 Sample areas for questionnaire survey 78

Figure 4.1 Location of the Three selected study area (D, E and J) 84

Figure 4.2 Geographical Location of the study area 85

Figure 4.3 Percentage of respondents by sex 89

Figure 4.4 Age structure of the respondents 89

Figure 4.5 Education levels of the respondents..... 90

Figure 4.6 Ownership of the land where respondent live 91

Figure 4.7 Historical developments and land use pattern of Dhaka city (1700-1962).... 93

Figure 4.8 Development and land use pattern of Dhaka city in Bangladesh period 94

Figure 4.9 Historical growth of Dhaka..... 98

Figure 4.10 Trend of urbanization in Bangladesh (% of urban population) 100

Figure 4.11 Trend of urban population in Dhaka 101

Figure 4.12 Diagrammatic model of overall function and implication of land use changes 104

Figure 5.1 Trends of land use change pattern in Bangladesh 1965-2005 126

Figure 5.2 Land use change pattern in the study area during 1960-2008 133

Figure 5.3 Land use map in the study area, 1960..... 134

Figure 5.4 Land use map in the study area, 1991..... 136

Figure 5.5 Land use map in the study area, 2008..... 137

Figure 5.6 Trends of land use change in Ashulia area, 1960-2008..... 139

Figure 5.7 Land use change of Ashulia area (1960-2008) 140

Figure 5.8 Trends of land use change in Uttara area, 1960-2008 142

Figure 5.9 Land use change of Uttara area (1960-2008)..... 143

Figure 5.10 Trends of land use change in Amin Bazar area, 1960-2008..... 145

Figure 5.11 Land use change of Amin Bazar area (1960-2008) 146

Figure 5.12 Land use change pattern in Ashulia-Uttara-Amin Bazar areas, 1960-2008 148

Figure 5.13 Trends of land use change in Ashulia-Uttara-Amin Bazar area, 1960-2008.... 148

Figure 5.14 Trends of cultivated land change in Ashulia-Uttara-Amin Bazar area, 1960-2008..... 149

Figure 5.15 Trends of vegeted land change in Ashulia-Uttara-Amin Bazar area, 1960-2008 149

Figure 5.16 Trends of wetland change in Ashulia-Uttara-Amin Bazar area, 1960-2008....150

Figure 6.1 Land use change trends within 1960-2008 153

Figure 6.2 Gains and losses of land use categories between 1960 and 1991 154

Figure 6.3 Gains and losses of land use categories between 1991 and 2008 154

Figure 6.4 Contribution to the net change in agricultural land (1960-1991) 155

Figure 6.5 Contribution to the net change in agricultural land (1991-2008) 156

Figure 6.6 Contribution to the net change in wet/lowland (1960-1991) 156

Figure 6.7 Contribution to the net change in wet/lowland (1991-2008) 157

Figure 6.8 Contribution to the net change in vegetation (1960-1991) 157

Figure 6.9 Contribution to the net change in vegetation (1991-2008) 158

Figure 6.10 Contribution to the net change in built-up (1960-1991) 158

Figure 6.11 Contribution to the net change in built-up land (1991-2008) 159

Figure 6.12 Contribution to the net change in bare soil/landfill (1960-1991) 159

Figure 6.13 Contribution to the net change in bare soil/landfill (1991-2008) 160

Figure 6.14 Combined land use change map of 1991 and 2008 161

Figure 6.15 Projected Markov conditional probability matrixes for built up area 2020..... 165

Figure 6.16 Projected land use/cover map for the study area, 2020 167

Figure 6.17 Projected land use/cover map for the study area, 2050 169

Figure 6.18 Accuracy assessment of multi-layer perception classifier 172

Figure 7.1 Types of sanitation problem caused by flash flood and water logging 176

Figure 7.2 Ground water depletion in Dhaka city and its surrounding areas..... 177

Figure 7.3 Types of diseases suffered during water and air borne..... 191

Figure 7.4 Place of treatment during suffering from diseases..... 191

List of Photographs

Photograph 4.1 Fast growing "Concrete Jungle" tells the tale of and unplanned city 107

Photograph 4.2 Environmental pollution due to unplanned industrialization.....108

Photograph 4.3 Lowland encroachments the area of Ashulia 111

Photograph 4.4 Land filling in the Turag river.....112

Photograph 4.5 Lowlands and flood flow zones are filling-up rapidly for housing development 113

Photograph 7.1 Water logging situations at Mohammedpur johori mohalla in Dhaka city....177

Photograph 7.2 Traffic congestion in Kazi Nuzrul Islam Avenue around 2 pm 178

Photograph 7.3 Toxic effluent from dyeing factory at Ashulia goes into a canal linked with the river Turag 180

Photograph 7.4 Brick kilns to air pollution (Near Amin bazar) 183

Photograph 7.5 Collected safe drinking water under the supervision of army 185

Photograph 7.6 Solid wastes are disposed in lowland area.....189

List of Abbreviations

AC	Assistant Commissioner
ADB	Asian Development Bank
ADP	Annual Development Programme
ANN	Artificial Neural Network
BAPA	Bangladesh Poribesh Andolon
BBS	Bangladesh Bureau of Statistics
BCAS	Bangladesh Center for Advanced Studies
BELA	Bangladesh Environmental Lawyers Association
BETS	Bangladesh Engineering and Technological Services
BGMEA	Bangladesh Garments Manufacturers and Exporters Association
BSCIC	Bangladesh Small and Cottage Industries Corporation
BWDB	Bangladesh Water Development Board
CBO	Community Based Organization
CNG	Compressed Natural Gas
CPC	Civil Procedure Code
CrPC	Criminal Procedure Code
CS	Cadastral Survey
CSO	Civil Society Organization
CUS	Centre for Urban Studies
DAP	Detailed Area Plan
DC	Deputy Commissioner
DCC	Dhaka City Corporation
DDC	District Development Committee
DGLRS	Director General of Land Records and Survey
DIFPP	Dhaka Integrated Flood Protection Project

DIT	Dacca (Dhaka) Improvement Trust
DMA	Dhaka Metropolitan Area
DMAIUDP	Dhaka Metropolitan Area Integrated Urban Development Plan
DMDP	Dhaka Metropolitan Development Plan
DND	Dhaka- Narayanganj- Demra
DOE	Department of Environment
DOF	Department of Forest
DPHE	Department of Public Health Engineering
DSMA	Dhaka Statistical Metropolitan Area
DWASA	Dhaka Water and Sewerage Authority
ECA	Environment Conservation Act
ECR	Environment Conservation Rules
EIA	Environmental Impact Assessment
EQS	Environmental Quality Standard
ERD	External Resource Division
FAP	Flood Action Plan
FEJB	Forum of Environmental Journalist of Bangladesh
GIS	Geographic Information System
GO	Government Organization
GOB	Government of Bangladesh
GPS	Global Positioning System
HUDA	Hyderabad Urban Development Authority
ICTP	International Convention, Treaty and Protocol
IEE	Initial Environmental Examination
IUCN	International Union for Conservation of Nature and Natural Resources
IWFM	Institute of Water and Flood Management
IWM	Institute of Water Modeling
JICA	Japan International Cooperation Agency
LCM	Land Change Modeler
LTM	Land Transformation Model

LUC	Land Use Change
LUT	Land Use Type
MIS	Management Information System
MoEF	Ministry of Environment and Forest
MoL	Ministry of Land
NEMAP	National Environment Management Action Plan
NGO	Non Government Organization
PIL	Public Interest Litigation
PLDC	Private Land Development Company
PLDHPR	Private Land Development Housing Project Rules
PPS	Probability Proportional to Size
RAJUK	Rajdhani Unnayan Kartripakkha
RHD	Roads and Highways Department
RS	Rivisional Survey
SA	State Acquisition
SEMP	Sustainable Environment Management Programme
SOB	Survey of Bangladesh
SPARRSO	Space Research and Remote Sensing Organization
SPSS	Statistical Package for Social Scientist
TM	Thematic Mapper
UAP	Urban Area Plan
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
VNIR	Visible, Near Infrared
WAPDA	Water and Power Development Board
WB	World Bank
WCED	World Commission on Environment and Development
WWI	World Water Institute

Chapter 1

Introduction

Chapter 1
Introduction

1.1 Background

In the last few decades, the world's population grew rapidly at an alarming rate. The increase in the population has created a stress on land and environment simultaneously that has already caused wide spread damage to human-environment-resource system setup. Human activities has acted explanatory attribute to land cover and land use change and appears as a major contributory component to the understanding of the vast system covering the earth's surface. The activity stress and land use change is apparently due to human need and system's demand and fundamentally linked to the ever increasing questions of development and food security. This vast population may and might have already causes a deteriorating impact on the existing land surface. The development of technology throughout the world is being introduced to us by converting land from one land use type to another. Moreover, the land use types are getting changed in a gradually shorter span of time, which ultimately results in a complex and wide-spread impact on the environment.

Land use is as old as the human civilization started on the planet. The phenomenon changes as it is required or needed by the human being in course of time. It involves the management and modification of natural environment or wilderness into fields and human settlements, a type of built-up environment. It has also been defined as the arrangements, activities and inputs that people have undertaken in a certain land cover type to change or maintain their needs and necessaries.

Land is one of the most important resources, which play an eminent role in determining economic, social and cultural progress. Land use is the surface utilization of all developed and vacant lands on a specific space at a given time. Lands are used for crops, forest, pasture, transportation, gardening and recreational, industrial and commercial and residential purpose. Land use is also related to conservation of land from one major use to another general use. In most definitions of land use, priority is accorded to function. The OECD defines land use as the 'functional dimension of land for different human purposes or economic activities' and this has usually been seen as the dominant concern (Stamp, 1948; Best, 1981). The use of land changes varies according to human needs. Stamp, L. D., (1948) has classified the needs of land use into six major categories, viz., agriculture, residence, foodstuff, transportation, communication, defense and recreation.

Land is always in a constant flux of continual change due to transformation resulting from either natural processes or human activities. Large scale of land use change is presently witnessed in and around major cities, metropolitans and towns of Bangladesh. Some of these are very dynamic and rapid particularly in the urban area. The main factors affecting the land use change of urban areas are aparently related to or a result of the rapid growth of population, urbanization, industrialization and institutional activities. Another noticeable factor is the urbanization and increasing trend towards urban migration for employment and other developmental opportunity.

Land use change is a complex, dynamic process that links together with natural and human activities. It has direct impact on soil, water and atmosphere (Meyer and Tuner, 1994) and is thus directly related to many environmental issues of global importance. The large-scale deforestations and subsequent transformations of agricultural land in the tropics are examples of land use change with strong likely impacts on biodiversity, soil and environmental change and the earth's ability to support human needs (Lambin *et al.,* 2003). Land use change is also one of the important factors in the environmental degradation and the relationship between the two is interdependent. Changes in land use may affect the environment whilst environmental degradation will also influence future land use (Islam *et al.,* 2000).

Bangladesh has two major natural resources such as, land and water. The total area of Bangladesh is 147,570 sq km of which 9,734 sq km is under inland water-bodies (river, *beels* etc.), homesteads cover 11,227 sq km, urban fabric covers 950 sq km, and forests 2,154 sq km (Rashid, 1991). Physiographically, Bangladesh may be divided into three major units: hills of the north, northeast and southeast covering about 12 percent of the total area; Pleistocene terraces stretching over only 8 percent area and floodplains accounting for 80 percent of the total area. Of the three determinants, land levels in relation to flood depth are of major importance for land use. Even occupation types in the rural areas are dependent on flooding characteristics-depth, duration and timing. There are regional variations in the distribution of different land types and land use pattern.

Dhaka, the capital and the most populated city of Bangladesh, is now considered the member of the "mega-city" family of the world. It is the center of all political, administrative and economic activities. The population of Dhaka city is increasing day by day and the density of population of DCC is 19,286 per km^2 which is more than double of that of the mega city average having 7,918 per km^2 (DoE *et al.,* 2006). Area under

jurisdiction of different authorities serving Dhaka varies. Dhaka Metropolitan Area (DMA) is somewhat larger than the DCC. Dhaka Statistical Metropolitan Area (DSMA) is considered as Dhaka Mega city. Rajdhani Unnayan Kartripakkha (RAJUK) has a Strategic Planning Zone-wise definition of Dhaka city which is known as Dhaka Metropolitan Development Plan (DMDP). It currently consists of total 26 zones of which 19 may cover Dhaka Statistical Metropolitan Area, though the total area is about 1528 km^2 (RAJUK, 1997).

The recent trend of development in the study area appears to become an alarming threat for the remaining land use change. Expansion of Dhaka city is engulfing the remaining cultivated land, vegetation, wet/lowlands and water bodies disregard to the impact of the degradation on the environment of Dhaka city and sounding areas. This has resulted in widespread environmental problems across the city, largely stemming from unplanned urbanization, extensive urban poverty, and recurrent episodes of flooding, substantial growth of slums, exploitation of resources, and the mismanagement of limited land resources (Hasan and Mulamoottil, 1994). Such land filling and enforcement of land would lead to environmental disaster like flash flood, water logging, decrease of ground water level, destruction of natural drainage system, loss of fish and wildlife habitat, scarcity of water retention areas and increase of impervious areas. Thus it needs a comprehensive research work that will provide a clear perspective regarding the causes, factors, trend and the consequences of land use change and degradation of environment in the study area.

1.2 Statement of the Problem

Bangladesh has been passing through a hasty process of urbanization and population growth since the last few decades. Rapid growth of population, unplanned urbanization and industrialization in the outer periphery of Dhaka city has created pressure for the changes in land use pattern. The area has been experienced hasty changes in land use for infrastructure development in recent years. It is important to study the loss of cultivated land, vegetation, water bodies and wet/lowlands and also to see how and what changes occurred through. Most of the economic development activities are focused in and around Dhaka city. These changes have rapidly transformed Bangladesh from a subsistence agrarian economy into rapidly industrialized country. The growing urbanization in the outer periphery of Dhaka Metropolitan city has created pressure for the changes in the land use pattern.

1.2.1 Population Growth and Urbanization

The accelerating growth of population in and around the Dhaka city makes a tremendous pressure on the fringe areas of the Dhaka Metropolitan Area (Elahi and Hassan, 1991). The rapid growth of population and extraordinary growth of urban area are the most dramatic phenomena associated with urbanization. Land use is one of the essential factors influencing the pattern of urban development. The limited space within town centre, combined with growing space requirements for different purposes, has initiated the movement of urban high as well as middle class residents from city centre to the outlying suburbs. Thus, the pressure of the continuously growing town centre gradually changes the structure of surrounding neighborhood.

The physical transformation of Dhaka from a sleepy, trading town to a burgeoning capital city-one cannot help but get awed by the tremendous growth of the city. In 1875, Dhaka was a very small town located on the bank of the Buriganga River and at present it has been developed into a primate city of 1528 sq km (RAJUK, 1997). In the development process, the once lush green city with an intricate network of rivers, canals and lakes have been filled up by the unauthorized encroachment; and destroyed in its wake the thriving green and abundant open spaces within a matter of three decades. The question is "Does development has to be associated with such destruction?"

Bangladesh has been experiencing a population boom since the 1970s. At the time of independence in 1971 the population was 71.50 million, whereas at present it is more than 126 million (as on data of 2006). Dhaka is also experiencing huge population growth; the city's population was 1.06 million in 1959 which has increased to about 126 million in 2006 (RAJUK, 1997) since 1991-2016 the population has been forecast at **Table 1.1 and Figure 1.1.**

Table 1.1 Population forecast 1991-2016 of DMDP areas

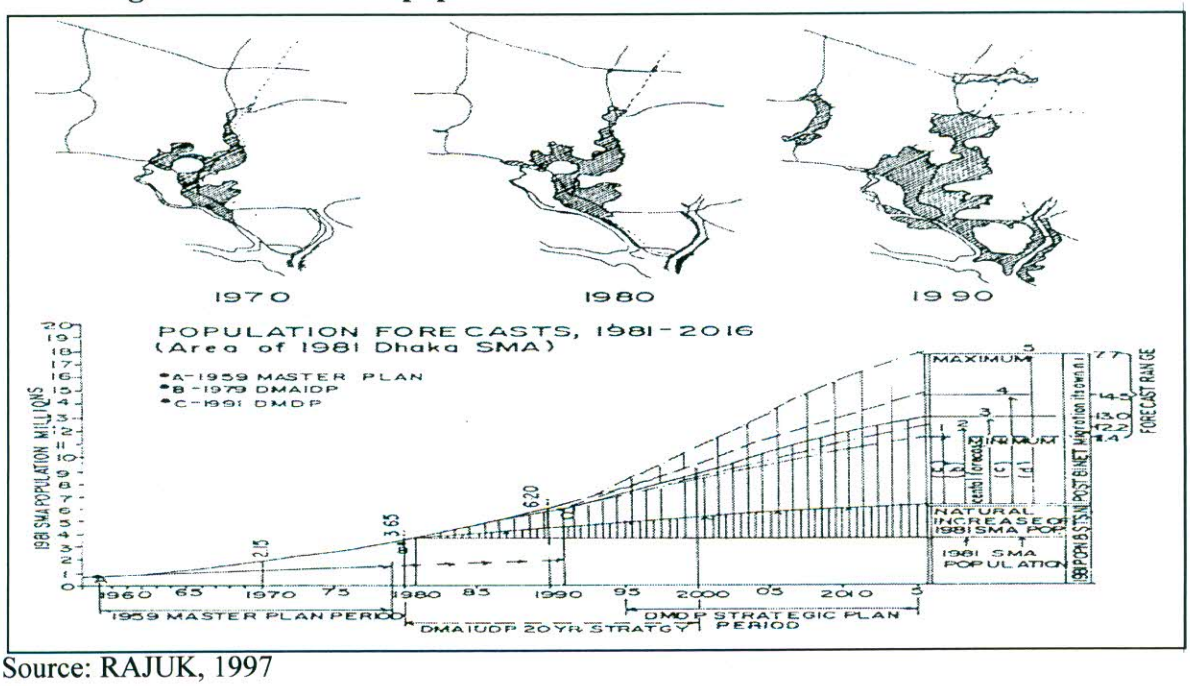
(Population in thousand)

Forecast Component	SPZ's	1991	1996	2001	2006	2011	2016
Total by Natural Increase of 1981 Population	1-7	3044	3272	3438	3675	3822	3917
	8-14	1584	1742	1899	2022	2124	2197
	15-18	890	993	1088	1188	1275	1365
	19	450	493	535	580	632	685
Net Migration in Previous Period.	1-7	800	552	499	456	449	410
	8-14	460	501	488	433	433	456
	15-18	115	89	89	85	76	67
	19	3	2	3	3	4	4
Cumulative Migration Totals Plus Natural Increase.	1-7	-	860	1764	2176	2737	3172
	8-14	-	501	1077	1659	2208	2747
	15-18	-	124	231	336	438	534

	19	-	3	5	8	11	16
Total Population	1-7	3844	4684	5747	6308	7008	7498
	8-14	2044	2744	3464	4114	4764	5400
	15-18	1005	1206	1408	1609	1789	1966
	19	453	498	543	588	647	705
Total Population	1-19	7334	9132	11162	12619	14208	15569

Source: RAJUK, 1997

Figure 1.1 Growth of population and forecast 1981-2016 of DMDP area



Source: RAJUK, 1997

Most parts of Bangladesh, including Dhaka, experience annual flooding as the country is located in delta. Initially, Dhaka's development took place on available flood-free lands. Before the 1970s, Dhaka was the Provincial capital and it had a little impetus for growth.

However, after the emergence of Bangladesh in 1971 as a sovereign state and the ascendance of Dhaka to that of a capital city, rapid increase in population was evident and the city limit extended fast. The triple characteristics of Dhaka as capital city, mega-city and prime-city, is attracting people from all over the country and, as a results, amplifying the demand for housing, industrial, commercial and other related services. However, the rapid population growth of Dhaka has led to rapid expansion of the city both horizontally and vertically. In this process land use change is played the dominant role while public sector is limited itself to infrastructure development and service provision. Lethargy and/ or reluctance on part of public sector to cope with the demands and needs of the populace have provided opportunities for the private real estate developers, private industrialization and commercial preprocess are to grab the opportunity for reaping unlimited profit.

1.2.2 Land use Change and Suburban Development

The enormous growth of population and associated rapid urbanization in the metropolitan area of Dhaka is affected by the existing land use and agricultural activities in the urban fringe (Ali, 1984). Impacts of urbanization upon the agricultural area are several: agricultural land use change, expansion of settlement, loss, conversion and sterilization of cropland, increases in land values, and changes in agricultural intensity, cropping patterns and agricultural investments and returns.

Land use change due to human activities is directly related to land generally and makes the use often on its resources and the pattern of impact is decided parallel. Land cover is the physical attributes of the land, while land use is a pattern of human activities undertaken within a socio-economic context. Natural land cover is changed by use of man in meeting cultivation, homestead or other demands.

The study area is a suburb and is located in north-west part of Dhaka metropolitan city. Main activity of the area is agriculture which generates income for the farmers. Farmers have changed their land use from other infrastructure development sector (e.g. housing developer from real state building, large and small scale industries and road networks) that has further enhanced the land use change process in the area. It is important to study the driving forces of land use changes to understand the change process. Spatially explicit land use models help to test hypotheses about landscape evolution under several scenarios.

Population change and suburban expansion in terms of urban land use transformation are the two important issues in the suburban development in the North-west part of Dhaka Metropolitan Area (DMA). The term 'suburb' is a part of the rural-urban continuum and is a zone of belt lying immediately outside a central city (Elahi and Hassan, 1991).

For instance, in the last three decades the peripheries of the Dhaka city connected with the national highway have experienced tremendous ribbon shaped development (Reza and Alam, 2002). Such development activities have resulted in huge pressure on land particularly on flood free highland. The study area is one of the most favorable flood free locations, with easy accessibility to the capital city and having required infrastructures, phenomenal industrialization took place in the last two decades (Rashid, 2003).

1.2.3 Destruction of Agricultural Land, Vegetation and Wetlands

With the expansion of urbanization, land use pattern is gradually changing from agricultural land to non agricultural purpose. In recent years DCC have experienced a number of geographic transformations in terms of an exceeding rate of population increase and functional changes in the agricultural and non-agricultural land uses due to impact of urbanization of the Dhaka city. As a result, there appeared a marked change in agricultural, residential and industrial land uses and a faster growth of population in the Study area. The land use transformation is also characterized by a marked land value change and a high degree of land speculation.

Socio-economic Factors

For sustainable development the balance between the population size and available resources, and the rate of population growth in relation to the capacity of the economy to provide the basic needs of the population, not just today, but for the future generations has been stressed in the Brundtland report (WCED, 1987). On this basis Bangladesh possesses some very serious negative aspects for achieving sustainability in land management. The current agricultural land- man ratio in this country stands at 0.07 ha per person, which is predicted to go down to 0.05 ha per person by the year 2020 (**Table 1.3**). Already around 60 percent of the country's total land area is under cultivation, and as the land-man ratio is gradually decreasing; there will be a need for adoption of high yielding agricultural technology to increase the agricultural production. Already the number of land-less farm owner is high and the number is gradually increasing with time (**Table 1.2**).

Table 1.2 Changing patterns of land use and agricultural development in Bangladesh

Changing Patterns	1983-'84	1996	Change over 1983-'84 (%)
Total farm holdings	10045	11798	+17
Small farm ('000)	7066	9423	+34
Medium farm ('000)	2483	2078	-16
Large farm ('000)	496	297	-40
Absolute landless ('000)	1198	1815	+51
Homestead area ('000 ha)	391	533	+36
Cultivated area ('000 ha)	8160	7194	-12
Average farm size (ha)	0.81	0.61	-25
Irrigated area ('000 ha)	1620	3762	+132
Cropping intensity (%)	140	172	-
Fertilizer use ('000 tons)	1129	2640	-

Source: Bangladesh Census of Agriculture, 1999

Note: Small farm; 0.02-1.008 ha, Medium farm; 1.01-3.03 ha and Large farm; 3.04 ha and >

The number of large farm holding as well as the area of homesteads is decreasing because of inheritance law. The only silver lining in the agricultural front is that the area of irrigated land is showing a trend of increase. The lack of financial ability for adoption of appropriate modern technology for improving the agricultural practices by the small farmers resulted in the adoption of low-cost low-input technology, which in turn resulted in stagnancy in agricultural growth, continued soil-nutrient mining, decline in soil fertility status and gradual degradation of land resource.

Land Ownership and Landlessness

In rural Bangladesh owning of agricultural land is traditionally a symbol of richness and power in the society. Land is regarded as the permanent asset. The fast declining land-man ratio has set off an acute competition for acquiring agricultural land (**Table 1.2 and 1.3**). Because of scarcity the transactions of land has slowed down and have become survival-oriented. The present size of land holdings and their distribution can be taken as an indicator of the extent of marginalization and pauperization in the rural society. The quantity of land is unable to support the rural population. Pattern of land gain, land losses and the modes of clinging to land by the rural population may reveal some aspects of social reality (**Table 1.2**). In the existing unequal competition, many households succeed in gaining lands, many lose lands and many persist in retaining their initial land over time.

As time passes more and more people become landless for varieties of causes. The important cause, as noted above, is the paucity of land as compared to the number of people. This acute problem of landlessness and poverty in rural Bangladesh is a matter of grave concern. As the structure of production is given and the traditional nature of agriculture in Bangladesh, the distribution of landed property has important implications for distribution of assets and income. For example, at present 55 percent farmers are landless. What is going to happen in 2050 when the population will exceed 200 million marks? In 1901, the agricultural land-man ratio in Bangladesh was 0.30 ha/capita, which had been maintained a deleterious rend since then and came down to 0.12 ha/capita in 1974 and 0.07 ha/capita in the year 2001 (BBS, 2001).

Table 1.3 Changing land-man relationships in Bangladesh

Year	Population (million)	Increase in percent	Cultivated hectare per capita	Population per cultivated hectare
1901	29	-	0.30	3.3
1911	31	9.1	0.28	3.5
1921	33	5.4	0.26	3.7
1931	36	7.1	0.25	4.1
1941	41	13.9	0.21	4.6
1951	44	7.3	0.20	5.0
1961	51	15.4	0.17	5.8
1974	71	40.6	0.12	8.0
1981	90	25.9	0.10	10.2
1991	111	24.0	0.08	12.6
2001	129	16.3	0.07	14.6
2010	150	16.3	0.06	16.9
2020	170	13.3	0.05	19.2
2030	189	11.2	0.04	21.4

Source: BBS, 1999 and 2001

As noted before the process of landlessness in Bangladesh has been triggered off by subdivision and fragmentation of holdings due to the existing law of inheritance over generations by gradual split of households. Because of this splitting for generation after generation the economic viability of the fragmented holdings has been lost. Becoming gradually resource-less and unable to survive on the income from farm holding the poor farmers are compelled to move to the big cities in the hope of finding better living. As a consequence of this mass migration, the urban infrastructure and facilities have reached close to a status of collapse with the gradual degradation of urban environment.

Land filling and encroachment in wet/lowlands occurs when earthen or other miscellaneous material is used to fill the area of a wetland and to raise the final elevation of the site (Nakashima and Khan, 1994). This is done frequently to provide new sites for buildings, infrastructure alignments, and for disposal of garbage and waste. The Private Land Development Companies (PLDCs) implement housing projects in low lying areas with their own style ignoring the existing laws, restrictions and even they are not sincere and co-operative with government agencies. The PLDCs flout laws and fill-up low-lying

areas by carrying sand/earth from other areas using country boats and engine boats. In Dhaka city, RAJUK (*Rajdhani Unnayan Kartripakkha* - Capital Development Corporation) plays a key role in implementing public sector for housing projects. But the RAJUK is also implementing their housing project in wetland areas like the PLDCs. Therefore, wetlands are shrinking day by day in the Dhaka city.

1.2.4 Construction of Haphazard Infrastructure and Industrial Establishments

Construction of real state housing, institutional, administrative, educational, industrial and commercial complex, roads and embankment were developed in an unplanned way. Due to lack of foresightedness and lack of appropriate perspective plans urban centers in Bangladesh have grown without any legitimate control. Plans were made in isolation to deal with specific and immediate problems without any coordination of the agencies involved in the land use change.

As government agencies, such as Rajdhani Unnayan Kartripakkha (RAJUK) has to keep pace with the growth of Dhaka, they gear their efforts to the development of the city in a planned manner. Thus, most of the urban areas, specifically residential, industrial and commercial areas within the city, have grown according to private initiatives without any coordination or much legitimate control. Land development schemes for residential purposes, undertaken by the RAJUK, were mainly targeted towards high income group of the society and this income group later converted their low-rise, low-density residential areas to high density, high-rise residential, commercial or residential-cum-commercial and industrial utilization for more profit.

The city expanded to a north-south direction in vertical manner because of the physical constraints in east and west. There has been overall shortage of flood-free and developable land and land prices have increased at rates substantially above general inflation levels. Due to location advantage and close proximity to the Central Business District (CBD) the expansion is going in the north-west direction at present. Private real estate developers have mainly spearheaded the latter expansion. Private developers have used agricultural and wet/lowlands, by moderating to a large scale and filling, for residential, industrial and commercial development.

In this regard, government agencies were helpless onlookers and their actions were mostly futile in restraining the Private Land Development Companies (PLDCs) and unplanned industrialization in taking up development programs that change in land use pattern, and those adverse impacts on the local environment.

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1.2.5 Deterioration of Urban Air and Water Quality

The environmental changes that took place in Bangladesh did not occur homogeneously, neither spatially not temporally. Besides the matter complicates as the land use change through development activities or initiative concentration in and around major cities particularly, the metropolitan cities like Dhaka (UNEP, 2001).

Unplanned extensive development of urban area and industrialization has been creating environmental problems such as air and water pollution in Dhaka city. These are not a new problem but the frequency of this problem is increasing every day.

While the problem is most severe in Dhaka, where air and water quality is worst and most people are exposed, air pollution is a growing concern in other major cities. Measurements and data from Dhaka indicate that particulate matter is the most significant pollutant, especially fine particulates that cause the most severe health effects. The effect is seasonal, however, with particulate concentrations falling within acceptable levels during the summer rainy season. Currently, other pollutants rarely exceed standards for ambient air quality.

Dhaka's environmental challenges are risks to human health and natural resource productivity from the poor quality of air, inadequate management of solid waste, and contamination of surface and groundwater in and around the city. While initiatives go underway to manage better air quality and solid waste, little has yet been done to improve water quality, although the economic costs associated with water pollution are estimated to exceed those attributable to poor air quality and solid waste.

Dhaka surface water is in very poor condition, especially in the dry season. For some six months of the year, the flow rate of the rivers is negligible, often with only a tidal pulse, but the volume of effluent entering the canal and river system remains about the same as during the wet season. Consequently, dilution of contaminants is drastically reduced in the dry season.

1.2.6 Depletion of Ground Water Level

Due to excessive abstraction of ground water, underground water level is going downwards and at the same time due to change of wetlands, underground aquifer can not recharge proportionately. Ground water depletion is now at alarming rate, more than 3 meter/year at most places (Al-Mamun, 2006). With low ground water levels and insufficient infiltration the capital could slowly start to sink. While this may seem highly implausible now, there is a definite possibility that it may occur (The Daily Star, June 22,

2007). The water bodies played a part in holding excess water and maintaining ground water level to ensure supply of water in Dhaka city. The water bodies played a part in holding excess water. Thus largely deprived of this natural drainage system, the city in these days, suffers chronically from flooding and water-logging and the phenomena is turning worse every year. Currently 30 minutes of rain eventually floods the city. Flooding due to rainfall is a severe problem for Dhaka city that is inundated for several days mainly due to the illegal filling up of natural wet/lowlands along with alarming unplanned urbanization. The water depth in some of the areas may be as much as 50-70 cm, which creates large infrastructure problems for the city and a huge economical loss in production for the city together with large damages of existing property and goods (Tawhid, 2004). In addition, diseases spread out and creates problems to the citizen e.g. in terms of diarrhea.

1.3 Rationale of the Study

It has been already mentioned that rapid population growth of Dhaka has led to rapid expansion of the city both horizontally and vertically. It is necessary to investigate the changes in land use pattern to have a better understanding of the process. In the development process, the once lush green city with an intricate network of rivers, canals and lakes has been filled up. This study allows us to identify the driving factors and causes of the peoples' suffering that lead them to change their land use and degradation of physical and socio-economic environment of Bangladesh, and relatively very few efforts have been made to conduct studies and research in this field. Besides, the problem and issues relating to land use change and its adverse effects on different part of the study areas have not yet been seriously studied. It is important to mention that the land use planning document such as the Dhaka master Plan, 1959 was prepared on behalf of Dacca (Dhaka) Improvement Trust (DIT) by foreign consultants working with officials of DIT and was submitted in 1959. Dhaka Metropolitan Area Integrated Urban Development Plan (DMAIUDP) 1979-80 and the final report submitted in March 1981 and Dhaka Metropolitan Area Development Plan (DMDP) 1995-2015 was started in 1991 (after the single the City Master Plan of Dhaka, 1959). This plan has been prepared comprising 1528 sq. km area administered by the RAJUK. Under this Master Plan of Dhaka (Dhaka Metropolitan Development Plan) a comprehensive development plan for the future development of Dhaka city has been prepared with the objective of forming a framework of development planning, preparation of sector based master plans and feasibility studies for metropolitan infrastructure elements lacking development policies. As a result, serious

environmental consequences and problems have been creeping up. Reliable data for the development of land use and its impacts on environment are inadequate. No thorough investigations are carried out for the spatio-temporal analysis to assess the impact on physical environment and socio-economic component in Dhaka city.

Further, the review of literature in the next chapter (Chapter Two) reveals that the studies and research so far carried out on the land use change and environmental degradation are largely limited to socio-economic fact findings and are highly descriptive in nature. The concerned emerging issues related to land use change pattern, agriculture, vegetation, wet / lowlands and environmental degradation have failed to enlighten quantitatively and qualitatively.

To understand the different aspects of the issues and intervenes the problems faced by planner, environmentalist, policy makers and social workers, generating adequate data and information on concerned problems is required. The present study is thus very important on environmental groups to investigate into pertaining issues and problems relating to land use changes along side increase in developing areas in Dhaka city. The outcome of this interdisciplinary research will be an important input in producing useful guidelines for planner and decision makers in developing viable plan for land use change in Dhaka city that can be undertaken on an economically efficient and environmentally sustainable basis. So these studies can prove a benchmark research on the sustainable land use change in Dhaka city.

1.4 Research Questions

The study concerns the following research questions:

- What are the factors of land use changes?
- What is the nature of environmental degradation that happened from land use change?
- What is the appropriateness of policies for environmental management in Dhaka city and to what extent those are implemented?

1.5 Hypothesis

The primary purpose of the study is as one can find is the following hypothesis:

> The present pace of land use change resulting from unplanned urbanization leads to diversified environmental degradation.

1.6 Aim and objectives of the study

Aim

The primary objective of this thesis is to develop a model for sustainable land use management.

General Objectives

The objective of the study is to assess and review the past and present situation of land use change and environmental degradation in Dhaka city, particularly the problems as well as the identification of the emerging trends with causes and extent of land use changes over a period of time.

- To examine environmental degradation though land use change due to the fact of unplanned urbanization.

Specific Objectives

More specifically, the objectives of the study are as follows:

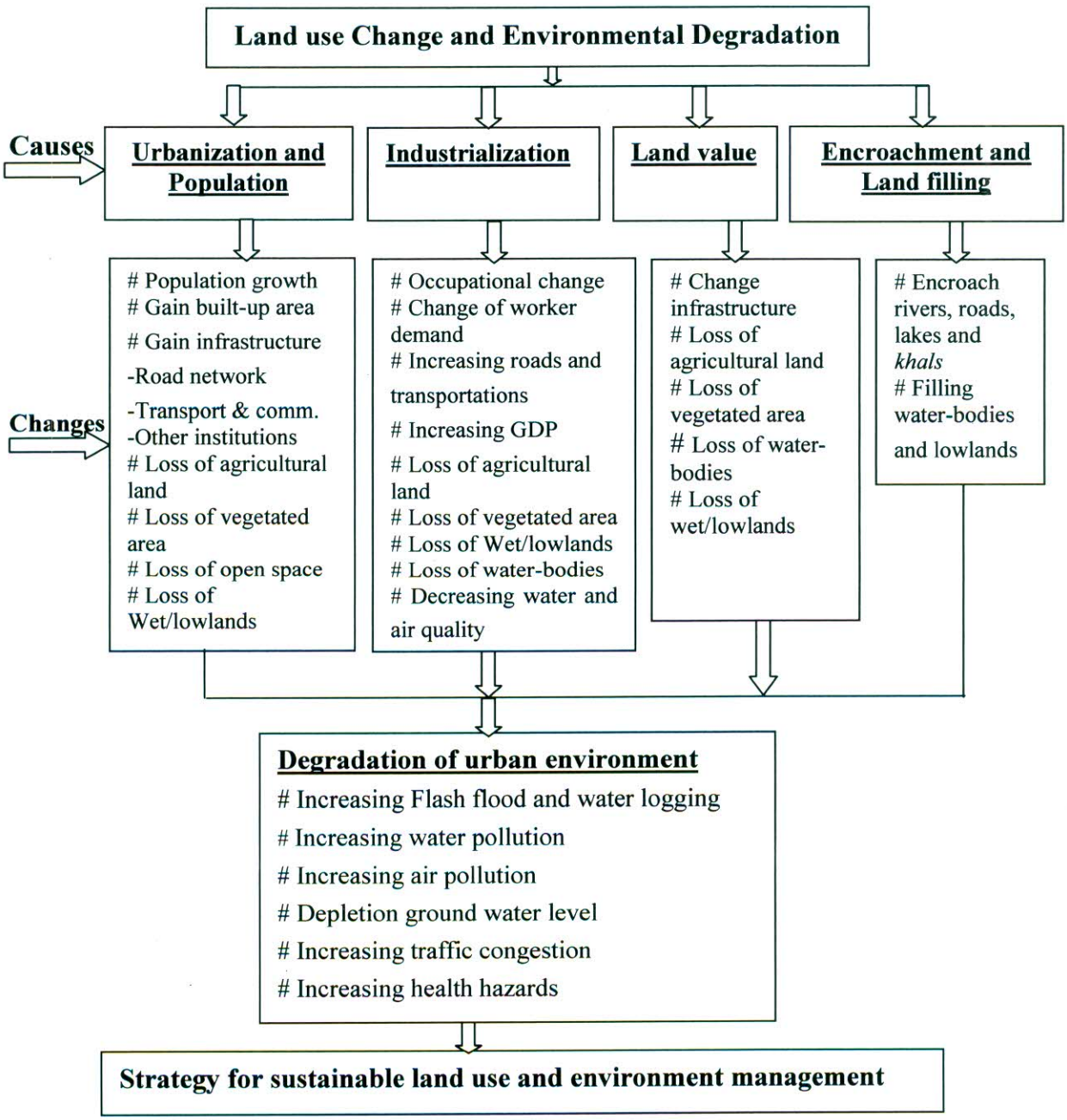
- To examine causes, factors and trends of land use change;
- To explore environmental degradation through land use change in Dhaka;
- To develop a trend in the spatial change in land use pattern in a certain span of future time in the study area using a software module;
- To suggest a sustainable land use model;

1.7 Conceptual Framework

The conceptual framework of the study is developed on the assumption that in order to have a sustainable environment, extensive land use change in Dhaka city and critical concerns relating to the urban environment have to be explicitly considered. This includes the status of past, present and future land use change and its consequences for the physical and socio-economic environment and also the human activities in the area. For the physical and socio-economic concerns, land uses in context of agricultural land, vegetation, water-bodies, wet/lowlands and the environmental consequences over time are emphasized. For human activities, the item under investigation includes geographical location, rapid growth of population, urbanization, industrialization, encroachment and land filling, lack of public awareness and lack of regulations and its implementation by the policy matter towards land use change and the government's institutional and

organizational arrangements. All these aspects relating to various factors of land use change and environmental concerns interact and influence each other.

Figure 1.2 Conceptual Frame work of the Study



1.8 Scope and Limitation

The Scope of the study is limited to land use change areas in the urban area of Bangladesh. The study emphasized on land use changes and environmental degradation on the north-west part of Dhaka city and Savar area, which is about 414 sq. km in area. Although the area might not to be ideal to develop a generic model of land use change dynamics for

large-scale land use change process, it was selected due to its sharp land use change from 1960 to 2008. The empirical data is however collected from a part of Dhaka city and Savar area through a deep investigation and questionnaire survey over a period of time. Land development by land filling process in the depression significantly reduces the "Natural Storage area" within the city. The proportions of impervious area increased, reducing cultivated land, vegetation, water bodies and wet/lowlands. As a result the quality of environment such as: air, water and soil quality was decreased.

Some scope and limitations of this study are as follows:

- The study has provided the greater scope to identify the bottlenecks of existing urban land use management system.
- To overcome the environmental problem of a part of Dhaka city and Savar area, it was necessary to find out the inherent causes of this problem considering its associated impacts on the human life. Thus this study has provided a guideline/policy to take appropriate steps for better management of the problem.
- This study will help to promote awareness regarding the conservation of wet/lowlands and the modifications of the degradation of environment in the urban areas.
- For the limitation of time and lack of budget it was not possible to analyze all the impacts of wet/lowlands, vegetation and cultivated land loss. The study has mainly focused on developing a methodological framework for dynamic spatial land use pattern and modification of environmental degradation in the study area.
- During the questionnaire survey some interviewee did not want to make any comments against the responsive development authorities even they know the lack of efficiency of those authorities, because they think negative comments can be harmful for them in near future.
- Some respondents believed that this work carried out only for the personal benefit of the researcher and they will not get any benefit from it. So they did not want to show any interest in co-operating with the researcher and investigator.

However, this study was concentrated only on land use change from cultivated land, vegetation, water-bodies and wet/lowlands to built-up of any variety. This research mainly focused on causes of land use change pattern and modification of environmental degradation in the study area.

1.9 Structure of the Thesis

- The present work is organized in eight chapters. This first chapter contains introductory subject matter of the study which covers background, statement of the problem, research questions, hypothesis, aims and objectives, rationale of the study scope and limitation and organization of the thesis.
- The second chapter deals with theoretical framework and the review of literature, in which relevant literary works from articles in journals, internet sources, books, thesis, manuscripts etc. have been reviewed.
- The third chapter is about work methodology which has discussed types of research, sources of data, selection of study area, sample size determination and selection of respondents, methods of data processing and analysis and overall research methodology.
- The fourth chapter deals about profile of Dhaka city and land use change, which has focused about study area, profile of the respondent, physical and demographic development, factors/causes of land use change, and impact of urban environment in Dhaka city.
- The fifth chapter analyses about land use change pattern, land use change trend, major land use change areas and comparative land use change trend in selected areas.
- Chapter six presents and evaluates a selection of models of land use change, change detection using land change modeler, transition probability matrix and prediction using Markov chain analysis according to the modeling and accuracy assessment to which they belong.
- The seventh chapter deals with the problems of urban environment, physical and social environmental degradation and people's perception to diminish the problems and promote awareness to reduce the environmental degradation.

Lastly, the eighth chapter summarizes the main issues pertaining to theories and a model of land use change, also discusses selected issues of a more general concern in the context of the analysis of land use change and outlines future research directions.

Chapter 2

Review of Literature

Chapter 2
Review of Literature

Review of literature is an important section that links previous knowledge with that of objectives of the work and finds out the gap. Some important works relevant to the present research work are reviewed and briefly cited. The study of land use is very important both to the user of the land parcel as well as to understand the environment around. The land use pattern of an area changes along with time, according to need. The change is related to the overall functional demand and physical and social environmental degradation.

2.1 Issues Related to Land use Change

Various issues are related to the land use change. Ecosystem, bio-diversity, bio-physical environment, wetlands and water-bodies etc; undergo changes with the change of land use over time on the earth. Land use is the layer of soil and bio-mass, including natural vegetation, crops and man made infrastructures that cover the land surface. Land use is the purpose for which human exploits the land cover (Verburg *et al.*, 2000).

Land use change is the modification in the purpose of the land, which brings not only the change in land cover but also changes in intensity and management (Soepboer *et al.*, 2002). Land use and land cover change are critical issues due to their great influence in global warming, loss of bio-diversity, and impact in human life. Because of their enormous impact and implications, the International Geo-sphere-Bio-sphere Program (IGBP) and the International Human Dimension Program (IHDP) initiated a joint international program of study on Land Use/Cover Change (LU/LCC). They recognized the necessity to improve understanding, modeling, and projections of land dynamics from global to regional scale and focusing particularly on the spatial explicitness of processes and outcomes (Geoghegan *et al.,* 2001).

The spatial setting of landscape elements is characterized by the combination of both bio-physical and human forces (Fernandez *et al.,* 1992). In temporal scales of decades, human activities are basic factors in shaping land use change. Some of them are due to specific management practices and the rest are due to social, political and economical forces that control land uses (Medley *et al.,* 1995). There are many factors and causes of land use change. Those are population growth, urbanization, industrialization, changes of

lifestyles, and political and institutional factors (Heilig, 1996; Lambin and Geist, 2001). The landscape is dynamic in relation to spatial, structural and functional patterns. The purpose of land use change in simulation modeling is to describe, explain, predict, assess impact, and to evaluate hypothesis (Briassoulis, 2000).

Change detection is a process of identifying and analyzing the differences of an object or a phenomenon through monitoring at different times (Singh, 1989; Mouat *et al.,* 1993). The detection and analysis of changes in multi-temporal remote-sensing data have assumed an ever-increasing strategic role in several application domains. A wide range of applications can be benefited from the study of change process over a specified area at different times. Information about land use change is necessary to update land use/cover maps and for effective management and planning of the resources for sustainable development.

2.1.1 Land use in Global Scenario

Land is the stage on which all human activities are being conducted and the source of the materials needed for this purpose. Human use of land resources gives rise to "land use" which varies with the purposes it serves, whether they be food production, provision of shelter, recreation, extraction and processing of materials, and so on, as well as the bio-physical characteristics of land itself (Briassoulis, 2000).

Hence, land use is being shaped under the influence of two broad sets of forces of human needs and environmental features and processes. Neither of these forces stays still; they are in a constant state of flux as change is the quintessence of life. Changes in the uses of land occurring at various spatial levels and within various time periods are the material expressions, among others, of environmental and human dynamics and interactions which are mediated by land. These changes have at times beneficial, at times harmful impacts and effects, the latter being the chief causes of concern as they impinge variously on human well-being and welfare.

The magnitude of land use change varies with the time period being examined as well as with the geographical area. Moreover, assessments of these changes depend on the source, the definitions of land use types, the spatial groupings, and the data sets used. A few indicative figures are given here to show salient changes in major uses of land. **Table 2.1** contains data on global and regional land use and population change in the last 300 years for three main land use types. **Figures 2.1 and 2.2** depict these changes.

Table 2.1 Global and regional land use and population change during 1700-1980

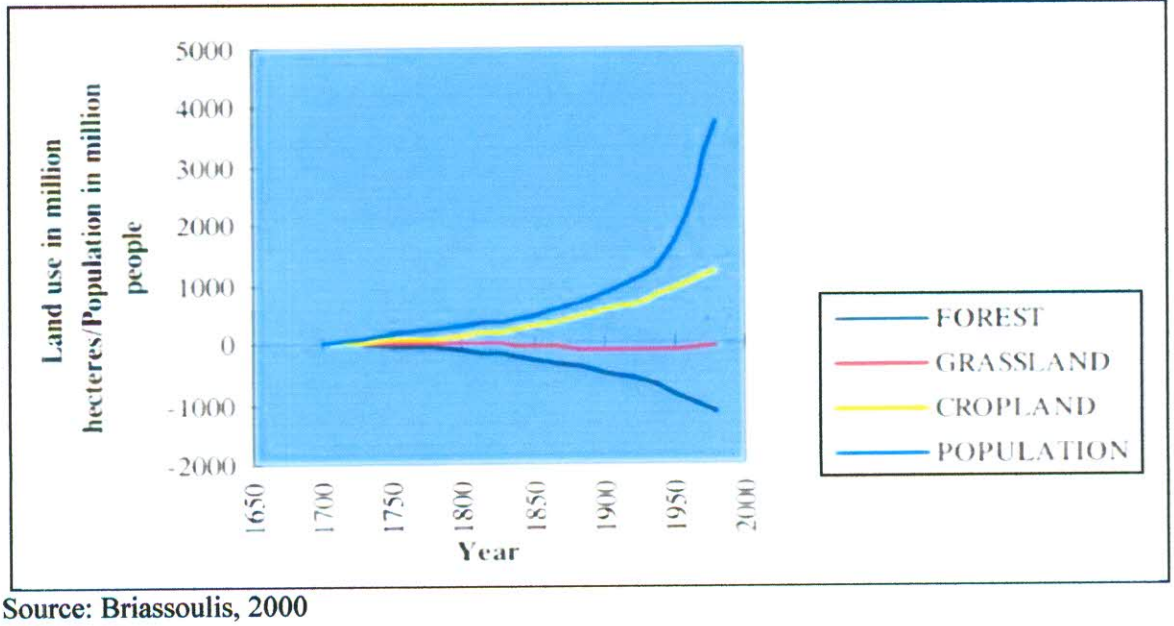
(Area in million ha and million people)

	1700 to 1800	1800 to 1850	1850 to 1920	1920 to 1950	1950 to 1980	Total 1700 to 1980 LUC	1980 Land Use and Pop^{n}.	Total land area 1980	LUC as % of Total 1980 Land area
WORLD								13342	
Forest	-105	-145	-285	-289	-336	-1162	5053		-8.71
Grassland	-12	-11	-89	32	8	-72	6788		-0.54
Cropland	116	156	376	257	331	1236	1501		9.26
Population	278	203	578	686	1909	3755	4433		
ASIA								2074	
Forest	-38	-20	-50	-53	-89	-250	473		-12.05
Grassland	-13	-8	-11	-12	-34	-63	1202		-3.03
Cropland	38	29	61	65	120	313	390		15.10
Population	195	171	216	372	1190	2144	2579		

Source: Adopted from Grubbler, 1990 and Briassoulis, 2000

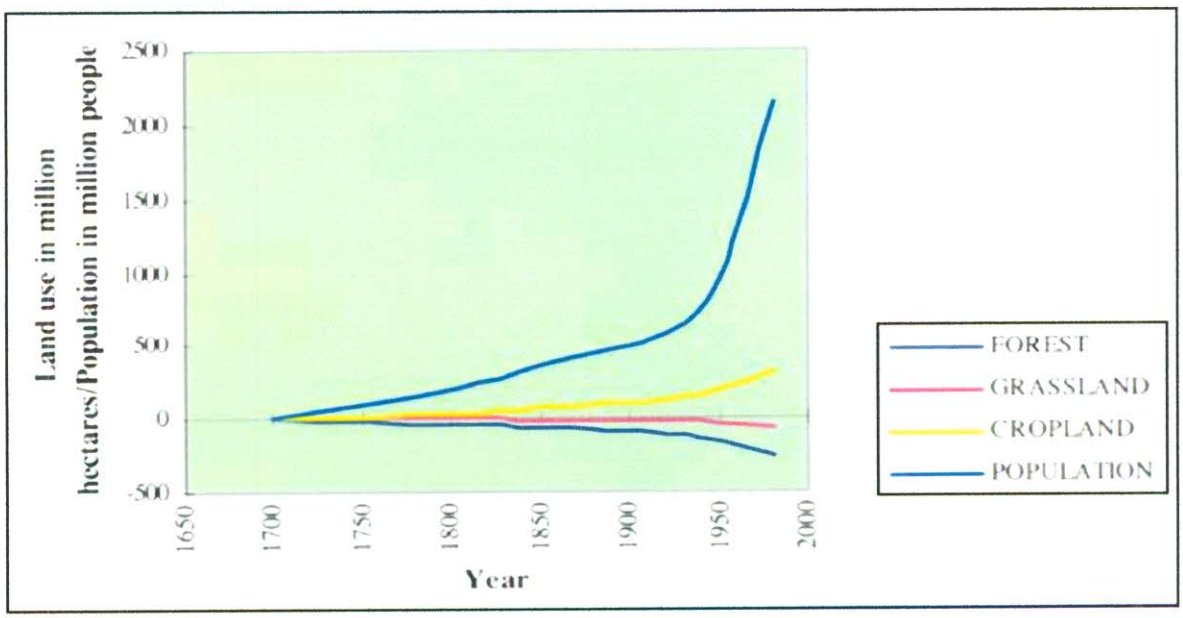
Table 2.1 represents the magnitude of change in each of the three major land use types distinguished in percent of total land area, as we had in 1980, of each regional grouping and for the world as a whole. The variability of changes among the major land use types as well as the geographical variability of land use changes within and between land use types. Population change is used as a proxy measure of changes in the area of human settlements especially in urban areas. These latter changes are difficult to assess unambiguously as they are haunted by definitional and data problems (Douglas, 1994).

Figure 2.1 Global land use and population change (1700-1980)



Source: Briassoulis, 2000

Figure 2.2 Land use and population change in Asia (1700-1980)



Source: Briassoulis, 2000

In the last 300 years the impacts of land use change have increasingly assumed from significant to threatening proportions. What is most important, however, is that, with few exceptions, it is human and not natural force which brings about these changes and which is responsible for their magnitude and severity. To consider simply, these major environmental problems are desertification, acidification, climate change, ecstatic sea-level rise, greenhouse effect, bio-diversity loss. In all of them and in myriad other less publicized and less visible, land use change caused by human activities is implicated to a greater or lesser extent. The impacts of these environmental problems are serious both in the short and in the long term. In the short term, food security, human vulnerability, health and safety are at stake; in the longer term, the viability of earth is being threatened. Hence, the impetus to study global environmental change in general and land use change in particular is to change the area as a whole.

2.1.2 Land use in South Asia

The region has a land area of 641.08 M ha and a population of 1200.36 million (**Table 2.2**). The agricultural population is 731.31 million, 61 % out of the total population. The area of cropland is 35% (224.38 M ha), of pasture 15 % (96.16 M ha) of the total land, and thus of cropland and pasture together, here called agricultural land, 50% (321 M ha) of the total land (FAO, UNDP and UNEP, 1994).

Table 2.2 Land use and population in South Asia, 1990

Country	Total Land (Mha)**	Total Popula. (million)	Popula. Density (per km2)	Agri. Popula. (million)	Crop lands (Mha) %	Pasture (Mha) %	Forest lands (Mha) %	Other lands (Mha) %	Land per capita (ha)
Afghanistan*	65.21	16.56	30	9.07	12	46	3	39	4.20
Bangladesh	13.02	115.59	888	79.22	70	5	14	11	0.12
Bhutan	4.70	1.52	32	1.38	3	6	56	35	0.29
India	297.32	853.09	287	535.60	57	4	22	17	0.34
Iran	163.60	54.61	33	14.64	9	27	11	53	4.03
Nepal	13.68	19.14	139	17.56	19	15	18	48	0.26
Pakistan	77.09	122.63	159	64.94	27	6	5	62	0.40
Sri Lanka	6.46	17.22	267	8.90	29	7	32	32	0.26
Region	641.08	1200.36	187	731.31	35	15	15	35	0.44
Asia-Pacific	3001.46	2980.23	99	1738.81	15	23	22	40	0.86
World	13079.15	5314.75	41	2389.91	11	26	31	22	2.03

Source: Adopted from FAO, UNDP and UNEP, 1994

** Mha = Million heaters; * FAO Production Yearbook, Vol. 45, 1991

These bare statistics indicate three basic characteristics of the region: the large total population, high density in relation to land resources, and large proportion of total land under agricultural use. Over 22% of the world's agricultural population lives on just under 5% of its land area; whilst almost exactly 50% of the total land is under agricultural use, a far higher proportion for the world as a whole.

2.1.3 Land use in Bangladesh

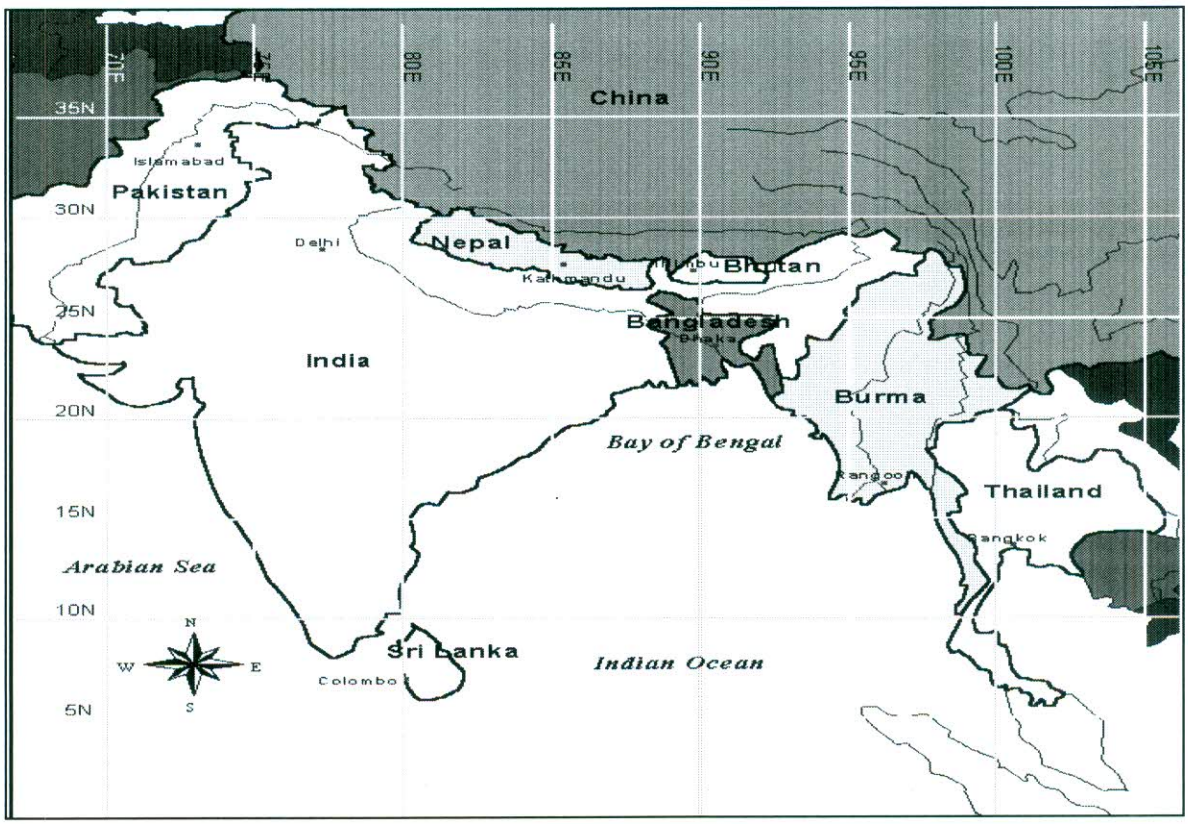
Bangladesh is situated in the monsoon region of South Asia. Though, comparatively a small country in terms of area, its population has made it 11th largest country of the world. Its location with the Bay of Bengal and Indian Ocean to the south, iced cap Himalayan range to the north has made it sensitive to the any changes in world monsoon climate **(Figure 2.3).**

2.1.3.1 Physiography

Bangladesh occupies a unique geographic location- spanning a relatively short stretch of land between the mighty Himalayan mountain chain and the open ocean. It is virtually the only drainage outlet for a vast river basin complex made up of the Ganges, Brahmaputra and Meghna rivers and their network of tributaries. These rivers, which cause almost regular and serious floods over much of the country during the summer monsoons, are

reduced seriously during the dry winter months. If basin-wide collaboration could be mobilized to generate a higher dry weather flow and control the same during the monsoon, the benefits to millions of people could be immeasurable.

Figure 2.3 Location of Bangladesh in the South Asia monsoon region

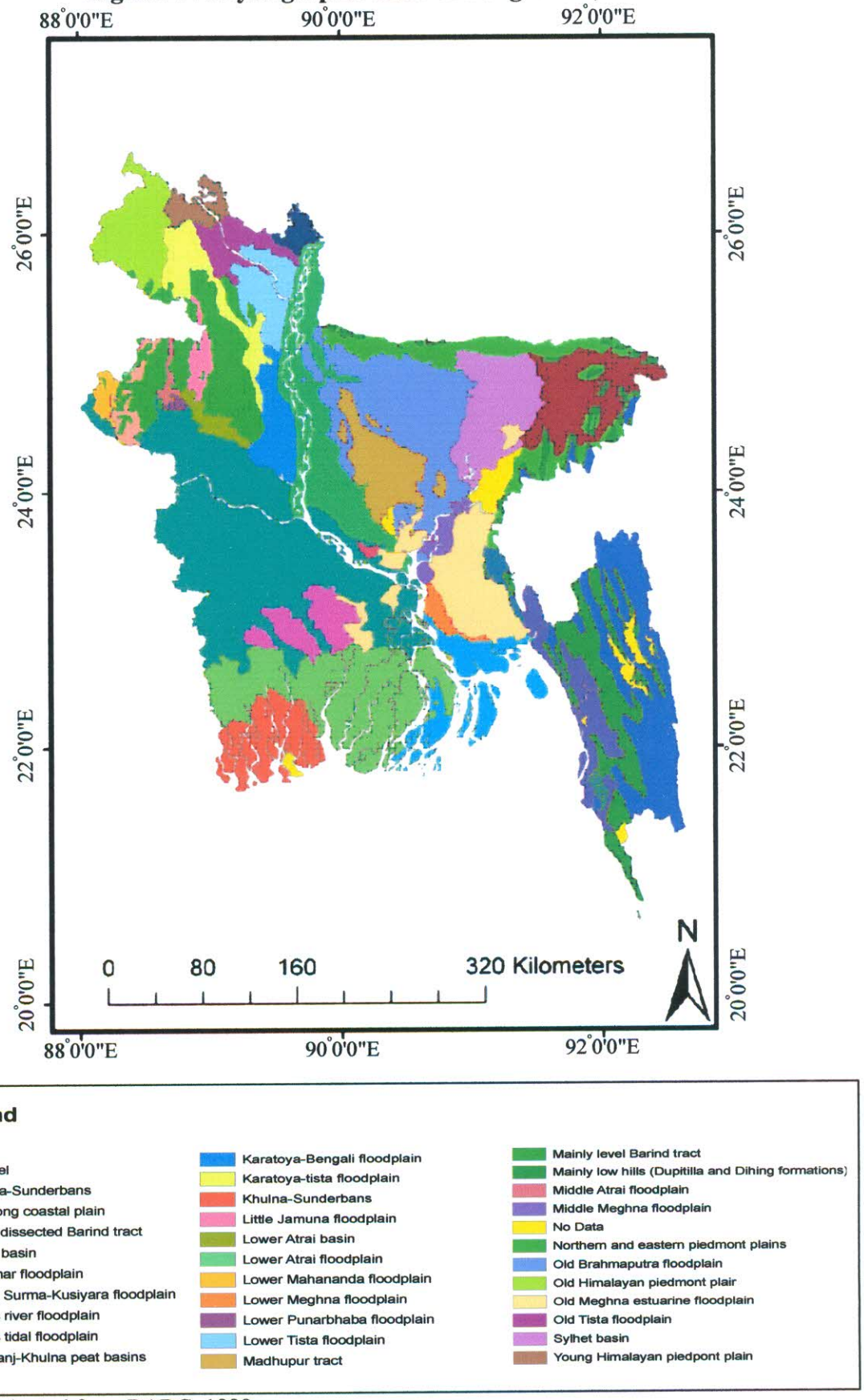


Source: BARC, 1999

Three broad physiographic regions are discernible - floodplains occupy about 80 per cent, terraces (slightly uplifted fault blocks) about 8 per cent, and hills about 12 per cent of the land area. Each of these regions exhibits its own geo-morphological characteristics, which make convenient a further sub-division into 19/20 generalized physiographic units as follows **(Figure 2.4).**

The most two important areas of environmental concern are rainy season inundation characteristics of land and frequency of occurrences of hazardous flood. Inundation characteristics provide information on whether a land is still inundated or not. If inundated, to what depth and how long the water stays on the land surface? So the topographic position of land in relation to the monsoon season inundation which, in other words called 'inundation land type' will largely decide the LUT in the country **(Table 2.3).**

Figure 2.4 Physiographic units of Bangladesh, 1999



Source: Adopted from BARC, 1999

Taking consideration of crop availability, six inundation land types have been recognized in Bangladesh.

Table 2.3 Inundation land types in Bangladesh

Land Type	Features
Highland (H)	Land which is the above normal inundation level and would normally not develop wetland conditions unless rainwater is pounded
Medium Highland – 1(MH1)	Land which normally is inundated less than 30 cm deep
Medium Highland – 2(MH2)	Land which normally is inundated between a depth of 30 cm and 90 cm
Medium Lowland (ML)	Land which normally is inundated to a depth between 90 cm and 180 cm
Lowland (LL)	Land which normally is inundated to a depth between 180 cm and 300 cm
Very Low Land (VLL)	Land which normally is inundated to a depth more than 300 cm

Source: BARC, 1999

Land use in Bangladesh has involved through natural forces as well as human needs. Cultivated land, forestland, and the area not available for cultivation are the major land use types in Bangladesh. With the growing population and their increasing needs in various sectors, land use patterns are undergoing a qualitative change in which the areas under the net cropped land, water bodies and forestlands are gradually decreasing (Hussain *et al.*, 2002).

A large part of the forestlands is now under different types of non-forest land use for example, industry, shifting agriculture, illegal occupation for homestead, shrimp culture etc. Another important feature in land use in Bangladesh at present is the small area (only 3%) of fallow land, which indicates that land in this country is not allowed sufficiently long rest period for regaining their natural biophysical properties which is vitally needed for good maintenance of soil health. It is perhaps needless to say that for sustained agricultural production maintenance of good biophysical condition of soil is essential. The land area under the head 'not available for cultivation' includes mainly urban, rural settlements, and industrial lands covering around one-fourth of the total national land area **(Table 2.4).** Area covered by homestead is around 9.3% of the total land area and is characterized by intensively planted but is not efficiently managed (Basher, 2001).

Table 2.4 Land use scenarios in Bangladesh, 1999

Land use Types	Hectares (in,000)	(%)
Homestead	1381	9.3
Not available for cultivation	2319	15.6
Forest	2255	15.2
Cultivable	445	3.0
Current fallow	451	3.0
Single cropped area	2999	20.0
Double cropped area	4013	27.0
Triple cropped area	979	6.6
Net cropped area	7991	53.8
Total cropped area	13962	-
Net cultivable area	8436	56.9
Total land area	14842	100

Source: Analysis from BBS, 1999

2.1.4 Land use in Dhaka City

There are two types of land ownership in Dhaka city. Firstly, the privately owned land and secondly, the government owned land. Ministry of Land (MoL, 1982) has conducted a study on urban land ownership in Dhaka city in 1981. This study has observed that the distribution of land for use in various purposes is anomalous. Areas under private ownership are mainly uses for residential purposes (**Table 2.5**).

Table 2.5 Land use distribution in greater Dhaka city, 1990

Types of Land use	Occupied Area (ha)	(%)
Residential area	6,050	22
Commercial	550	2
Industrial	275	1
Institutional	1,100	4
Roads	1,650	6
Other urban	1,650	6
Agriculture	12,650	46
Water	3,575	13
Total	27,500	100

Source: JICA, 1991, 1992

2.2 In Global Land Classification

The development of land classification systems has a long history in various countries of the world. Soil classification systems were the first produced by both national and international organizations to serve the needs of producing soil maps and provide a basis for determining land capability and suitability for growing various types of crops (Marsh, 1991). The need for developing land use and land cover classification systems ensued first focusing as it was natural on agriculture and forestry-uses of land occupying large tracts of land and playing important environmental and economic roles. After the 1960s and 1970s, efforts to develop land use and cover classification systems for other types of land use proliferated, a response to grow urban and industrial pressures on land and the need to provide a basis for rational land use planning and management (Kleckner, 1981). In the following table, examples of land use and cover classification systems at various spatial scales and for various purposes are offered.

At the sub global level, (mostly in the *national level)*, several land use classification systems are used. In the U.S.A., the U. S. Geological Survey has developed the Land Use and Cover Classification System using remotely sensed data (Anderson *et al.,* 1976). This system, like the FAO system, uses a 2-level hierarchy to define classes of land use and it is suitable up to the sub-state regional level **(Table 2.6).**

Table 2.6 Land use/cover classification system for use with remote sensor data

Level I	**Level II**
1 Urban or Built-up Land	11 Residential 12 Commercial and Services 13 Industrial 14 Transportation, Communications, and Utilities 15 Industrial and Commercial Complexes 16 Mixed Urban or Built-up Land 17 Other Urban or Built-up Land
2 Agricultural Land	21 Cropland and Pasture 22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas 23 Confined Feeding Operations 24 Other Agricultural Land
3 Rangeland	31 Herbaceous Rangeland 32 Shrub and Brush Rangeland 33 Mixed Rangeland
4 Forest Land	41 Deciduous Forest Land

	42 Evergreen Forest Land 43 Mixed Forest Land
5 Water	51 Streams and Canals 52 Lakes 53 Reservoirs 54 Bays and Estuaries
6 Wetland	61 Forested Wetland 62 Non-forested Wetland
7 Barren Land	71 Dry Salt Flats. 72 Beaches 73 Sandy Areas other than Beaches 74 Bare Exposed Rock 75 Strip Mines Quarries, and Gravel Pits 76 Transitional Areas 77 Mixed Barren Land
8 Tundra	81 Shrub and Brush Tundra 82 Herbaceous Tundra 83 Bare Ground Tundra 84 Wet Tundra 85 Mixed Tundra
9 Perennial Snow or Ice	91 Perennial Snowfields 92 Glaciers

Source: Anderson *et al.*, 1976

2.3 Land use/cover Change

2.3.1 In Global Context

Meyer and Turner (1994) land use affects land cover and changes in land cover affect land use. A change in either, however, is not necessarily the product of the other. Changes in land cover by land use do not necessarily imply a degradation of the land. However, many shifting land use patterns, driven by a variety of social causes, result in land cover changes that affect biodiversity, water and radiation budgets, trace gas emissions and other processes that, cumulatively, affect global climate and biosphere. The authors discussed different causes of land cover change and affect in to land use and impacts of environment but did not categorically discuss about the main factors of land use change in urban area.

Meyer (1995) every parcel of land on the Earth's surface is unique in the cover it possesses. Land use and land cover are distinct yet closely linked characteristics of the Earth's surface. Land use is the manner in which human beings employ the land and its resources. Examples of land use include agriculture, urban development, grazing,

logging, and mining. In contrast, land cover describes the physical state of the land surface. Land cover categories include cropland, forests, wetlands, pasture, roads and urban areas. The term land cover originally referred to the kind and state of vegetation, such as forest or grass cover, but it has broadened in subsequent usage to include human structures such as buildings or pavement and other aspects of the natural environment, such as soil type, biodiversity and surface and groundwater. But the researcher did not discuss about the social environment of urban areas.

Dimyati *et al.,* (1995) an analysis of land use and land cover changes using the combination of MSS Landsat and land use map of Indonesia reveals that land use and land cover change were evaluated by using remote sensing to calculate the index of changes which was done by the superimposition of land use and land cover images of 1972, 1984 and land use maps of 1990. This was done to analyze the pattern of change in the area, which was rather difficult with the traditional method of surveying as noted by Olorunfemi in 1983 when he was using aerial photographic approach to monitor urban land use in developing countries with Ilorin in Nigeria as the case study. But the author did not discuss the causes of land use and land cover change.

Sangawongse (1995) detected the land use/cover change in Chiang Mai, the second largest city of Thailand. Due to rapid growth of population and expansion of commerce and industry, cultivable and forest lands have been converted into residential and other purposes and the overall environmental condition was deteriorated in the study area. The researcher used Landsat TM digital data of 09 February 1988 and 17 February 1991 to detect the land cover change. Micro BRIAN version 3.01 PC-based software was used in the study. Land use/cover founded in 1988 and 1991 image senses were classified into 15 categories after being stretched uniformly. The accuracy assessment was conducted for both the classified data and obtained an overall accuracy level of 82% and 85% for the 1988 and 1991 respectively. But in his research he did not discuss about the water bodies or wetlands of urban areas.

Anwar (2002) the study was considered only in simulated land use change from 1981 to 2000 of Nong Chok area. The area was developed based on selected biophysical and human driving forces. The simulations were performed using land use data extracted from multi temporal aerial photographs. The result of the simulation showed considerable performance of the model to diffuse fishponds from paddy field. In 1981, the land use pattern of the study area was simply paddy field, resident & orchard and water body but in 2000 land use had been changed to fishpond and other type. The rate of change is not

linear in temporal scale. But the author doses not mention the land use changes and the effect of environmental condition.

Zubair (2006) the study was to map out the status of land use land cover of Ilorin between 1972 and 2001 with a view to detecting the land consumption rate and the changes that has taken place in this status particularly in the built-up land. So was to predict possible changes that might take place in this status in the next 14 years using both Geographic Information System and Remote Sensing data. The static land use distribution for each study area was categories in five classes viz. farmland, waste land, built-up land, forest land and water body. However, the result of the work shows a rapid growth in built-up land between 1972 and 1986 while the periods between 1986 and 2001 witnessed a reduction in this class. It was also observed that change by 2015 may likely follow the trend in 1986/2001 things being equal. But the researcher did not mention the factors of land use change and the impact of environment.

2.3.2 In Bangladesh Context

Alam and Rashid (1996) studied the landform and land cover of Maheskhali Islands (Bangladesh) and adjoining areas along the south-eastern coastal part of Bangladesh. The researchers used Landsat MSS Data acquired on 14 January 1980 two types of image analysis techniques, manual and digital interpretations were followed in this study. The emphasis was placed more on digital interpretation. Both supervised and unsupervised image classification were attempted. The FCC was created for supervised image classification using training areas. The whole area was divided into 10 (ten) spectral classes viz dense forest, degraded forest, scrub vegetation, agricultural vegetation, mangrove vegetation, salt bed shrimp bed, bare sand, estuary, and bay using the maximum likelihood method . The unsupervised classification appeared to be less useful. Six physical environmental classes were identified from manual interpretation viz hill, piedmont plain, coastal plain, mud flat, beach, and water body, According to the authors, Landsat MSS data could be used to monitor and update changes in broad land cover characteristics at varying levels.

Chowdhury and Ahmed (1998) studied the land use features and its change in the rapidly developing district of Gazipur in Bangladesh has been identified, mapped and analyzed using multi-date satellite images and to a data base system to be used for geographical analysis using GIS. In spite of deferent types of satellite scanners used, such as Landsat MSS, Landsat TM and SPOT pan it was possible to detect a broad land use category of 5 types. The study covered a period from 1980 to 1992. The identified land

uses are settlement, agricultural land, forest, water bodies and uncovered soil. The features are generally considered for analysis in wider regional context. The accuracy achieved was 77.71% for Landsat MSS, 83.27% for Landsat TM and 89.17% for SPOT. It was found that, because of Dhaka city's urban pressure, agricultural land and particularly. The forest cover is alarmingly decreasing. But researchers do not discuss the loss of forest land and decrease agricultural land and affect of the change of environment.

Islam and Hoque (1999) studied the land use change of Maheshkhali Island in Bangladesh using to based on remotely sensed data and field records, the environmental vulnerability due to changing land use practices of Maheshkhali has been studied. The accreted *khas* lands, which previously remained water logged and unused, have been made suitable primarily for salt production. A considerable volume of agriculture lands has also been converted to such activities. The destruction of reserve forest and the expansion of salt farms have generated a series of ecological problems, particularly soil erosion and loss of biodiversity. To identify the fragile environmental issues of the Maheshkhali island due to such land use pattern, with particular reference to shrimp and salt farming and noticeable degradations have been found. However, environmental issues relating to surface soil erosion, loss of bio-diversity and economic feasibility of salt farming need further investigation, is a multidisciplinary approach, on priority.

Karim (2000) in his research develops a spatial analysis for changing land use due to shrimp cultivation from a period of 1975 to 1999. The integrated approach of investigation including the changing land use, socio-economic condition and environmental impact on overall coastal ecosystem was tested in Rampal Thana (Upazila) of Bagerhat District. The progressive accumulation of salt in the soil of the shrimp farm is now threatening permanent soil fertility in the area, which is one of the major factors for decreases in crop production in the study area. Thus, decline in crop production has resulted in many environmental problems in form of shortage of livestock fodder, loss of soil fertility, fuel scarcity and decrease in traditional labour forces. These have ultimately affected the economy of the landless and marginal farmers making it difficult for to survive in the area. The environmental system of study area was under increasing threats due to changing land use pattern and present shrimp cultivation.

Islam (2001) identified the land use change and Environmental Degradation of Chakoria Sandarban in Bangladesh between 1961 and 1991. Toposheet, remote sensing data, landsat MSS, Landsat TM, SPOT PAN images and color infrared (CIR) aerial photographs were interpreted manually for obtaining land use maps of the study area. The

result of this study was significant and achieved good accuracy. But the author does not mention the factors of land use change and the impact of environmental degradation.

Rahman and Saha (2009), the study of the spatial patterns and temporal changes of crop land is important to understand the underlying factors and the functional effects of the agricultural landscape. The author addressed a spatio-temporal analysis of cropland and cropping pattern change in the Bogra district of Bangladesh over the last 16 years (between 1988/89 and 2004/05). In this paper, crop mapping from multi-temporal and multi-sensor satellite images was described. Landsat TM and IRS P6 LISS III satellite images were used with GIS for spatial dynamics of cropland and cropping pattern change analysis. First, seasonal cropland maps were derived from object-based classification of satellite images, then two-date classified image differencing with GIS overlay technique and decision rules were applied. Cropping pattern change was analyzed in a spatial and quantitative way for the 16 years and for this, Integrated Land and Water Information System (ILWIS) and Land Change Modular (LCM) of IDRISI Andes were used. The results showed that in the area, mono crop cultivation was found in summer, but in winter, areas under different crop cultivation had changed dramatically. Change analysis showed that the changes mainly occurred in the north northwest and southwest of the areas, and during the time the highest change area was found under the rice-potato pattern. The author does not describe the spatial change of the cropping pattern and the impact of land use practices and environment.

2.3.3 In Context of Dhaka

Dani (1962) "Dacca: A Record and its Changing Fortunes" is a systematic brief historical account of Dhaka city. This book contains the descriptive accounts of Dhaka city and some early urban maps of the city that have proved to be most important source material for the research of this field. Beside, this book provides some geographical and environmental description of the then Dhaka city.

Ahmad and Khan (1963) identified and discriminated the land use in Fayadabad area of the Dacca city during the years 1915-1962. The Fayadabad area is predominantly an agricultural area. In 1962, about 80.1 percent of the total land area was under crops and horticulture taken together as against 77.2 percent in 1915-16. In this study the land use features were classified into five major class's viz. Settlement and Associated Non-agricultural lands, Horticulture, Cropland, Unimproved Grazing Land and water bodies. The use of land is expected that such irrigational facilities will also be extended to the Fayadabad Area. Therefore, one can look forwards the future with some hope. But in the

meanwhile the possibility is not remote that some of the land use of this area may change from agricultural to urban uses.

Khan and Islam (1964) focused in an article titled "High Class Residential Areas in Dhaka City." about the present status and future trend of high class residential area and its effect on the other urban land uses. They pointed out that the central business districts generally tend to extend towards the residences of the rich. In colonial or ex-colonial countries, the administrative area has a close link with upper class residential areas. Similarly other land uses are also related to high class residential areas. They also mentioned that the development of Dhaka city is controlled by a number of governmental agencies without the desired coordination among them.

Mannan (1990) attempted to evaluate land for urban development of the north-west of Dhaka City. The study emphasized on a land classification for urban use taking Remote Sensing technique as an integral part of land evaluation method. It can be mentioned that remote sensing technique can play an important role in land use/cover data collection and a probable base for identifying the land use features within short time and accurately and this can provide such information that may be helpful to formulate a proper land use planning. The researcher does not discourse the effect of land evaluation and environmental degradation like soil, water, air and sound pollution in the study area.

Elahi and Hassan (1991) the present study provides a clear indication of the trend of fringe development of the DMA in terms of population change, patterns of land use transformation and land values in the areas under study. The process of fringe development of the DMA in recent decades is complemented by unprecedented population increase, expansion and development of housing and settlements, industrial, commercial and other non-agricultural functions and the consequent gradual decline in agricultural and related areas. But the researchers are not identifying the impacts of environment for fringe development.

Bari and Hasan (2001) in their study "Effect of Urbanization on Storm Runoff Characteristics of Dhaka City" investigated the impact of land use changes due to urbanization on storm runoff characteristics in the eastern part of Dhaka city. They found that the volume of peak rate runoff increases with growth in urbanization. Most of the low lying lands, which once acted as retarding basin, have been filled up. Computed results show that runoff volume is increasing with the increase in built-up area in Dhaka city.

Chowdhury (2001) depicted the actual characteristics of eastern part of Dhaka city along with the geomorphology, trend of land filling, its land use pattern and the environmental consequences of such land filling process in a paper namely " Impact of Land use Change and Urbanization on Geomorphologic Environment: A Case Study of Eastern Part of Dhaka Metropolitan Area". The author mentioned that expansion of Dhaka city is engulfing the remaining lowlands, disregarding the impact of the change in the natural terrain configuration system. Such land filling would lead to disasters like decline in underground water level, water logging, and scarcity of natural water retention areas.

Huq (2002) in a paper entitled "Optimum Land use in the Low-lying Area around Dhaka City: A Geological Perspective" pointed out that, urban development in a low-lying areas around Dhaka city is economically lucrative now. But in the long run, unplanned and indiscriminate development through lowland filling may threaten the very existence of the city. He also mentioned that, many of the canals that used to flow through Dhaka city have now been closed which has increased stress on the other bodies.

Shuq and Alam (2003) done a study named "Flood Management and Vulnerability of Dhaka City" described that after implementation of the flood control project in the Dhaka West, unplanned and uncontrolled expansion of urban area stretched rapidly toward the low-lying areas adjacent to the flood protection embankment. These are deeply flooded floodplain areas close to the river. The residents of the houses in these lowlands suffer from inundation due to accumulation of rainwater after heavy rainfall. Land development through land filling processes in the low-lying areas is causing a drastic reduction in water storage areas. Construction of embankments through low-lying areas without providing adequate drainage facilities has caused internal flooding adversely affecting the residents in those areas.

Hoque (2004) in his study shows an investigation into the effects of conversion of wetlands and seasonal agricultural lands to urban residential uses and its effects on the environmental condition of the local area and also the city. This study particularly focuses on the Eastern Fringe Areas (EFAs) where drastic land use change are taking place due to urban land development activities and which is assumed to have undesirable effects on the physical, social, economic conditions and natural environmental resources.

Elahi (2005) discussed about the deficiencies and potential in the planning processes some of the recurring problem of Dhaka city in an article namely "Understanding the Sustainability of Dhaka city: Some Preliminary Observations". He mentioned that due to ineffective city planning accelerating growth of population and associated architectural and environmental issues and all these aspects have reached to a state of imbalance in city

development and brought about massive socio-economic and environmental problems. The author also mentioned that no comprehensive steps were ever taken by the policy-makers to break the chain of unlawful practices of the parties involved .The author put some suggestions the solve the problems such as, used public media for aware the general people about the need for better environment, materialized building construction acts etc.

Dewan and Yamaguchi (2009) in this study evaluates land use/cover changes and urban expansion in Greater Dhaka, Bangladesh, between 1975 and 2003 using satellite images and socio-economic data. Spatial and temporal dynamics of land use/cover changes were quantified using three Landsat images, a supervised classification algorithm and the post-classification change detection technique in GIS. The researcher's analysis revealed that substantial growth of built-up areas in Greater Dhaka over the study period resulted significant decrease in the area of water bodies, cultivated land, vegetation and wet / lowlands. Urban land expansion has been largely driven by elevation, population growth and economic development. Rapid urban expansion through infilling of low-lying areas and clearing of vegetation resulted in a wide range of environmental impacts, including habitat quality. In this study will contribute to both the development of sustainable urban land use planning decisions and also for forecasting possible future changes in growth patterns. But the researcher does not study land use/cover change and the impact of environmental degradation in greater Dhaka.

2.4 Land Transformation Model

The Land Transformation Model (LTM) forecasts changes in land use by integrating geographic information systems (GIS), artificial neural networks, geo-statistics, and remote sensing technologies. The LTM can be used to study spatial interaction between various biophysical and socioeconomic drivers which have historically caused land use change. By determining the nature of the spatial interactions between these drivers through neural network technologies and machine learning, the model can simulate local land use changes.

Markov processes offer a potential advantage here. Markov analysis of land use change is an aggregate, macroscopic approach because it does not directly account for any of the drivers of land use change (Brassoulis, 2000). This being a probabilistic model, an important advantage in terms of land use change is that land use dynamics can be analyzed at a watershed or regional scale instead of dealing with every plot at the scales where land use changes actually occur, the farm and field levels. This makes these models particularly useful when dealing with uncertainty about the complex processes and

relationships between biophysical, economic, and social-cultural factors that affect land use changes.

There are numerous applications of Markov processes for modeling dynamics in land use and vegetation (Balzter, 2000; Logsdon *et al.*, 1996). The stochastic approach offered the advantage that land use dynamics could be simulated at a watershed level without having to describe the complex relationships between biophysical, economic and human factors that affect land use decisions at the farm and individual field level.

During the previous decades the conceptual and practical advantages have encouraged geographers to use Markov models to describe and predict changes in land use, population distribution, residential structure, transport networks and industrial structure and pattern. In the domain of land use planning, modeling of land use change as a Markov process has been attempted by a number of authors. Bourne (1976) utilized the Markov model to predict land use in the central city, and to aid in probing the questions of process stability and similarity.

Bell (1974) addressed the issues of dependence and process evaluation through the use of Markov model analysis. Robinson (1978) explored the utility of this model by addressing the issue of relationships between types of uses in terms of persistence and rigidity of land use environments. All of these studies showed that the model is capable of providing some answers, albeit tentative as they are too many questions concerning the land use change. The model has found a wide range of application in forest succession studies.

Turner (1987) used it for predicting the temporal changes in land use patterns in Piedmont County in Georgia. Petit *et al.*, (2000) use these models for quantifying processes of land cover change in southeastern Zambia. Muller and Middleton (1994) used Markov Model to make quantitative comparisons of land use changed dynamics in Niagra region. These models are relatively easy to apply to dynamics in highly complex vegetation, and have been used to study succession and obtain short-term quantitative predictions of land use and land cover changes (LU/LCC) (Balzter, 2000; Logofet & Lesnaya, 2000).

Inca (2009) land cover and land use maps for 1988, 1997 and 2007 were generated and compared statistically through a cross-tabulation obtaining an overall kappa index of: 0.41 for 1988-1997, and 0.40 for 1997- 2007, meaning significant changes between the LCLU classes in the studied periods. The LCLU change assessment evaluating area gains and losses and net change in each LCLU class revealed a high dynamic state of the Huatanay watershed landscape, where most of the classes represented changes more than 50% in the studied periods. Most of the LCLU changes were caused by the human action.

The estimated annual average of soil losses in the Huatanay watershed were 319.5, 299.4 and 306.0 ton/ha/year in 1988, 1997 and 2007, which means a slight soil loss declining due to LCLU change (P=0.009). However, more than 50% of the watershed area had soil loss from moderate to extreme, which means that the erosion problem is very relevant in the watershed. Finally, there was a clear quantitative sediment production and accumulation relationship between the upper and lower parts of the watershed, high sediment production by soil erosion occurring in the middle and upper part and high sediment accumulation occurring in the lower part of the watershed.

2.5 Plans for the Development of Dhaka and Land use Change

Land use planning is an extremely complex matter, combining physical, social and economic aspects of land use with an assessment of potential future needs. The land use planning system should be efficient, effective and simple in conception and operation, to facilitate and bring about the desired level of development. Land use planning should not be regarded simply as a tool for preventing change. Properly used it can help to secure economy, efficiency and amenity in the area of development and use of the land. The land use planning function was increasingly employed as an enabling function to encourage private enterprise to undertake development programs in circumstances that would otherwise have been difficult or unattractive. The purpose of land use planning is to select land to maintain land use practices that will meet the needs of the people best while safeguarding resources for the future. The driving force in planning is the need for change, the need for improved management or the need for a quite different pattern of land use dictated by changing economic, political or social circumstances.

Planners of the developing countries, such as Bangladesh, face a daunting task. Population of the country is growing at a phenomenal rate. The number of population in the country has doubled within only three decades. The population of Dhaka makes close to 12 million at present whereas it was 10 million in the 2001. Such population growth overwhelms all efforts to improve the living and environmental conditions of the mass people.

Rapid population growth has obvious implications for infrastructure and service needs of cities and regions. The failure to match safe water supply, sanitation system, adequate housing and unplanned industrialization and efficient transportation with increasing population has become a prime source of misery in the developing world and also in Bangladesh. It is argued that even with a limited level of economic development, resources can be better managed to provide an improved living environment for all if the right plans are implemented at the appropriate moment. Such efforts are lacking in Bangladesh, specifically in Dhaka.

2.5.1 The Dacca (Dhaka) City Master Plan, 1959

The Dhaka master Plan, 1959 was prepared on behalf of Dacca (Dhaka) Improvement Trust (DIT) by foreign consultants working with officials of DIT and was submitted in 1959. A short report was supplemented by a map of the DIT area at 1:40000 scales and the Dhaka city area at around 1: 20000.

The consultants emphasized that the plan was meant to establish broad planning principles, not lay down a detailed inflexible basis for future development. The need for follow-up detailed plan and continuous review was also noted.

Average annual population increase was assumed at 1.75% and the Dhaka-Mirpur-Tongi (1978) population was estimated at 900,000. The plan provided for major expansion areas at Mirpur, Tongi and Gulshan-Banani-Badda proposed large-scale reclamation at Keranigong, Postogola and part of the DND triangle, to accommodate a population increase of 250,000 between 1958 and 1978. The Dhaka Master Plan has clearly marked and reserved 12 percent of areas for flood retention (Tawhid, 2004).

The results in 1980 show that not all the development areas proposed in the Master Plan, 1959 have been developed yet. Two examples are Uttara Model Town and the proposed development areas north of Tongi. On the other hand, there has been substantial unplanned growth around the edges of city.

The 1959 Dhaka Master Plan was a land use type Master Plan. The major deficiencies of the 1959 Dhaka Master Plan were:

- Its development control framework was not fully formulated nor effectively implemented.
- It did not effectively relate the issue of urban density with its impact on infrastructure.
- It was never linked to the ADP and government budget.
- Its various development components were not prioritized and funding sources were not identified.
- The 1959 plan has been interpreted too rigidly and is not adaptable to the rapidly changing urban circumstance of Dhaka.
- It does not provide a suitable framework for inter-sectoral coordination of spatial planning with the capital budgeting of government development agencies.

2.5.2 Dhaka Metropolitan Area Integrated Urban Development Plan (DMAIUDP), 1981

The work of DMAIUDP study was undertaken in 1979-80 and the final report was submitted in March 1981. DMAIUDP evolved from a series of reports and missions were

concerned with storm water drainage and flood protection. It was funded by ADB/UNDP. ADB strongly recommended that despite all previous studies and partial implementation of a flood control embankment, further flood protection investment should await the outcome of a broad multi-sectoral strategic study to evaluate metropolitan planning alternatives.

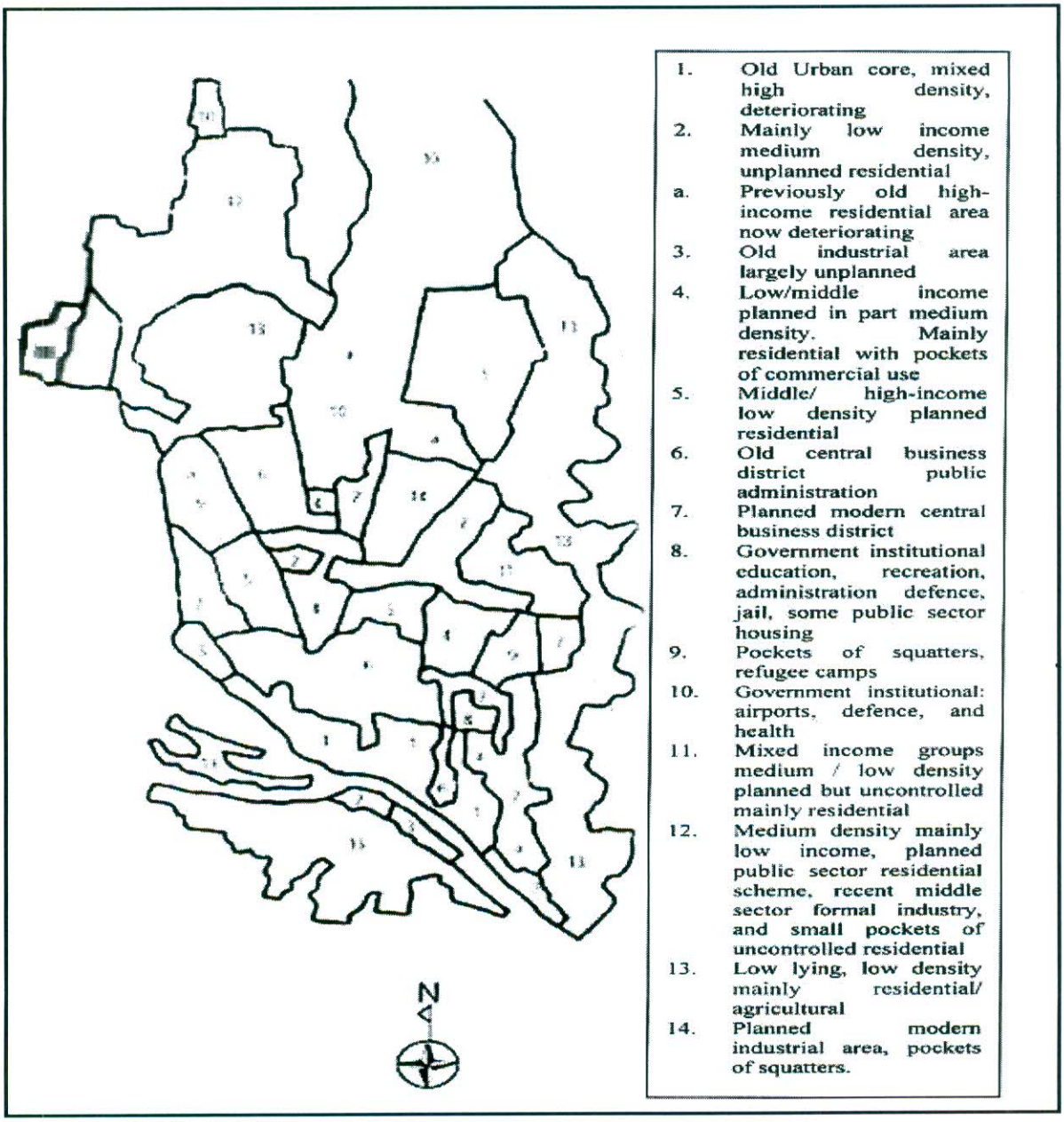
The primary objectives of DMAIUDP were:

- To prepare a long-term development strategy to guide and regulate future growth in the Dhaka Metropolitan Area.
- To set up policies to implement the strategy and facilitate implementation of priority projects.
- To identify priority projects and prepare prototype proposals for the low-income housing.
- To develop local staff skills and establish effective institutions for implementation.
- Continuation of current trends-sustained peripheral growth, limited expansion towards Tonigi-Joydebpur.
- Peri-urban development-low-density resettlement with intensive agricultural production surrounding city.
- Comprehensive flood control protection of the city and development areas by embankments.
- Sub-regional dispersal-decentralization of urban development to maximum number of existing towns in the regions.
- Limiting urban growth by reducing investment in favor of rural areas.

The recommendations were made that the northern expansion and peripheral development should be directed towards the flood free land in areas. Moreover, the short and midterm strategies should be undertaken urban development like public increase, transport links within city areas and improve employment situation and so on; therefore the available resources should be applied to:

- The immediate initiation of a public sector land bank in order to reserve in advance at acceptable costs
- The provision of industrial incentives and the promotion of employment generating activities in the Tongi area
- The improvement and extension of transportation links
- The comprehensively planned and integrated extension of physical and social infrastructure.

Figure 2.5 Characteristics zones of Dhaka city, 1981



Source: DMAIUDP, 1981

DMAIUDP is the only comprehensive approach to planning and development in the Dhaka region since the 1958 Master Plan. Many of the constraints, opportunities and issues it considered are equally relevant now. It remains a lucid statement of the urban development issues facing Dhaka. This form of planning is particularly appropriate for metropolitan Dhaka where the growth of population and economic development cannot be determined with any degree of precision.

2.5.3 Dhaka Metropolitan Development Plan (1995-2015)

Keeping the above issues in mind the preparation of the Dhaka Metropolitan Area Development Plan (DMDP) was started in 1991 (after the single the City Master Plan of Dhaka, 1959). This plan has been prepared comprising 1528 sq. km area administered by the RAJUK **(Figure 2.6).** Under this Master Plan of Dhaka (Dhaka Metropolitan Development Plan) a comprehensive development plan for the future development of Dhaka city has been prepared with the objective of forming a framework of development planning, preparation of sectoral master plans and feasibility studies for metropolitan infrastructure elements lacking development policies.

The DMDP addressed urban planning issues at three geographic levels: sub regional, urban and sub–urban and covered area now defined as the RAJUK area. It contains three districts: Dhaka, Narayanganj, and Gazipur. In addition to the DCC and all of the 'thanas' contained partially or wholly within the DCC, the RAJUK area includes all or portions of eight surrounding non-municipal 'thanas' - Gazipur sadar and Kaligonj 'thanas' in Gazipur district; Rupganj, Sonargaon, Bandar and Narayanganj thanas in Narayangonj district; Keranigonj and Savar thana in Dhaka district.

The DMDP is not intended to present a single land use Master Plan describing plot based land use zoning. Rather it intends to address long term strategic and short-term implementation guidelines along with a set of policies and programs.

The DMDP is comprised of the three following components:

A. Dhaka Structure Plan

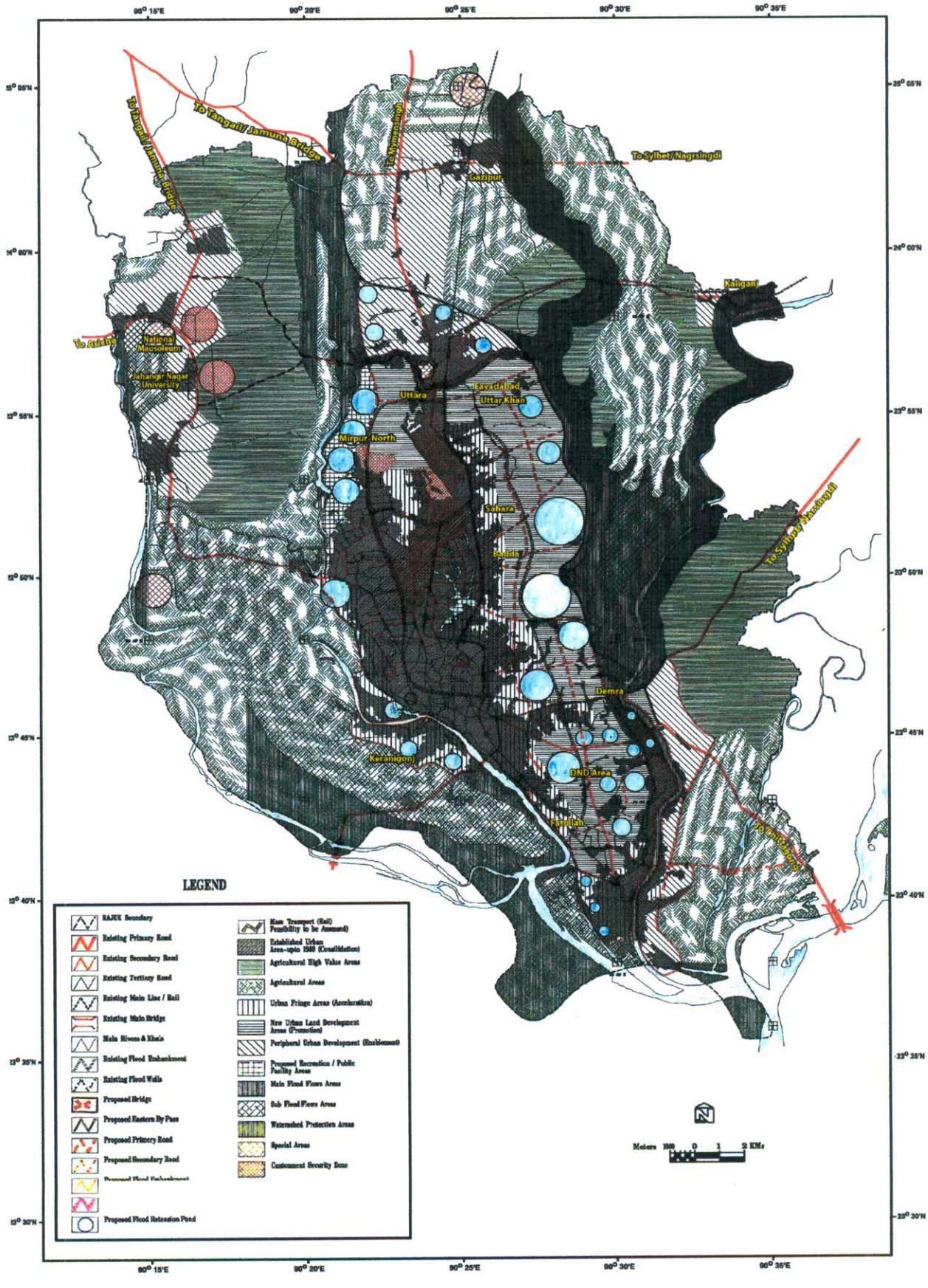
B. Urban Area Plan

C. Detailed Area Plan

A) Dhaka Structure Plan (DSP)

Dhaka Structure Plan is prepared to provide a long term (20-year) strategy for development of greater Dhaka. It projects a population of 15 million by 2015. The Dhaka Structure Plan is presented both in written and graphic form. The documentation is as important as the physical plans- they should be read in conjunction with each other. In this extensive study the future flood protection in Dhaka city (SMA, 1991) along with the future development of urban structure plan, some related aspects of physiographical and hydrological influences on the urbanization process of Dhaka city and its adjoining areas have been discussed.

Figure 2.6 Dhaka metropolitan development plan 1995-2015



Source: RAJUK, 1997

Besides, here the role of topographical conditions of the peripherals of the city has also been highlighted with reference to the future fringe development of the city.

Topics covered by the Dhaka Structure Plan include the following policies and provide guidelines:

- Population
- Land use provision
- Economic development
- Industrial development
- Shelter and housing
- Physical infrastructure, social infrastructure
- Flood control and drainage
- Utility services etc.

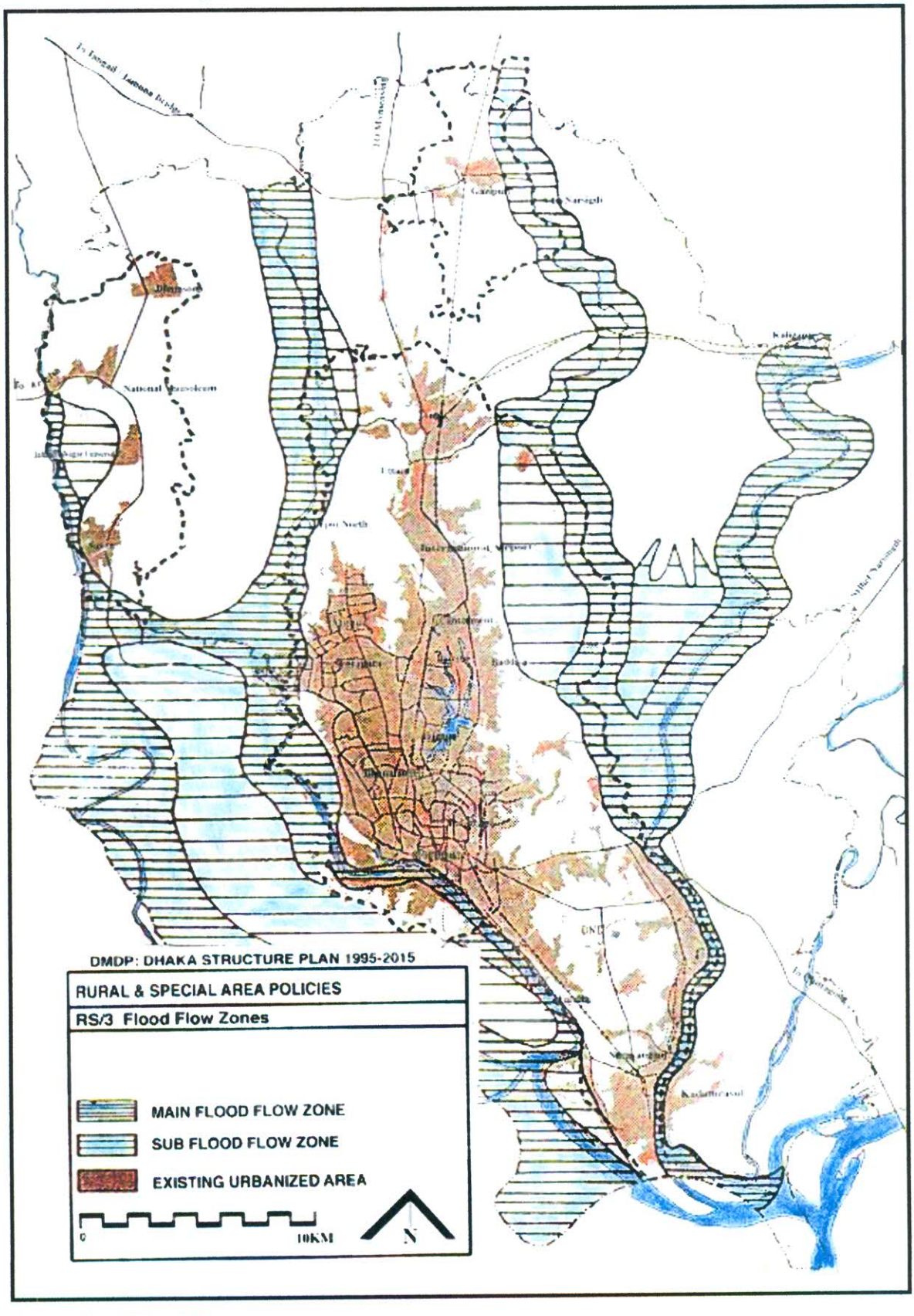
Dhaka Structure Plan controls the whole development area of RAJUK. The main function includes:

- Interpret national policies
- Establish aims and policies and general proposals to guide metropolitan Dhaka's long-term growth and development
- Provide a framework and the mechanism necessary to ensure that all the public and private agencies coordinate and priorities their respective development planning and investment programs and decision within the metropolitan area, in particular, phasing of development.

Dhaka Structure Plan defines a broad set of policies to achieve the overall plan objectives. Its supporting documentation proposes actions for the preservation of high quality wetlands, agricultural lands and watercourses. It highlights the need for ponds around the city limits for rainwater retention and maintenance of an ecological balance and a healthy environment.

Dhaka Structure Plan also calls for the adoption of land use controls and building regulations that would make its storm water retention and other recommendations meaningful. Dhaka Structure Plan calls for plan reviews every five years. Regrettably, no formal plan review or revision has occurred since the publication of the Structure Plan This, in spite of the fact, at least one of its major features (the Eastern bypass), has been downgraded with profoundly different land use implications. Another major feature with structural implications has been added. Purbachal is a planned new town located in contradiction to the DMDP recommendations.

Figure 2.7 Flood flow zones in Dhaka structure plan



Source: RAJUK, 1997

B. Urban Area Plan (UAP, 1995-2005)

The vicinity designated in the Dhaka Structure Plan (DMDP) is for strategic planning purposes, subdivided into following broad categories.

The content of the UAP (DMDP):

- The UAP provides for a mid-term strategy programme for 10 years (1995-2005) and cover for the development of urban areas within the metro Dhaka management area;
- The geographic boundaries comprising the UAP area are the areas within the proposed FAP 8A and 8B (JICA) as well as the Tongi-Gazipur and Savar Dhamsona areas.
- The UAP (DMDP) has several components consisting of an Explanatory Report, Resources Maps, Interim Management Report, Interim Planning Rules, Urban Area Plan Map, and a mulit-sectoral Investment Program (explained as below).

i. Explanatory Report: This report explains the basis for the UAP and describes the salient features for each of the 26 spatial planning Zones (SPZs).

ii. Resources Map: This is an arced of existing in restructure locations, along with the public and private sector development commitments.

iii. Interim Management Report: This report describes the basis and approach taken toward urban land use management.

iv. Interim Planning Rules: It states in a legal format the rules for urban land use management within the UAP.

v. UAP It designates various land use management zones.

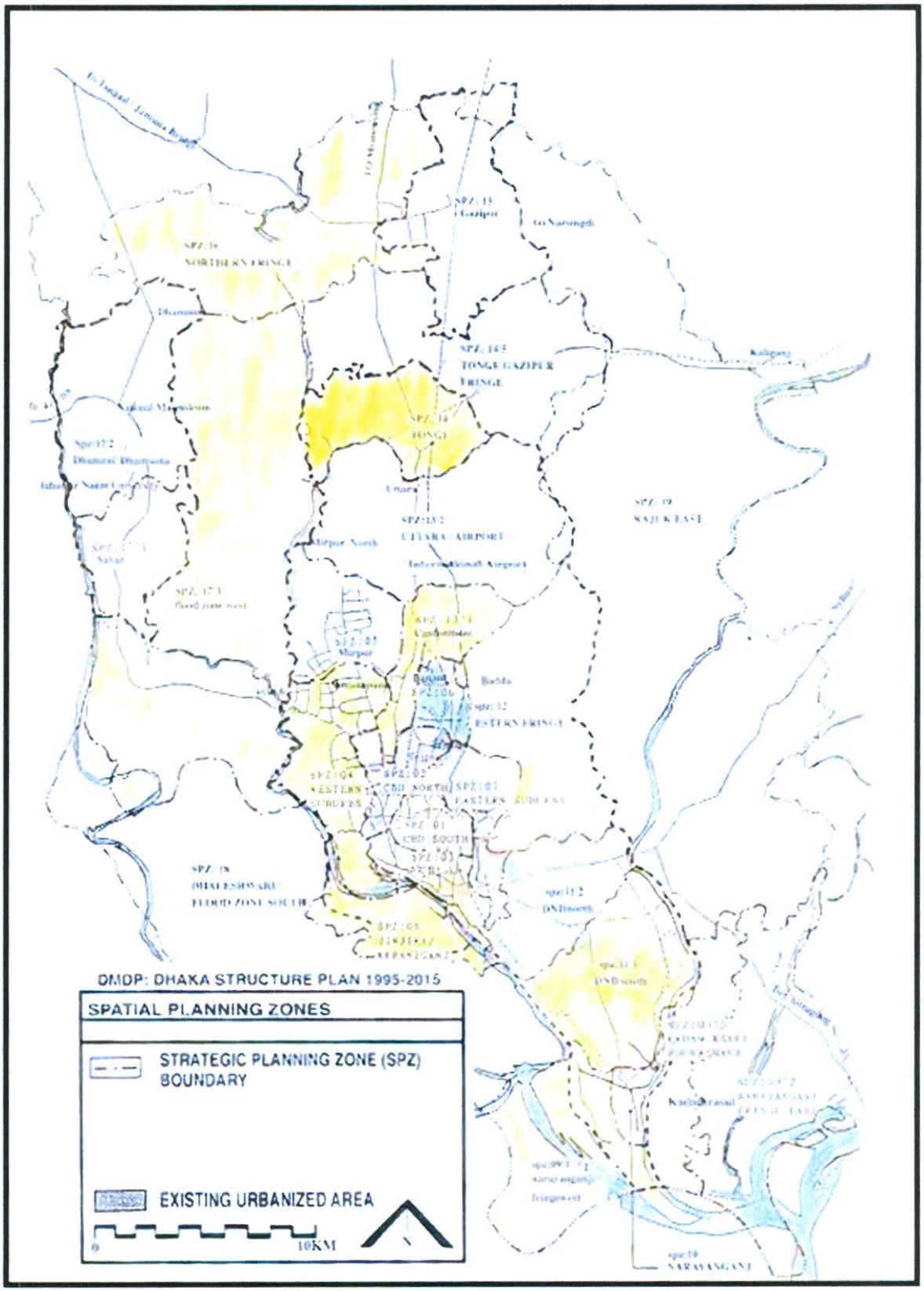
vi. Multi-Sectoral Investment Program: This integrates and priorities urban development investments over the next 3-5 years.

C. Detailed Area Plan (DAP)

Detailed area Plan (DAP) provides more specific and detail planning proposal for specific sub-areas. DAP consists of reports and maps at 1: 3960 scale with supporting documents. The draft DAP is prepared but yet to final. Until a DAP is prepared for sub area, land use management function will be exercised through the policies, guidelines and rules found in the structure Plan and Urban Area Plan.

Rajdhani Unnayan Kartipakkha (RAJUK) is the custodian of the Detailed Area Plan. Duration prescribed in the Structure Plan for the implementation of this Detailed Area Plan is up to the year 2015. RAJUK will guide the other authorities to implement their projects according to the Detailed Area Plan and all the physical development activities will follow the proposals prescribed in the Detailed Area plan.

Figure 2.8 Spatial planning zones of Dhaka city structure plan



Source: RAJUK, 1997

RAJUK may change (when necessary), amendment and alteration of this Detailed Area Plan as and when necessary.

Detailed objectives of the plan were to:

- Provide a detail analysis of the area in context of existing land use, land value, geological structure and socio-economic condition of the people.
- Preparation of engineering survey in context of physical components of the area.
- Preparation of topographical survey to know the land level of the area.
- Identification of highest floods level including average depth of the river and canal.
- Preparation of sub-soil investigation including load bearing capacity of the soil.
- Ground verification through Global Positioning System (GPS) of all major physical features in the area.
- Preparation of the report including all types of survey components and with the analysis of data and maps in view to the preparation of Detail Area Plan.

DAP has been conducted to fulfill the obligation of Dhaka Metropolitan Development Plan (DMDP). It is a legal document (SRO No. 184- law/97 dated 3rd August, 1997). It is not legal to violate DMDP. As the lowest tower of DMDP, DAP must conform to policies stated in DMDP Structure and Urban Area Plan.

2.5.4 Integrated Transport Network Plan for Metropolitan Dhaka (1995-2015)

Transportation would play a major role for Dhaka's growth both for the structure plan strategy and also for the alternate options. At this moment Dhaka is one of the least motorized cities in the world. Non motorized movement is dominant in the intercity transportation. The proportion of all travels by motorized vehicle is low. Dhaka integrated Transport Study estimated 66% of all work trips are on foot, 11% by rickshaw. Public transport is poor and disorganized with limited coverage and non motorized transport is inadequate for long distances. Mobility levels are low and consequently dwelling areas remain in close proximity to the workplace.

The average work trip has a size of eleven minutes only. Without major transport changes, in future most of the population would live near to work. Institutional/ regulatory framework and low-enforcement tendency, everything lagging behind the current needs. The road hierarchy is poorly established and most new development is taking place without any coherent road system. As population grows and as traffic density increases, accessibility will deteriorate. With every new phase of peripheral growth, especially in the east, the ability of such fringe areas to function at levels of even minimal

efficiency is increasingly compromised. Planning and safeguarding assess to rapidly growing areas must be prioritized. To boost up the peripheral and satellite expansion and to ease transportation problems of the urbanized areas infrastructure scheme for 20 years time frame has been prepared by the DMDP Project Management Cell. The scheme for the aforesaid period has been phased as:

1) Short Term(1995-2000)
2) Mid Term(2000-2005; 2005-2010)
3) Long Term(2010-2015)

In addition, for better transportation and urban expansion, institutional/regulatory reform, integrated management and community participation would be prior option to mitigate the existing and the future needs. The scheme has been prepared considering the proposals of the DITS and concerned sectoral recommendations. The scheme would be coherent to the growth defined by the structure plan and to the alternate options, and will ease the transportation problems of the urbanized areas. It includes the following components.

Major Road Development Program

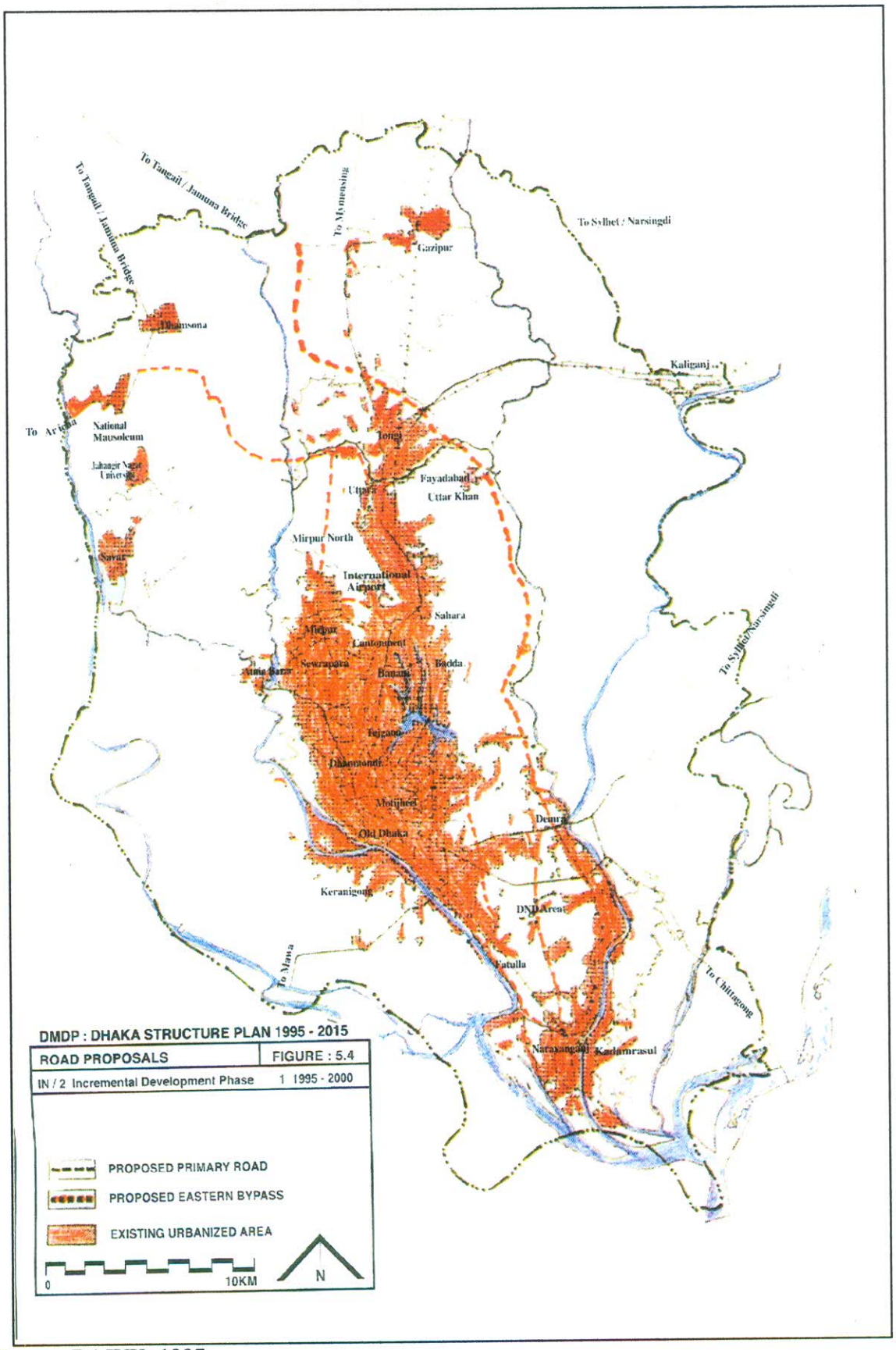
Total lengths of 217 km. of roads have been programmed to construct with some basic options:

1) To provide diversions for the national grids;
2) To provide infrastructural facility for urban dispersion; and
3) To provide East-West intercity connection for reducing core city traffic congestion.

Of which 9% i.e., 19.50 km. of roads are under construction by the LGED. By the year 2000, 87.50 km. have been targeted for completion; which is 40.30% of the total. By the year 2010, 28 km. i. e., 12.90% of the total would be completed. Another 27.40 km. i.e., 12.60% of the total has been phased to be done by the year 2015. And the rest 54.70 km. i.e., 25.20% would be completed after 2015.

After the completion of the Jamuna Multipurpose Bridge and this Major Road Program, movement of goods from Chittagong port to other Northern districts will be very time saving. They can easily bypass Dhaka city to their destiny, moreover, one will have more options to enter/leave Dhaka. Traffic movements around Dhaka will be easier. Lastly, this will prove that congestion at Sayedabad and Gabtoli are not insurmountable.

Figure 2.9 Integrated Transport Network Plan

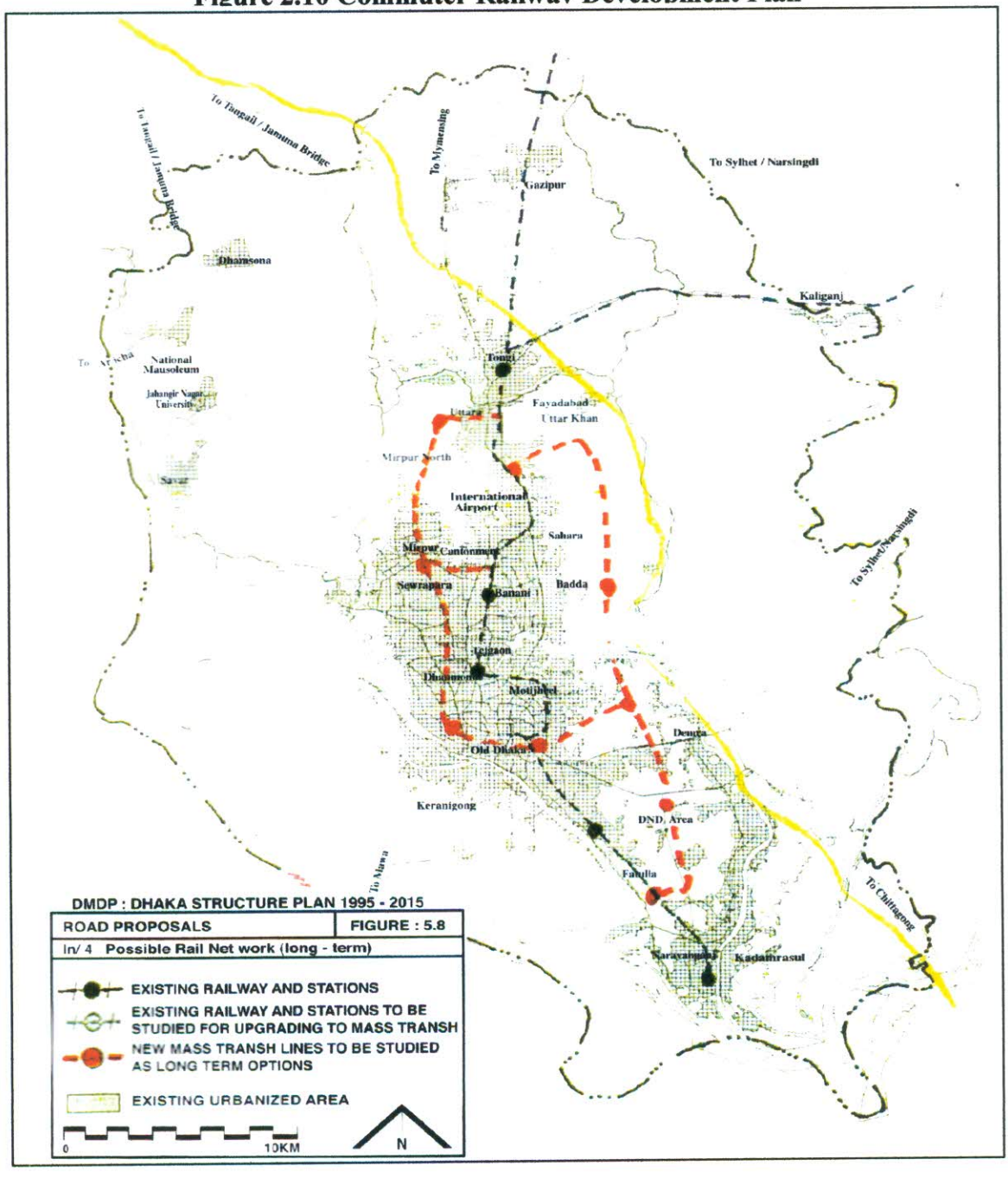


Source: RAJUK, 1997

Link Road Development Program

The scheme includes construction of 25.8 km. of links with a view to provide corridors to ease the intercity traffic movement, to reduce the traffic hazards/ congestions and to connect the west Dhaka with spine. By the year 2000 targeted length for completion is 8.3 km. which is 34.50% of the total. In the next phase 13.5 km of links i.e., 56% of the total program will be completed. And the rest 2.3 km. i.e., 9.5% of the whole will be completed by 2010.

Figure 2.10 Commuter Railway Development Plan



Source: RAJUK, 1997

The name itself tells the benefit of this program. This will provide the smooth movements within the city, rational utilization of all city roads and better access to different areas of the city. Most noted this will provide more long needed East-West connections to the relief of the city dwellers.

Commuter Light Railway Development Program

To commute the South-East, Northern high land and proposed satellite towns, this program has been prepared with relocation of existing track between Khilgaon and Khilkhet. This relocation will provide highly valuable central land around Karwan Bazar, Tejgaon and Banani areas for the uses of greater benefits. This will even give an opportunity to make new roads for smoother movements. The commuter light railway tracks within the city will be above grade in order to avoid fifty road rail crossing points and thus allow free of road traffic. This will eventually help to avoid conflict with the existing road network as it does now a day. So city dwellers will be relieved from unwanted congestions. Total program has been phased from 1995 to 2000.

2.5.5 Land use Characteristics and Dynamics of the SPZs[4] (DMDP)

The DMDP areas have been divided into 26 Spatial Planning Zones and sub-zones (SPZs)[5] **Figure 2.8** describes the characteristics of land use and dynamics of different spatial zones of the study area, which are summarized and presented in **Table 2.7.**

Table 2.7 Characteristics of land use SPZs of DMDP areas

SPZs (Spatial Planning Zones)	Locations	Characteristics of Land use	Dynamics
SPZ-2 Central Business Business District (CBD) North	Dhanmondi, Kalabagan, DBR Area Tajgoan, Nakhal Para and Surrounding areas	Mixed Use (Residential, Institutional and Industrial)	Densifying
SPZ-4 Western Suburbs	Lalmatia, Mohammadpur, Rayerbazaar, Hazaribagh, Shewrapara, Kamrangir Char Areas	-Planned Residential -Spontaneous Development and Concentration of Slums	Intensifying
SPZ-5 Mirpur	Mirpur And Surrounding Areas	-Predominantly Planned Residential Use -Institutional and -Recreational Use	Densifying and Intensifying
SPZ-6	Gulshan, Banani,	-Planned Residential Areas	Densifying and

[4] SPZ (Spatial Planning Zones)-Geographic unit of the DMA, which is laid down in the DMDP.
[5] SPZ (Spatial Planning Zones) Geographic unit of Metropolitan Area

Gulshan, Banani, Baridhara, Badda	Baridhara, Badda, Mohakhali and Surrounding areas	with commercial cum-Residential	Intensifying
SPZ-13.1 Cantonment	Dhaka Cantonment	-Restricted Area, (Controlled by Cantt. Board)	Densifying
SPZ -13.2 Uttara	Uttara (Northern Part of City)	-Planned Residential Area – Spontaneous Dev. Area	Densifying
SPZ-17.1 Savar	Savar	Mixed Use (Institutional, Industrial and Commercial)	Intensifying
SPZ-17.2 Dhamsona	Dhamsona (Savar)	Mixed Use (Institutional, DEPZ National Mausoleum, Industrial	Intensifying
SPZ-17.3 Flood Zone West	In between Savar and Dhamsona	Flood Plan Character (Rural/Pisculture	Mostly Static

Source: RAJUK, 1997

2.6 Flood Protection, Drainage Master Plan and Land use

2.6.1 Flood Action Plan (FAP) Studies

After the devastating flood of 1988, various studies were conducted by different agencies, countries and Government of Bangladesh. Several action plans were proposed. The World Bank coordinated the studies and framed a Flood Action Plan (FAP) with 26 components as the initial stage for the development of a long term comprehensive system of flood control and drainage works.

In response to the request of the Government of Bangladesh, the Government of Japan decided to conduct the study on Greater Dhaka Protection Project in the Dhaka Metropolitan Area of Bangladesh (FAP 8A) within the general framework of technical cooperation between Japan and Bangladesh.

The Greater Dhaka Protection Project (FAP 8A)

The Greater Dhaka Protection Project (FAP 8A), funded by JICA, formulated a framework for comprehensive flood control and storm water drainage in the Dhaka metropolitan area, covering an area of 850 km^2. The total area was divided into 12 drainage zones. In order to identify an optimum drainage improvement plan, alternative studies for drainage system were conducted for three drainage zones: DB, DC and NA. Alternative plans were designed under the following conditions:

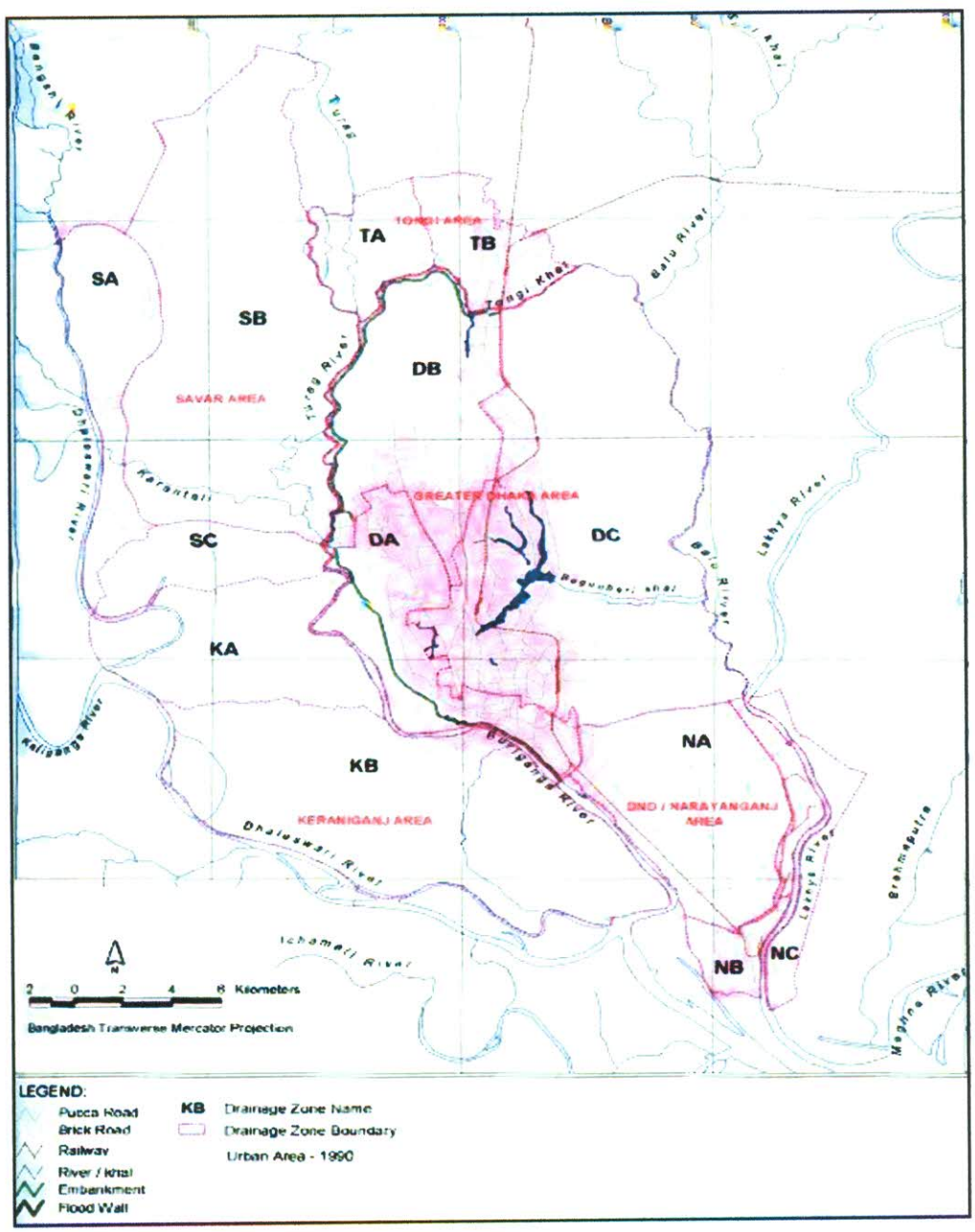
- The plans for the prevailing built-up areas of both the DB and DC zones shall incorporate previous JICA study recommendations

- Major drainage facilities, such as pumping station with retarding ponds, sluice gates and khals, for the future development areas shall be studied.

For DC and NA zones, more intensive studies were recommended at the feasibility stage. The study emphasized on the following four issues:

- Flood forecasting and warning system
- Flood evacuation system
- Land regulation
- Zoning of khals and retarding pond areas.

Figure 2.11 Drainage zones proposed in FAP 8A study cited in IWM, 2006



Source: IWM, 2006

The project was aimed at protecting the future urban areas of 456 km^2 in the year 2010, from potential flood damage by means of structural measures of flood mitigation and storm water drainage improvement. Non-structural measures, such as flood plain management, are proposed for the remaining low-lying areas of 328 km^2, the area to be left undeveloped with no significant change in land use. The opportunity for planned urbanization with due flood mitigation and drainage improvement is a major advantage offered by this project.

2.6.2 Dhaka Integrated Flood Protection Project (FAP-8B)

Dhaka Integrated Flood Protection Project (FAP-8B) for the western part of greater Dhaka is under execution and funded by ADB. The project objective was to undertake an integrated urban development program consisting of:

- Flood control and drainage works
- Complementary environmental improvement programs in low cost water supply and sanitation programs for the low income residents, solid waste management, and slum and squatter area development; and
- Institutional support for improved efficiencies in urban management and revenue generation

In the final report of FAB-8B, it has been mentioned that due to high costs of providing full protection for all of Dhaka city and lack of available funding for the overall plan, consideration was given to phase the project works to provide maximum early benefits at minimum costs. There are two parts in the phased programme: Part-A, flood protection and part-B, Drainage.

In part-A, it was mentioned that there would be construction of gate control structures at each of the 13 drainage channel crossings, including Begunbari Khal. Moreover, there was provision of temporary pumping facilities along the easterly boundary for evacuation of internal rainfall during periods of high river stage combined with heavy rainfall. BWDB is responsible for the execution of part-A.

The project components concerning the flood protection are:

- Specialized remedial works and foundation stabilization on 7.8 km of the existing embankment;
- Erosion control and slope protection over 11.5 km;
- Minor remedial works and slope protection over 24.2 km;
- Repair and stabilization of parts of 5.3 km of existing concrete flood wall;
- Construction of 1.6 km of new flood wall / embankment;

- Construction of 5 additional sluices along the existing embankment;
- Raising and flood proofing of the central spine road;
- Construction of the first stage (22.5 cm^3/s) of pump station No. 3 at Goranchat bari along the westerly embankment;
- Establishment of a maintenance program and supply of maintenance equipment to safeguard the flood protection investment.

In part-B, the proposed drainage works were a necessary complement to the flood protection works, and the primary focus of the drainage improvement programme was on creating an integrated drainage system within the Dhaka urban area to eliminate /reduce the drainage congestion and regular local flooding which prevails during the monsoon season. DWASA is responsible for the execution of part-B.

The project components concerning the drainage are:

- Rehabilitation and upgrading of 21 existing priority khals (including completion of the crash program initiated by the government), for a total length 78.6 km;
- Rehabilitation and construction of 50.7 km of pipe drains;
- Implementation of a rigorous operations and maintenance programme for the drainage works over the project implementation period as the project construction works are completed.

Under phase-1 of the DIFPP, construction of the Dhaka western embankment was completed in 1997. That is why the western part of the Dhaka city was flood free during the 1988 flood. After the flood, the Government of Bangladesh decided to construct the Dhaka eastern embankment presently.

2.7 Urban Land use Management

Iqbal (1992) discussed in an article namely "Residential Land Price Inflation in the Dhaka Metropolitan Area: 1976-88" about the land price inflation, demand and supply factors which explain changes the residential land price. The factors were population increase, rise in income, private housing construction, the creation of vacant allotments and public and private investment on local infrastructure development. He mentioned that lack of firm control by the government over land traders have caused instability in the land markets of DMA and suggested that a fruitful and positive urban land management policy is required to market the control of the anomalies present in the property market of the DMA.

Siddiqui (1997) has identified in a book named "Land Management in South Asia: A Comparative Study" how the land management runs in different parts of south Asia,

delineated similarities and differences in land management practices, determined their reasons. He mentioned the major themes of land management in the South Asian context, which are:

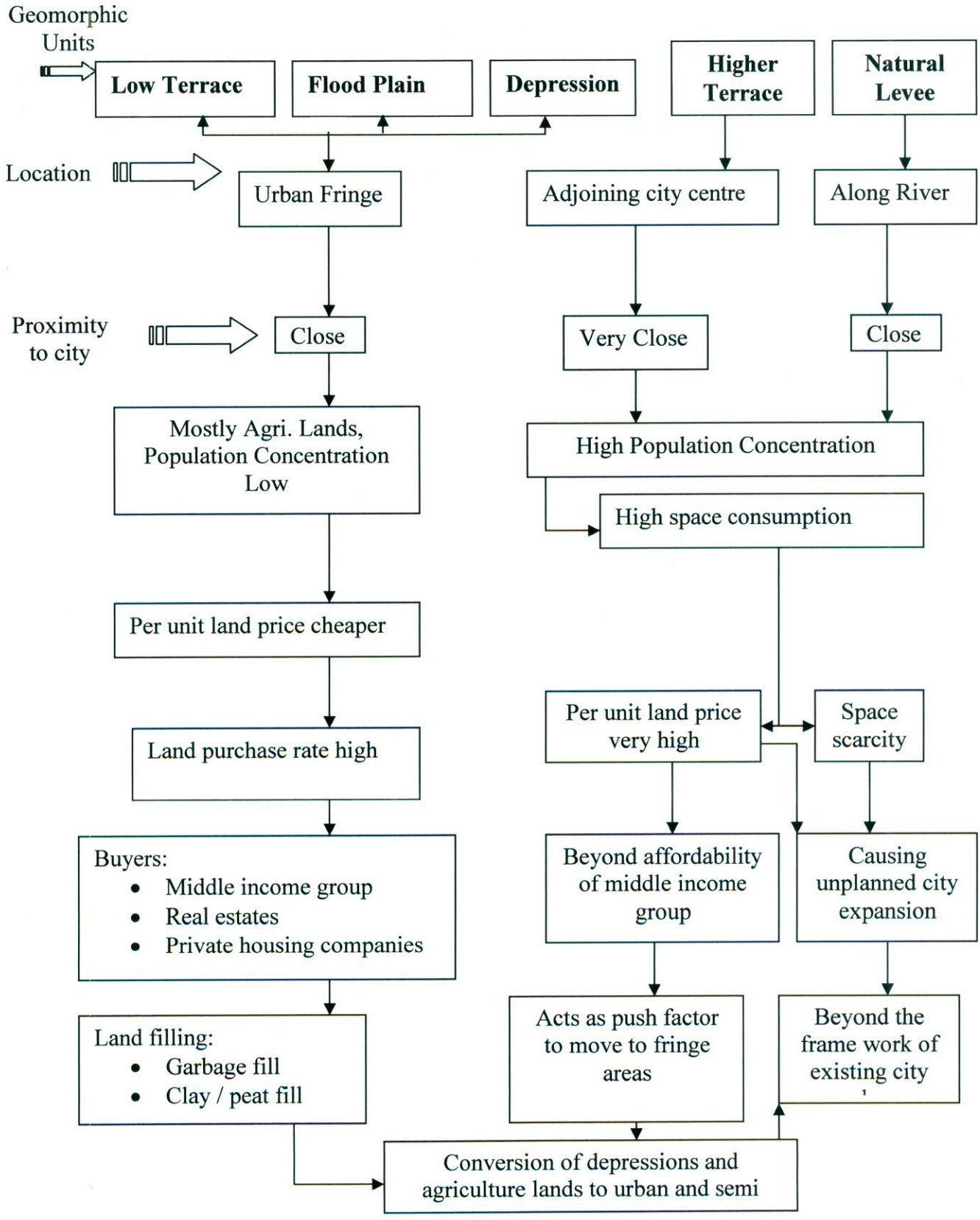
- processes relating to changes in land titles, such as land records preparation and updating, land transfer registration, land mutation, etc;
- land based disputes adjudication/resolution;
- management of state land and water resources consisting of distributable/leasable resources, such as agricultural land, non-agricultural land, water bodies, haats and bazars, minor minerals, etc. and non-distributable/non-leasable common property resources such as grazing land, forest land, pathways open water bodies, etc;
- government intervention in land use through regulation, direct participation, taxation, consolidation and acquisition for development process;
- land revenue/tax and other sources of land-based revenues;
- land management organizational setup and its vertical and horizontal linkages; and
- People's participation in land management, particularly through the involvement of NGOs, peasant associations, local government bodies, etc.

The author provided an analytical basis for shaping an appropriate land management policy in the three major South Asian countries, namely India, Pakistan and Bangladesh. For each of the three South Asian countries, delineated the present situation and changes since independence in respect of major land management practices in both urban and rural areas.

The author has not mentioned elaborately about the poor land management records, substantial encroachment of state land and its consequence impacts on the environment.

Choudhury (2001) depicted the actual characteristics of eastern part of Dhaka city along with the geomorphology, trend of land filling, its land use pattern and the environmental consequences of such land filling process in a paper namely " Impact of Land use Change and Urbanization on Geomorphologic Environment: A Case Study of Eastern Part of Dhaka Metropolitan Area". The author mentioned that expansion of Dhaka city is engulfing the remaining lowlands, disregarding the impact of the change in the natural terrain configuration system. Such land filling would lead to disasters like decline in underground water level, water logging and scarcity of natural water retention areas. All the higher grounds that are visible today in the landscape are not tectonically uplifted terraces or deposited ridges; rather they are the result of land filling due to urban expansion. Such land filling is mainly occurring on wetlands. The author summarized the overall process of change within the natural environment due to urban expansion **(Figure 2.12).**

Figure 2.12 Changing Geomorphic Environment through Land use Change



Source: Choudhury, 2001

2.8 Problems of Urban Environment

Mafizuddin and Hossain (1992) pointed out in a paper titled "Spatio-temporal Variation of Ground Water Level in Dhaka City" about the nature and trend of ground water level variations, environmental and social factors responsible for such variation. They mentioned that the depth of ground water level is increasing rapidly elapse of time and the ground water level is fallen up to 30m during 1970-90 periods. The authors also mentioned that if present rate of ground water level falling continues, the peizometric surface level will fall up to 110 m below the measuring point up to 2050 AD that the result in the subsidence of the land surface up to 5.8m.

MoEF (1992) prepared this report namely "Bangladesh Country Report for United Nations Conference on Environment and Development (UNCED)" in 1991 for presentation at UNCED, held at Brazil from 1-12 June, 1992. This report contains a discussion of key environment development issues and the Government of Bangladesh strategy to address these issues. This report is helpful as it provides the total environmental scenario of Bangladesh from the geographical, legal and administrative perspectives briefly.

World Bank (1994) reported that in "Managing Urban Environmental Quality in Asia" without substantial improvement in management, many Asian cities could become the most polluted human settlements in the world and slow down much of the regions' economic growth. Thus to combat with these problems effective environmental planning and management is needed. Most serious threat to effective urban environmental quality management at present in Asia is the lack of an institutional mechanism that will be coherent and compelling enough to generate the resources and political will that the challenge demands and to coordinate the response efficiently.

Islam (1995) showed in his book entitled "Environmental Land use and Natural Hazards in Bangladesh", as discussed above, land use change in Bangladesh involves a number of processes, namely (a) Conversion of forests to cropland, the intentional and adverting burring of forests and the removal of wood for fuel; (b) The conversion of wetlands to agricultural and urban uses; (c) Losses of productive cropland through erosion, natural hazards and human activities involving natural processes; and (d) The conversion of other types of land to uses associated with urbanization, development of infrastructures for transportation, energy production and irrigation structures.

Asaduzzaman (1997) discussed in a research titled "Geo-morphological Controls over Urbanization: A Case Study of Dhaka City" about the various geo-morphological and physiological situation of Dhaka city. He mentioned that the main reason of water logging in the city is attributing to the drainage congestion due to unplanned structural growth. Most of the natural *khals* are choked by encroachment, earth filling and deposition of city garbage. He pointed out that the total water logging area in the city is 3.51 sq. km.

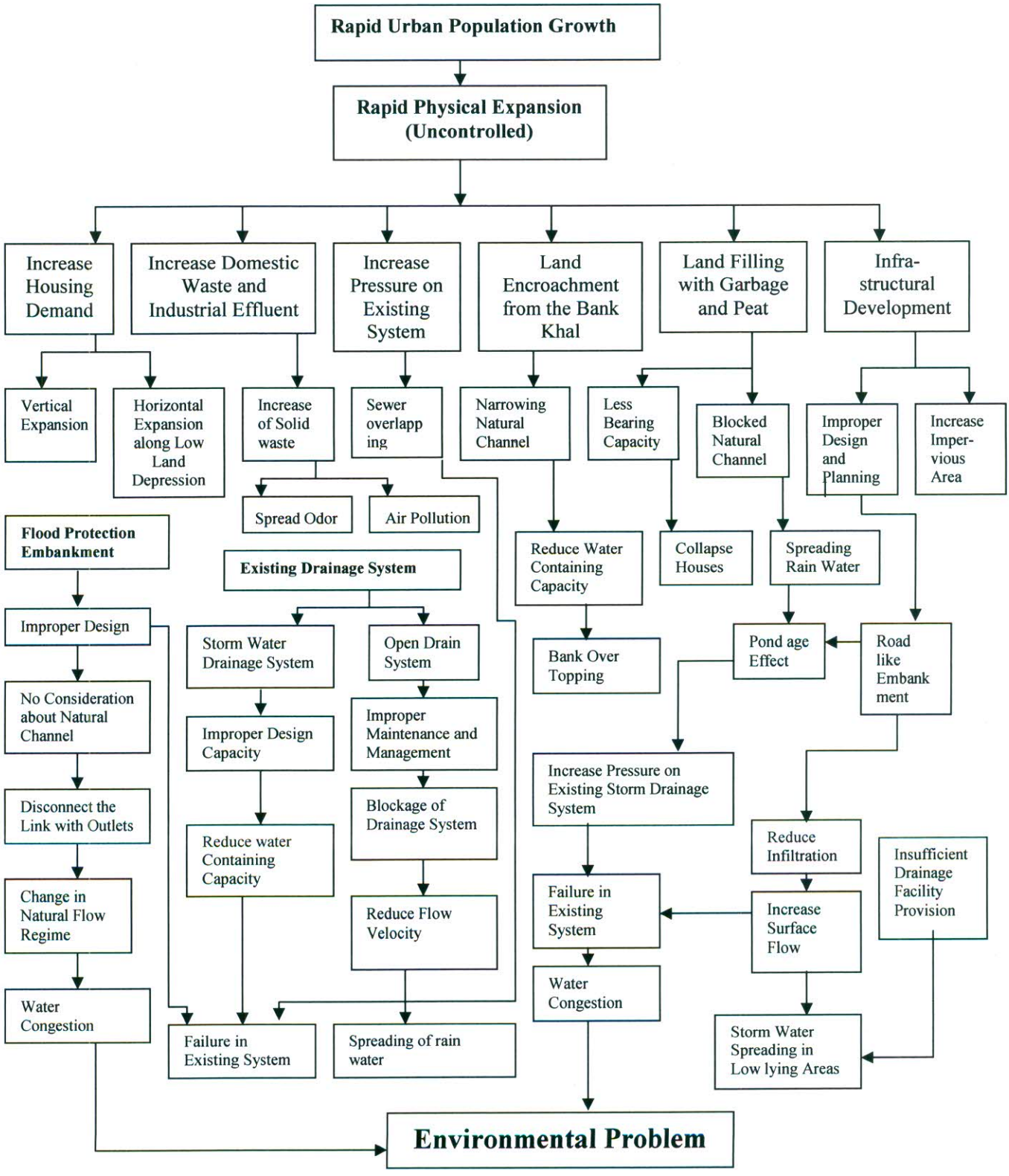
Khan (1997) expressed that unplanned urbanization, industrialization and indiscriminate earth-filling activities in the study area trigger environmental problems in such areas and the city as well. The main emerging problems are:

- The study areas have been used for agriculture (seasonal), aquaculture and retention purposes. Thus landfills activities damage agriculture productions, fisheries and other natural resources.
- The study areas are expanded in the rainy season and create a vast open water body submerging its surroundings due to squeezing wetlands and low-lying areas.
- The landscape and character of the fringe areas particularly in the north western part of Dhaka city have been changed by the landfill activities.
- The existing natural canal networks in the North western part of Dhaka Mega city have been used up for drainage, navigation and retention purposes but these canal networks are gradually disappearing owing to land filling activities by the PLDCs. Resulting that, the water flow have been obstructed in such canals (*Khals*) and create water logging particularly in lean season in city areas.
- The land use character in the study area is being changed by unregulated and unplanned landfills activities and settlements; as a result, the area faces environmental problems are follows the **Figure 2.13.**

Islam (1998) mentioned in an edited book entitled "Recent Urban Studies, Bangladesh" about urban planning, urbanization, urban physical environment, urban land use, slum up gradation and industrial pollution control. But he did not discuss in detail about the impact of urban water bodied loss on urban life.

Rahman *et al.*, (2001a) has discussed in a report entitled "People's Report on Bangladesh Environment 2001" about the people's perception on environmental degradation and their creative options for improving the surroundings they live in and also mentioned that land resources are crucial to the environment of Bangladesh. Unfortunately, land use habitat is under constant threat through human encroachment and by flood control and irrigation schemes. The editors have discussed different aspects of environmental degradation but did not categorically discuss about the changes of lands in urban area.

Figure 2.13 Relationship between urban expansion and environmental problems



Source: Adopted from Khan, 1997

Rahman *et al.*, (2001b) the aim of this paper is to understand the environmental condition from citizens' perception as well as from various factual data. It has been found

that city dwellers have reacted differentially with their surrounding physical and neighborhood environmental problems. The urban environmental facilities in this city are under tremendous pressure due to increasing population number, insufficient supply of urban facilities and reluctance of taking proper development initiative by city authorities. The city authorities with governmental and non-governmental organizations should take proper development initiatives to save the degradation of urban environment. Community people should offer a cooperative hand to such organization for creating proper community action programs. The authors mentioned some general recommendations i.e. proper development initiatives of GOs and NGOs, community people cooperation. But they did not mention specific recommendation for solving the identified problems.

UNEP (2001) identified five key environmental issues and relevant impacts in Bangladesh State of Environment Report; these are shown in **(Table 2.8).**

Table 2.8 Key environmental issues in Bangladesh and impacts

Potential Key Issues	Impacts
Land degradation	Ecology and quality of life
Water pollution and Scarcity	Ecology and quality of life
Air pollution	Environment and health
Biodiversity	Ecology, development and quality of life
Natural disasters	Environment, development and quality of life

Source: UNEP, 2001

It was mentioned in the report about land degradation that there were two major constraints in prevailing degradation. The first one is high population pressure on land and the second constraint is the absence of a comprehensive national land use policy. Poverty with rapid population growth, absence of a proper land use policy, and other driving forces compel people in Bangladesh to over- exploit natural resources like land, which form a major focus for human economic activities. In addition, urban sprawling and infrastructure development have reduced the availability of land. There is a wide gap between awareness of land degradation problems and actions necessary to combat with them. Land degradation in many areas goes unnoticed from generation to generation, and therefore the concept of land resource conservation fails to attract politicians and planners. In this report it was also pointed out that in order to combat land degradation and to attain sustainable land management and development, it is very urgent to build up institutional capacity to conduct field level research and apply the results through extension programs along with enabling policy makers to take necessary decision and to undertake appropriate mitigation measures.

Kabir (2003) this paper mainly focuses on the role of brick industries, which produce enormous quantity of pollutants over the sky of Dhaka, particularly in the dry season. The paper is based on a field survey conducted during 1990-2000. Results from the survey clearly indicate that the city is encircled by a mushrooming growth of open air brick industries. As a result, Dhaka has already been recognized as one of the most polluted cities on earth. The pollution level is further deteriorating due to the city's growing industries, automobiles, household garbage etc.

Tawhid (2004) analyzed in a study that water logging becomes a burden for the inhabitant of Dhaka city and creating adverse social, physical, economical and environmental impacts. Disruption of traffic movement and normal life; damage of structure and infrastructure; destruction of vegetation and aquatic habitats; loss of income potentials are the encountered effects of water logging on city life. The author recommended some steps of measures for comprehensive management of storm water, which are:

- Saving natural drainage system and waterbodies through development control;
- Proper waste management system;
- Drainage capacity adjustment, comprehensive drainage development plan and improvement of drainage management system;
- Awareness development against closing of drains and
- Legal instrument- consolidation of all environment laws in a single law and arrangement of all environmental activities under one umbrella.

2.9 Urban Environment Management

SGTZ and DOLA (1990) described Environmental Management and Urban Environmental Management in the manual for "Urban Environmental Management". Here, it is mentioned that environmental management is concerned with creating a healthy and pleasant physical environment with which we can all enjoy our lives. It is concerned with ensuring that we look for physical resources in a sustainable way and, as per as possible, eliminate, or at least minimize pollution. Urban environmental management is concerned with much of what municipalities are used to doing: providing and maintaining infrastructure, looking after public health, maintaining a pleasant plans to ensure an efficient and pleasant city into future. Urban environmental management differs from environmental management in the sense that the latter is concerned with prioritizing issues to be dealt with and integrating the management of various aspect of municipal activities. Above all, environmental management is concerned with devising effective ways in which municipalities and local communities can cooperate to look after the urban environment properly.

Leitman (1992) identified the most important issue in their paper titled "Environmental Management and Urban Development Issues and Options for Third World Cities" that need to be resolved to improve the urban environmental quality are:

- Poor governance, including weak institutional capacity in planning as well as the managerial and operational aspects of urban service delivery, jurisdictional complexity;
- Lack of public awareness of environmental problems and the unwillingness of environmental authorities to adequately address them;
- Ill conceived regulatory and economic policies that encourage environmental degradation and fail to provide the necessary basis for comprehensive environmental management; and
- Insufficient knowledge and understanding of the extent, impacts and processes of environmental decay.

Kruger (1996) envisaged a strategic approach to environmental management in his report on "Urban environmental Management in Thailand", which emphasizes:

- Mechanism to prioritize key issues for attention rather than to cover all issues simultaneously;
- Multiple stakeholders in decision making in and outside government than one decision maker ;
- Actions to mobilize rather than command social energies;
- Planning as an interactive process rather than " once-and for all" plan making activity;
- Social, political and economic factors accepted as part of the strategic planning process rather than treated as internal to it;
- Emphasis on clearing bottlenecks rather than on designing comprehensive interventions;
- Focus on breakthrough initiatives with the participation of key stakeholder rather than on government programs alone ;
- Capacity building with private sector and civic actors rather than by government alone.

Bhuiyan *et al.*, (2002) has discussed in a paper titled "Unplanned Waste Disposal and Its Possible Impact on Subsurface Environment of Dhaka City, Bangladesh" that only domestic solid waste are collected and dumped by Dhaka City Corporation (DCC), but other industrial waste are thrown into urban run off or nearby drainage systems. These types of open dumping can make a serious threat to the ground water as well as surface water.

Huq (2002) had edited his book titled *Paribes Ain Sangkalan* (in Bangla), while he provided valuable service as a legal specialist at the Bangladesh Environmental Management Project (BEMP) under taken by DoE. This book is a compilation of the ECA, ECR and other few acts and rules and of environment related Government Notifications, Orders, Directions, Declarations, etc., as administered by DoE. The limitation of this book is that the editor did not address any problem or issue in implementation of the above environmental laws.

Seraj and Sadeque (2005) discussed in an article entitled "An Evaluation of Urban Governance of Dhaka City and Its Effects on the Growth of Private Real Estate Sector" about the accountability, responsiveness, management innovation, public private partnership, decentralized management and networking of urban governance and local government-citizen interaction. The authors confined themselves in the discussion on the role of urban governance and its effect on real estate sector. But they did not discuss the obstacles of urban governance activities and the effects on other sectors of urban governance.

Shaik (2006) has discussed in a research about the impacts of urbanization in Bogra municipal area of Bangladesh. In this research he has identified some social, economic and environmental impacts of urbanization. In the discussion about the environmental impact of urbanization, he discussed about the on Flora and Fauna, cultivation, sanitary facilities, sewerage system, population, slums, drug addiction, prostitution, law and order situation. But in his research he has not discussed about the unplanned land use change of urban areas.

2.10 Exiting Environmental Polices, Laws and Regulations

BELA (1995) organized the seminar in March 1995, titled "Commitments on conservation of Environment at the Mandates of Political Parties"; the political leaders of different parties, Members of the Parliament; teachers of universities, journalist, and other groups of professionals participated and expressed their opinion on protection of environment. The publication in the name of *Paribes: Rajnaitik Daler Bhumika* (Environment: Role of Political parties) is the compilation of those opinions in the form of articles. Most of the political leaders opined to include their commitment for protection of environment at the party's mandate in different ways. For this reason this compilation can be a ready reference for the policy maskers, the researchers and the general readers working on environment.

Farooque (1996) compiled the text of environment related Acts, Orders, Ordinances, Rules, etc. including a list of all environment related international instruments to which Bangladesh is a party. The environment related laws have uniquely been presented fewer than nineteen different sectors like pollution and conservation etc. Though no interpretation of the laws can be found in the book, it is a useful book for the present research as it provides a reader with the overall picture of environmental laws of Bangladesh.

Razzaque (2000) illustrated in this article namely "Access to environmental Justice: Role of Judiciary in Bangladesh", about four main areas where the Judiciary is active in accommodating environmental protection. These areas are constitution and environmental protection, standing in the court, remedies to facilitate the environmental justice and national application of international environmental law. The article discussed only on the access to environmental justice to the Supreme Court of Bangladesh; and no elaborative research was undertaken on the role of entire judiciary of Bangladesh with regard to conducting environmental justice.

UNEP (2001) reports that poverty with rapid population growth, absence of a proper land use policy, and other driving forces compel people in Bangladesh to over- exploit natural resources like land, which form a major focus for human economic activities. In addition, urban sprawling and infrastructure development have reduced the availability of land.

Gain (2002) edited this book namely "Bangladesh Environment: Facing the 21st century" a country report on the state of Bangladesh's environment-attempts to tell the signs of the times with regard to our environment, resources and people. Reports from the field and real life stories, matched and mixed with expert analyses on major environmental issues of Bangladesh, also attempt to develop a context to understand Bangladesh better.

HUDA (2002), The Hyderabad Urban Development Authority (HUDA) in collaboration with the Pune based World Water Institute (WWI) and with support from the Royal Netherlands Embassy (RNE) hosted an international workshop on urban water bodies at Hyderabad, Andhra Pradesh, India from 16-18 June 2003. It was mentioned in the conclusion of the proceeding of the workshop that one of the major problems faced all over the world is rapid urbanization coupled with encroachment, leading to the loss of catchments of lakes. On the management front, observed that active participation of all stakeholders that include primarily the dwellers (e.g., resident welfare associations, fisherman) and tourists in and around the lake who derive benefits (mostly direct) from it,

government departments under whose jurisdiction the lake and its catchments falls helps in managing it better. Below was the set of final recommendations of the workshop:

Global:

- Work towards the establishment of an international protocol for urban water bodies;
- Establish an international network of individuals and organizations exclusively devoted to issues of conservation, utilization and management of urban water bodies;
- Call for an international conference to debate and discuss experiences related to conservation and management of urban water bodies;
- Establish an international training center at Hyderabad for training in waste water treatment, pollution control and management of urban water bodies to build on the experiences of the lakes restoration in and around Hyderabad;
- Documentation of best practices in management of urban water bodies with relation to financial, technology, social and ecological sustainability;

National:

- Need for an over arching policy to address issues related to urban water bodies;
- Need for an appropriate legal framework to cover urban water bodies, especially making such areas, and their designated buffer zones, inalienable and enforcing principle of 'polluter pays'

State:

- Enact the Lake Conservation Act which calls for interdepartmental coordination and provides a legal framework with flexibility for implementation of appropriate local solutions including the involvement of civil society at the highest level.

Local:

- Establish local stakeholder forums to support the management of urban water bodies
- Integrated management of urban catchments;
- Social, economic and cultural impact assessment of the interventions at the local level;
- Introduction of lake conservation as part of school and college education.

Khan (2004) wrote this book titled "An Introduction to Environmental Law: Principle and Practice". It contains the subjects of environmentalism and historical background, modern and current international environmental issues, main environmental issues in Bangladesh, environmental issues and laws, management of environment both in the global and national level, legal responses in the global, regional and national perspectives, some recommendations and suggestions etc. The researcher has found the book as a basic text book on environmental laws of Bangladesh.

Chowdhury (2007) wrote this book namely "Essays on Environment". The book addresses important environmental issues like conservation of forest and biodiversity, overview of Bangladesh GEF profile, environmental policy, laws, rules in Bangladesh as well international conventions, treaties and protocols on environment to which Bangladesh is a party. The significance of this book is that it points out the government initiatives to conserve the environment through various ways, but did not try to point out the failure stories of the government of Bangladesh in dealing with environmental issues.

2.11 Summary of the Literature Review

Literature review on urban management in general and wise management of land use practices in particular suggest that various aspect such as policies, laws and regulations, political will, people awareness and institutional capabilities are related to conserve the land use change in Dhaka city. The causes of land use change are manifold. Rapid growth of population, unplanned urbanization, industrialization, earth filling, encroachment, slums and squatters, enforcement of proper laws and regulations, institutional capacity and land use planning are closely related factors in respect of wise management of urban land use. In Bangladesh urban environment management including urban land use management is at an incipient stage. Even at present very little work has been done on the transformation of vegetation, water-bodies, wet/lowlands and its consequential effects. None of the works covered the Dhaka city and its surrounding areas and most of these works used satellite images up to the year 2001 or earlier. It is well agreed in all relevant literature that land use change such as: vegetation, water-bodies and wet/lowlands of Dhaka should be conserved considering its immense environmental and socioeconomic contributions. But there is no comprehensive study available to apprehend the extent of environmental degradation and social implications; the city is approaching with the change of land use. Thus it requires an updated and inclusive study regarding the changing pattern of land use and its consequential impacts.

After such an effective discussion on literary review, I try to define land use change, land use change pattern and trend, land use modeling and land transformation and environmental degradation in the following chapters.

The next chapter is on Research Methodology where I have present types of research, sources of data, selection of study area, sample size determination and selection of respondents, methods of data processing and analysis and overall research methodology.

Chapter 3

Research Methodology

Chapter 3
Research Methodology

This chapter deals with the research methods and design adopted to achieve the objectives set for this study. It describes justification of selecting tools and techniques and procedure of using those as well the selection the study area and samples for required primary and secondary data collection. Also it explains the analytical framework and techniques those used for this research.

3.1 Research Approach

Mixed method research approach is used for present research. Both qualitative data was used to achieve the objectives. Awareness of the people regarding environmental impact of land use change and quantity of land use changes etc; were the quantitative data and opinion regarding the existing management system of land use change pattern and alternative way to control the environmental degradation were the qualitative collected from study field. On the other hand, existing laws and regulations, programs/policies along with of its enforcement are evaluated and described by using the primary and secondary data according to need and availability.

3.2 Sources of Data

The Primary and secondary sources of data were the basis of the research. The primary data sources of this research were study field and study population. Secondary sources of data were official documents of various government, semi government and non government organizations as well as from different books, journals and web site.

3.2.1. Primary Data Collection

To collect the above mentioned data/information the researcher adopted following data collection techniques;

- Observations
- Land use Survey
- Questionnaire survey
- Photographs.

3.2.1.1 Observations

Direct and simple observation was conducted for the present research work. Observation was conducted in middle and last duration of the field survey. I went to different places of study sampled for observation. Every morning I visited those places to avoid the traffic rush and gatherings for saving time to observe and collect required qualitative data. In total fifteen days of observation was conducted to collect the data on flowing issues:

- Types of land use in the study area;
- The changing pattern, diversity, density, fragmentation and distribution of habitats or land use gradient;
- The effect of land use/cover change on the local to global environment;
- Observation of other factors which seemed to be related with the causes of environmental degradation.

3.2.1.2 Land use Survey

Land use survey was conducted by using remote sensing Landsat TM image of SPARRSO, Google image and Topographical map of Survey of Bangladesh (SOB) in order to determine the change of land use pattern in the study area. Topographical map, Landsat TM image and Google image were used for obtaining the temporal changes of land use of the study area from 1960, 1991 and 2008.

3.2.1.3 Questionnaire Survey

A questionnaire survey was conducted for primary data collection from selected study respondents. Total 397 households were selected as study samples from five selected areas purposively. Total two sets of questionnaires were developed for this research work. Both closed ended and open ended questions were incorporated in those questionnaires, after developing questionnaires were pre-tested on 20 study respondents from each category as a pilot survey for finalizing and checking its reliability and validity as required for the study.

A team comprised of three members was appointed as enumerators to collect data through questionnaire survey. One day training was conducted to train the enumerators. They were instructed about the procedures of questionnaire survey and the requirements of research work. Moreover, they were educated and made competent for appropriate understanding about local resident especially study samples, the environmental setting, infrastructure, etc. Questionnaire survey was incepted on 1st April 2010 and completed on May 2010. All

information was collected in line with the objectives and scope of the study. A copy of the questionnaire is enclosed in **Appendix A.**

3.2.1.4 Photographs

Photographs were taken from different spots of the study area to observe the filling of wet / lowlands, encroachment of influential elites, slums and '*Mastan*' (Musclemen), real estate development companies, consequence of land use change and effect on urban life, transportation modes and environmental degradation. Some of these photographs had been collected from daily newspaper.

3.2.2 Secondary Data Collection

3.2.2.1 Maps and Images

To see and analyze the land use change of Dhaka city, different maps and satellite images were needed. For assessing and observing the land cover map of 1960, 1991 and 2008, topographic map of 1960, Landsat TM of 1991 and Google earth image of 2008 were collected from respective organizations. Some other relevant maps were also collected to justify and validity of collected images and maps.

Table 3.1 Maps and images collected for this study

Maps and images	Scale/resolution	Sources	Year
Toposheet ($79\frac{I}{1}$, $79\frac{I}{2}$, $79\frac{I}{5}$ and $79\frac{I}{6}$)	1: 50,000	SOB	1960, 1991
Landsat TM image	Variable	SPARRSO	1991
Google earth image(Quick bird)	Variable	GOOGLE	2008
General land use map	1: 25000	SPARRSO	1991
Dhaka City Corporation map	1: 30,000	SPARRSO	2004
Dhaka city guide map	1: 20,000	SPARRSO	1987, 1995
Thana map	1:50000	LGED	1991, 2004

3.2.2.2 Other Secondary Data

Other required secondary data were collected from different official statistics and surveys carried out by the government and different research organizations. Secondary data also has been collected from relevant books, journals, reports and written documents. Different offices and organizations which were visited and consulted are mentioned below:

- Central Library, University of Rajshahi: Different publications and thesis.
- Department of Geography and Environmental Studies, University of Rajshahi: Different journals, urban geography related books and documents.
- Institute of Environmental Science, University of Rajshahi: Land use and environment related various documents have been taken from the seminar library of this institute.
- Department of Geography and Environment, Jahangirnagar University: Relevant Journals, books and unpublished thesis.
- Department of Environmental Science, Jahangirnagar University: Relevant Journals, books and unpublished thesis.
- Department of Geography and Environment, Dhaka University: Different Journals, flood related reports on Dhaka city, urban environment related books.
- Department of Urban and Regional Planning, BUET: Development plans of Dhaka City, journals and unpublished thesis.
- Centre for Urban Studies (CUS): Various research report on urban environment and urban planning.
- Dhaka City Corporation (DCC): DCC map, waste management papers.
- Rajdhani Unnayan Kartripakkha (RAJUK): Urban planning and development related documents (i.e. DIT Master Plan, DMDP).
- Ministry of Land: Land management, land administration and land policy.
- Ministry of Environment and Forest (MoEF): Environment related project paper, policy, rules and regulations.
- Department of Environment (DoE): Publications on World Environment Day, reports on State of Environment, annual reports, and other related books and documents on environment.
- Bangladesh Centre for Advanced Studies (BCAS): Land use conservation and management related books and journal and publications.
- Bangladesh Paribesh Andolon (BAPA): Land use and Land use change/conservation related unpublished papers.
- Bangladesh Bureau of Statistics: Rural-urban population and population growth related information.

3.3 Post Field Survey Work Phase

3.3.1 Maps and Images Interpretation

Collected maps and images were sorted and classified for analysis and interpretation. Classification was performed based on the Google Earth image 2008 utilizing observation points recorded during field visit. The topographic maps of 1960 and 1991 (scale 1: 50,000) were used to generate land use/cover types of 1960 and. 1991. Landsat TM image of 1991 and Google image of 2008 were employed in this study to produce land use/cover categories of 1991 and 2008 respectively. Arc GIS and Erdas Imagine software were used to device land use/cover classification in a multi-temporal approach.

A modified version of the Anderson Scheme Level I (Anderson *et al.,* 1976) was adopted to study the land use/cover change. This system produced multilevel land use/cover type classification of which Level I classes can be mapped from Landsat data or from high altitude air photo/imaging.

3.3.2. Classification

Maximum Likelihood classification was performed based on Google image 2008 using dry season imageries of Google Earth. This technique was chosen because it uses the mean values and covariance matrix of the classes to assign each pixel to the class with the highest probability, thus it gives a reliable result (Lillesand and Keifer, 2000). It assumes that the statistics for each band are normally distributed. Similarly for 1960 and 1991 images classification was carried out based on signatures extracted through visual interpretation and Land use maps.

Certain classes like dense mimosa and shrubs were not detected from the images of 1960 and 1991; a single pixel was assigned representing each of these classes to the burned area. By doing this IDRISI Andes calculated the change of the study areas by which statistics produced about each of the cover classes in the multi-temporal series. So if a particular class is completely absent and remains unrepresented in any one of the land cover images it is not possible to determine how many pixels have changed for that particular class from the previous to the next land cover image.

Thus single pixels representing transport and communication class was identified for both the Landsat TM and Google images on exactly the same geographic coordination using the IDRISI Andes modeler. All the three images were recoded and given exactly the same class names and numbers.

Eight separable land use/cover types have been identified in this study such as built-up, bare soil/landfill, cultivated land, vegetation, water bodies, wet/lowlands, transport and communication and others. These are shown in the following **(Table 3.2).**

Table 3.2 Land use/cover classification scheme in the study area

Land use/Land cover types	**Description**
Built-up	Residential, commercial and services, industrial, socio-economic infrastructure and mixed urban and other urban
Bare soil/landfill	Exposed soils, landfill sites, and areas of active excavation.
Cultivated land	Agricultural area, crop fields, fallow lands and vegetable lands.
Vegetation	Deciduous forest, mixed forest lands, palms and others.
Water-bodies	River, permanent open water, lakes, ponds and reservoirs.
Wet/lowlands	Permanent and seasonal wetlands, low-lying areas, marshy land, rills and gully, swamps.
Transport and communications	Transportation, roads and air port.
Others	Brick fields and unidentified soil.

Source: Adopted from Anderson *et al.,* 1976

Accuracy assessment was carried out for Google images using 43 validation points that were collected during the fieldwork. The overall accuracy, producer and users accuracy was calculated using Kappa statistics. Kappa statistics was also calculated to have an idea about magnitude of change agreements in classification.

3.3.3 Preparation of Land use Map

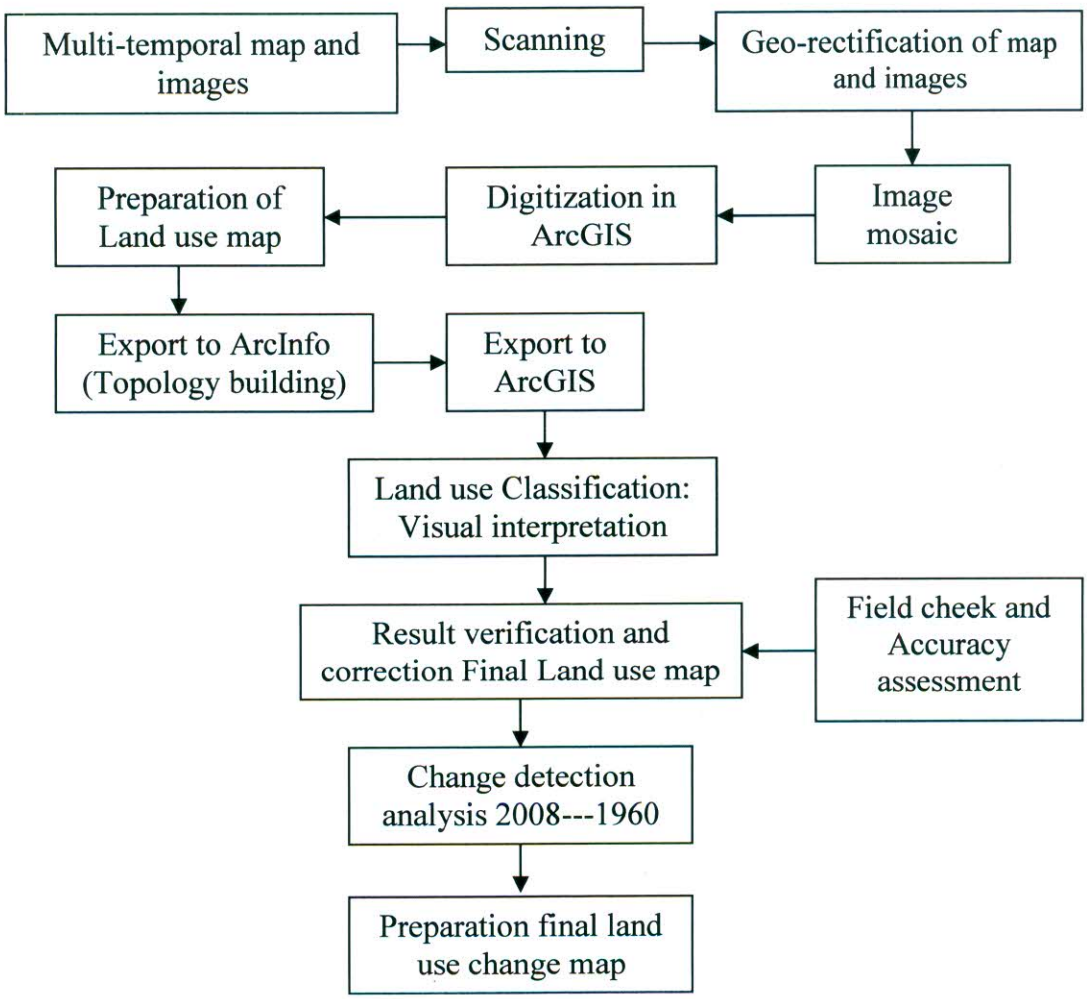
Topographical maps were scanned and saved as TIFF/Geo-TIFF format. The topographical maps were pre-processed before ultimate analysis. These were geo-referenced with proper co-ordinations by using image processing software and then performed final analysis. **Figure 3.2** describes flowchart of the steps of topographical maps interpretation and processing. In this study, multi-temporal topographical maps were used to detect land use change dynamics. Global positioning system (GPS) was used to identify and select the ground control points (GCPs) for geo-referencing of the photographs.

Scanned aerial photographs were then geo-rectified to remove geometric distortion. Raw digital images or aerial photographs usually contain significant geometric distortions that are not usually used directly as the base map without processing.

Both tabular and graphical representation was used for data presentation in respect of the research objectives. Relevant study maps and images were digitized, classified and

modified according to the requirement using Geographic Information systems (GIS) software such as Arc GIS, IDRISI Andes.

Figure 3.1 Flow chart preparation of land use change map



Source: Adopted from Anwar, 2002

3.4 Selection of the Study Area

Dhaka, the political, administrative, commercial and cultural center of Bangladesh has witnessed a phenomenal growth in population and urbanization during the last 48 years. The population of Dhaka has increased more than thirty times and the size of the city is expanded by 18 times during the last 50 years with minimal strategic guidance. Growth of Dhaka city is unabated by continued rural-urban migration, natural increases and expansion of urban boundaries and eventually demands for increased urban settlement and other infrastructure.

The natural adjustment between the landform and land use is being disturbed particularly in the urban areas like Dhaka due to fast growing population that resulted the changes in the

economic condition and technology as well. Two basic outcomes of such disturbance are: wet/lowland filled up and converted for urban expansion and unplanned encroachment of settlements. The effects of human interference over natural system caused serious environmental degradation throughout the Dhaka city and its surroundings. Considering the magnitude of the problem of land use/cover change, spatial change of wet/lowlands of Dhaka and its surroundings comparing with other cities of the country and some areas of Dhaka as focused by the mass media and environmental activist group as most degraded area are selected as the study area.

3.5 Sample Size Determination and Selection of the Major LUC Area

Sampling technique plays a vital role in research work. Sampling provides sufficient information about population. It plays role to select a portion of the population that displays all of the characteristics of the population. When we come into a decision about a population from sampling results then those results must be representative of the population as possible.

It is observed from the land use map of 1960, 1991 and 2008 for identifying the rapid land use change areas using Location Quotient (LQ) method (The term first used in European Union and later by Mack and Jacobson,1996).

The land use change map were divided into 11th Gradient (for example Grid, A, B, C, D, E, F, G, H, I, J and K) respectively. For this major land use change areas were selected through Location Quotient (LQ) formula.

The formula for computing Location Quotient is:

$$LQ = \frac{e_i/e}{E_i/E}$$

Where,

ei = Local area in Grid-A

e =Total local area

Ei =Reference area of the study area

E =Total reference area of the study area

The location quotient is most frequently used in economic geography and location analysis, but it has much wider applicability. The location quotient (LQ) is an index for comparing an area's share of a particular activity with the area's share of some basic or aggregate phenomenon. Following data were taken from a larger data set which details the land use categories in the study area were divided into eleven parts:

Table 3.3 Average location quotient value in the study area grid A to K

Grids	Land use categories								Total	Average
	1	2	3	4	5	6	7	8		
A	1.08	0.85	0.15	7.28	0.56	0.38	0.60	-	10.90	1.56
B	0.68	-	0.73	4.39	0.53	1.44	0.75	2.63	11.15	1.59
C	0.97	2.06	0.46	4.66	0.29	0.80	0.42	0.74	11.14	1.39
D	0.64	0.75	0.52	6.88	0.75	0.45	0.61	3.13	13.73	**1.71**
E	0.91	1.10	0.96	1.07	0.55	1.17	2.45	1.38	9.59	**1.99**
F	1.16	0.25	0.90	3.29	0.49	0.11	1.50	1.23	8.93	1.12
G	0.16	1.11	1.16	2.16	0.37	3.20	1.35	-	9.50	1.35
H	0.81	1.10	1.12	0.15	0.37	1.25	4.01	-	8.81	1.10
I	0.75	0.92	0.54	3.85	0.62	1.96	1.12	0.77	10.53	1.32
J	0.37	0.93	0.65	0.78	0.93	3.70	1.13	4.65	13.14	**1.64**
K	0.92	1.78	0.62	0.37	1.56	1.21	3.78	-	10.24	1.28

Finally, Grid D, E and J were selected after analyzing the location quotient formula and observing the rapid change areas. Then the household numbers of these areas were found out with the consultation of BBS Community Series, 2007.

Table 3.4 Sample areas, corresponding wards/union parishad and household number

Sl. No.	Name of the area	DCC ward number/Union Parishad	HH number
1	Grid-D (Ashulia area)	Yearpur Union(part)	2996
		Ashulia Union	11102
		Birulia Union(part)	1942
2	Grid-E (Uttara area)	DCC ward-01 (part)	11675
		Harirampur Union (part)	5324
3	Grid-J (Amin Bazar area)	08 (part)	12109
		09	11441
		10	14906
		11 (part)	8416
		12 (part)	10625
		43 (part)	13891
		46 (part)	11461
		Aminbazar Union	7011
		Kaundia (part)	670
		Banagram(part)	937
		Bhakurta (part)	3774
		Tetuljhora (part)	966

Here the units vary in sizes **(Table 3.4).** Under such circumstances, selection of units with unequal probabilities may provide more efficient estimators than equal probability sampling (Singh *et al.,* 1996).

For this reason Probability Proportional to Size (PPS) sampling procedure was applied for this study and for drawing the PPS sample cumulative total method was used. With this method five sampling area were selected such as bearing the 2nd,5th, 7th, 11th and 13th serial number of the following table and corresponding total households numbers are (11102+5324+11441+13891+7011) 48775. Due to time and budget constraint it was not possible to cover 48775 households. For this reason Yamane's mathematical formula was used for determining the sample size.

Taro Yamane's (1970) formula:

$$n = N/\ 1+Ne^2$$

Where, N = total household, n = sample size and e = level of confidence

Therefore the sample size, $n = 48775\ /\ 1+\ 48775*(0.05)^2$

$$n = 396.74$$

$$n = 397$$

Table 3.5 Cumulative totals of sizes and associated numbers

SL. no. of ward/union	Household size	Cumulative size	Numbers of associated
1	2996	2996	1-2996
2	11102	14098	2997-14098
3	1942	16040	14099-16040
4	11675	27715	16041-27715
5	5324	33039	27716-33039
6	12109	45148	33040-45148
7	11441	56589	45149-56589
8	14906	71495	56590-71495
9	8416	79911	71496-79911
10	10625	90536	79912-90536
11	13891	104427	90537-104427
12	11461	115888	104428-115888
13	7011	122899	115889-122899
14	670	123569	122900-123569
15	937	124506	123570-124506
16	3374	128280	124507-128280
17	966	129246	128281-129246

Figure 3.2 Sample areas for questionnaire survey

Source: Prepared by researcher based on figure 5.5

Then a stratum with proportion allocation formula was used to divide the sample number proportionally in each of the five strata.

$$\text{Here, } n_i \ \alpha \ N_i$$

$$\text{or, } n_i = K N_i$$

$$n_i = n/N * Ni$$

Where, i = 1, 2, 3, 4, 5; N = total household, n = sample size.

Therefore, $n_1 = 90$, $n_2 = 114$, $n_3 = 57$, $n_4 = 93$, $n_5 = 57$

$$n = \sum n_i$$
$$= n_1 + n_2 + n_3 + n_4 + n_5$$
$$= 90 + 114 + 57 + 93 + 57$$
$$= 397$$

To select the study areas from the each of the above five strata simple random sampling was used. Purposive sampling method was followed to select the 397 household as respondents to know their view about the causes of land use change and its impact on environment, applicability of acts and rules and way to relief from this problem.

3.6 Change Detection

3.6.1 Land Change Modeler

Land Change Modeler for ecological sustainability is integrated software developed by Idrisi Andes for analyzing land cover change by which maps were analyzed and found two land cover maps that have identical legends (same code for each class). The change analysis panel provides a rapid quantitative assessment of change by graphing gains and losses by land cover categories. A second option, net change, shows the result of taking the earlier land cover areas, adding the gains and then subtracting the losses. The third option is to examine the contributions to changes experienced by single land cover (Idrisi, 2006). The Change analysis was performed between pairs of images of 1960-1991, 1991-2008 and 1960-2008. Accordingly the transitions and exchanges that took place between the various classes during the years were obtained both in a map and graphical form. All the units were changed into hectares. Transitions below 0.1 *ha* were ignored. Cross classification found its most common application in land cover change analysis where a cross tabulation or a cross correlation is done between two qualitative maps of two different dates that targets on the same features (Idrisi, 2006). It is used to compare two classified images where the classification assigns the same unique and distinct identifier to each class on both the dates. The aim is to evaluate the whether areas fall into the same class on the two dates or whether a change to a new class has occurred. In Andes edition by running a CROSSTAB module we have got a new image based on all the unique combination of values from the two images in which each unique combination of input values has a unique output value and a cross tabulation table.

The cross tabulation matrix that shows the distribution of image cells between the classes. The categories of date 1 are displayed on the X axis while in Y-axis displays the same categories of date 2. The cross tabulation shows the frequencies with which classes have

remained in same (along with the diagonal) or have changed in different classes (off-diagonal frequencies). Cross correlation images show all possible combinations that are used to produce two types of change images. These relative frequencies are known as transition probabilities and are an underlying basis for Markov Chain prediction of future transitions.

3.7 Quantities Questionnaire Survey

The perceptual data were collected through a questionnaire survey. Major environmental problems have been identified from the perception of study population, which have further been assessed for the evaluation of environmental quality. Determination of the level of satisfaction of population and perception is based on the questionnaire survey. A questionnaire framed with 25 neighborhood environmental variables and statement (**Table 3.6**) on 5 points scale (Highly Satisfaction, Satisfied, Acceptable, dissatisfied, and highly dissatisfied).

Table 3.6 Major urban environmental variables

Major Environmental Variables	
1. Water Supply	14. Housing
2. Garbage disposal	15. Road Network
3. Drainage Condition	16. Poverty and slum
4. Electricity Supply	17. Cleaning and Maintenance
5. Gas Supply	18. Sanitation Facilities
6. Transport & Vehicle	19. Sewerage System
7. Parking Facilities	20. Recreation Facilities
8. Traffic Management	21. Tele-communications
9. Medical Facilities	22. Postal and Parcel Service
10. Employment scope	23. Community Facilities
11. Local Security	24. Anti-social Activities
12. Law &Order	25. Mastan (Musclemen)
13. Education Facilities	

Source: Field Survey, 2010

The study area was selected into three areas for the questionnaires. From the three areas total 397 questionnaires have been administered. A random sampling technique has been adopted in the survey. To determine citizen's level of satisfaction, a Satisfaction Index (Yen and Lee, 1975) was selected. In this respect negative index of satisfaction was taken to select a degrading environmental variable.

Satisfaction Index, $Is = f_s - f_d/N$

Here, f_s = Number of Satisfied Respondents

f_d = Number of Dissatisfied Respondents

N = Total Number of Respondents

Table 3.7 Index for spatial variation of urban environmental degradation in Dhaka city

Index Value (Is)	Meaning
Is = +1	Highly Satisfied
Is = -1	Highly dissatisfied
-1 - -0.50	Highly Degraded Area (HAD)
-0.50 - -0.25	Moderately Degraded Area (MDA)
-0.25 - -0.001	Lower Degraded Area (LDA)
+ Value	Not Degraded Area (NDA)

The assessment of spatial variation of degraded urban environmental perception has done on the basis of satisfaction Index **(Table 3.7).** Each degraded variable from negative index of satisfaction was taken to assess the area variation and their grand total was taken for final presentation of area variation of the city. For this reason the whole study area was divided into eleven parts and selected only three survey area **(Table 3.8).**

Table 3.8 Neighborhoods of three survey areas

Name of the area	Neighborhoods of DCC ward number/union Parishad
Area- 01	Ashulia Union; A part of yearpur and Birulia Union
Area-02	Uttara (a part of DCC ward-01) and Harirampur Union
Area- 03	Ward- 09, 10; and a part of ward- 08, 11, 12, 43, 46, and Aminbazar Union, and a part of Kaundia, Banagram, Bhakurta, and Tetuljhora Union.

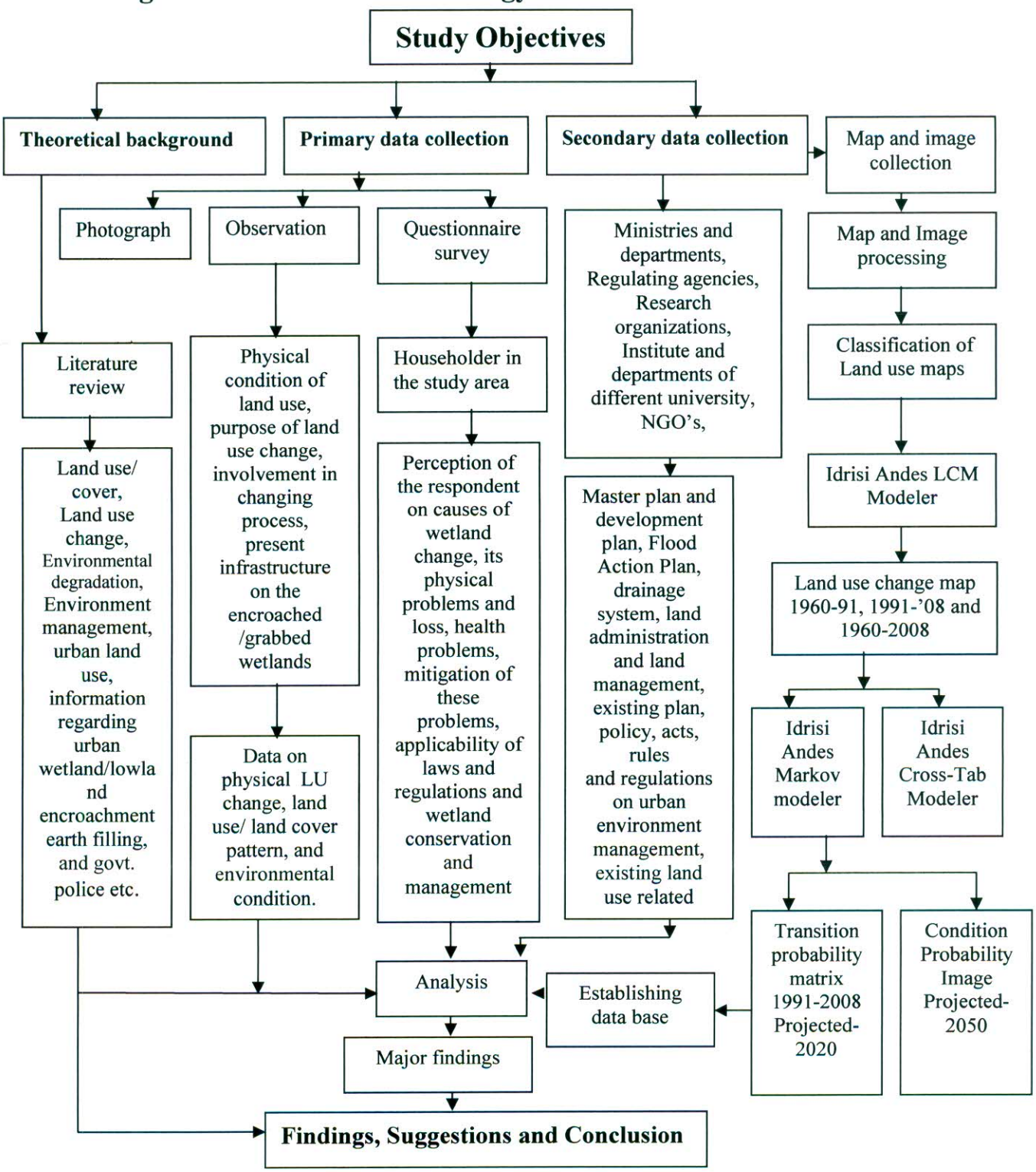
Source: Field Survey, 2010

Quantities of Data Analysis

After completion of primary data collection from the field level, the interviewed questionnaires were edited. Microsoft Excel was used for data processing and statistical analysis. The secondary data used in this research was included after checking its acceptability carefully. With a view to describing data percentage frequency distribution were widely applied.

Both tabular and graphical representation was used for data presentation responding to the objective to the research. Relevant study maps and images were digitized, classified and modified according to the requirement using some Geographic Information system (GIS) like Arc GIS and IDRISI Andes.

3.8 Diagram of Research Methodology



After the discussion of Research Methodology, the thesis ultimately requires the physical condition of the study area, profile of the respondent, physical and demographic development, causes of land use change, and impact of urban environment in Dhaka city that I've discussed in the upcoming chapter.

Chapter 4

Study Area Profile and Land use Change

Chapter 4
Study Area Profile and Land use Change

4.1 Physical Conditions of the Study Area

Physically, Dhaka's dominant feature is the small proportion of land which is permanently flood free, as brought home by the floods of 1987 and 1989. Virtually all flood-free land close to Dhaka has already been developed. Savar, some 25 km from central Dhaka to the north-west, still has remained undeveloped flood free land, though the pace of development in the area has increased in recent years. In contrast, the areas to the west, south-west, and east of Dhaka are low-lying and consequently under water for many months of the year. This imposes a major constraint, if not an absolute constraint, of development in these fringe areas.

4.1.1 Geographical Location

The study area is a part of Dhaka city and Savar area is located in the central part of Bangladesh. Geographically, this area is in the southern part of Madhupur region. The study area lies between $23^0 44'$ and $24^0 02'$ north latitude and $90^0 12'$ and $90^0 26'$ east longitudes and the total area about 414.68 sq km. The study area is included in the survey of Bangladesh Toposheet Nos. $79\frac{I}{1}$, $79\frac{I}{2}$, $79\frac{I}{5}$ and $79\frac{I}{6}$. Based on flood control infrastructures, the study area is divided into two parts: Turag river East and Turag river west **Figures 4.1 and 4.2.**

4.1.2 Area and Population

Dhaka, the capital and the most populated city of Bangladesh, is now a member of the 'mega-city' family of the world. Dhaka, the fifth largest mega city, comprises Dhaka City Corporation (DCC) and five adjacent municipal areas i. e. Savar, Narayanganj, Gazipur, Kadamrasul and Tongi (DoE *et al.*, 2006). The area of Dhaka mega city is 1353 sq km of which DCC occupies 276 sq km (BBS, 2001).

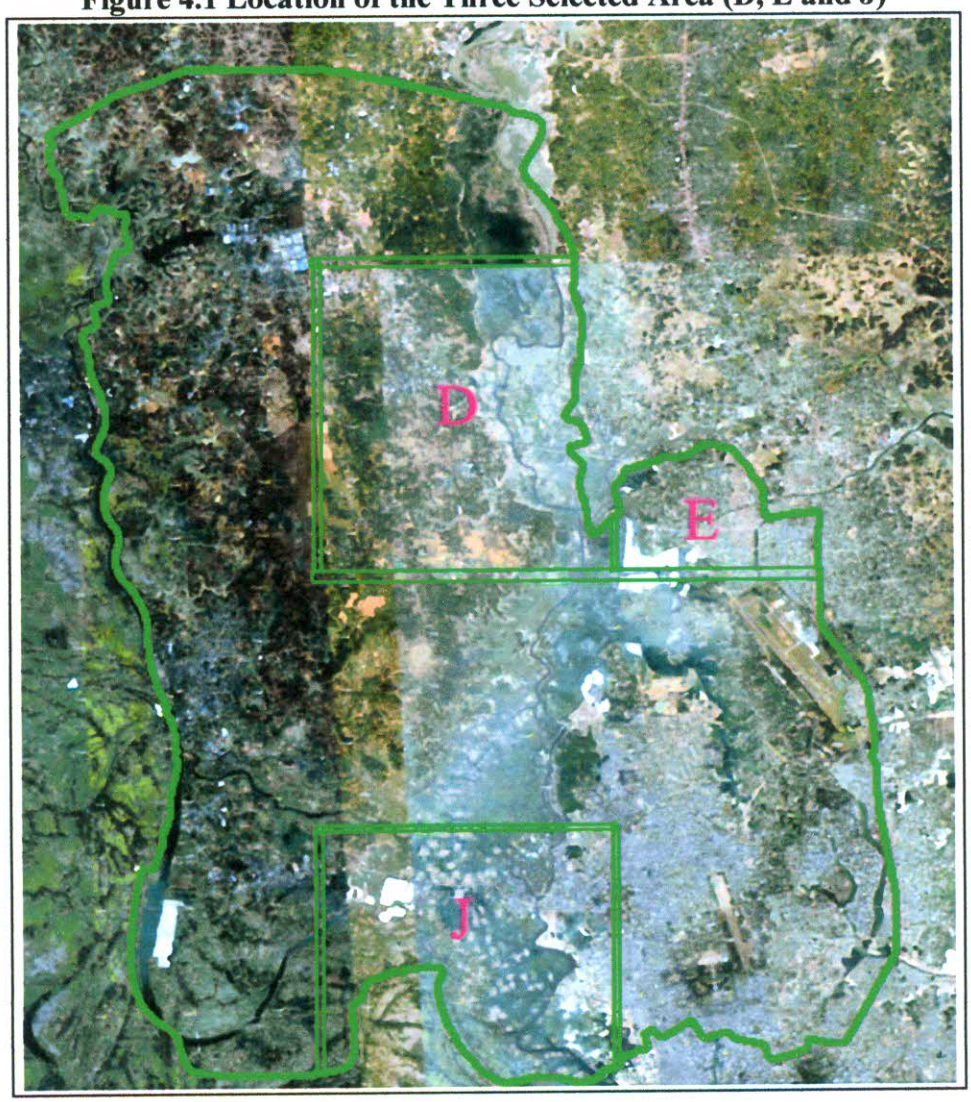
The study has mainly two connotations, *firstly*, a part of Dhaka City Corporation (DCC) and *secondly*, Savar area has a clear administrative boundary and its area can easily be measured. At present a part of DCC has area of 117.68 sq km (Out of 276 sq km) and Savar area has 296.84 sq km. The population of DCC area is about 673,774 (BBS, 2007b). Another, one is Dhaka Metropolitan Area (DMA), the area defined by the metropolitan police administration for the maintenance of law and order. DMA is somewhat larger than DCC. **Table 4.1** shows that projected population of DMA and DCC are given below:

Table 4.1 Population projection in Dhaka Mega City Area and Dhaka City Corporation Area

Year	Dhaka City Corporation			DMDP Area (RAJUK Area)		
	Population (000)	Growth (% per year)	Pop. Density (Person/ha)	Population (000)	Growth (% per year)	Pop. Density (Person/ha)
1991	6100	--	169	7300	--	48
1995	6900	3.0	192	9100	4.2	59
2000	8000	3.0	222	10900	3.6	71
2005	9000	2.5	251	12600	3.0	83
2010	9900	1.5	169	14200	2.4	93
2015	10200	1.0	283	15700	1.9	103

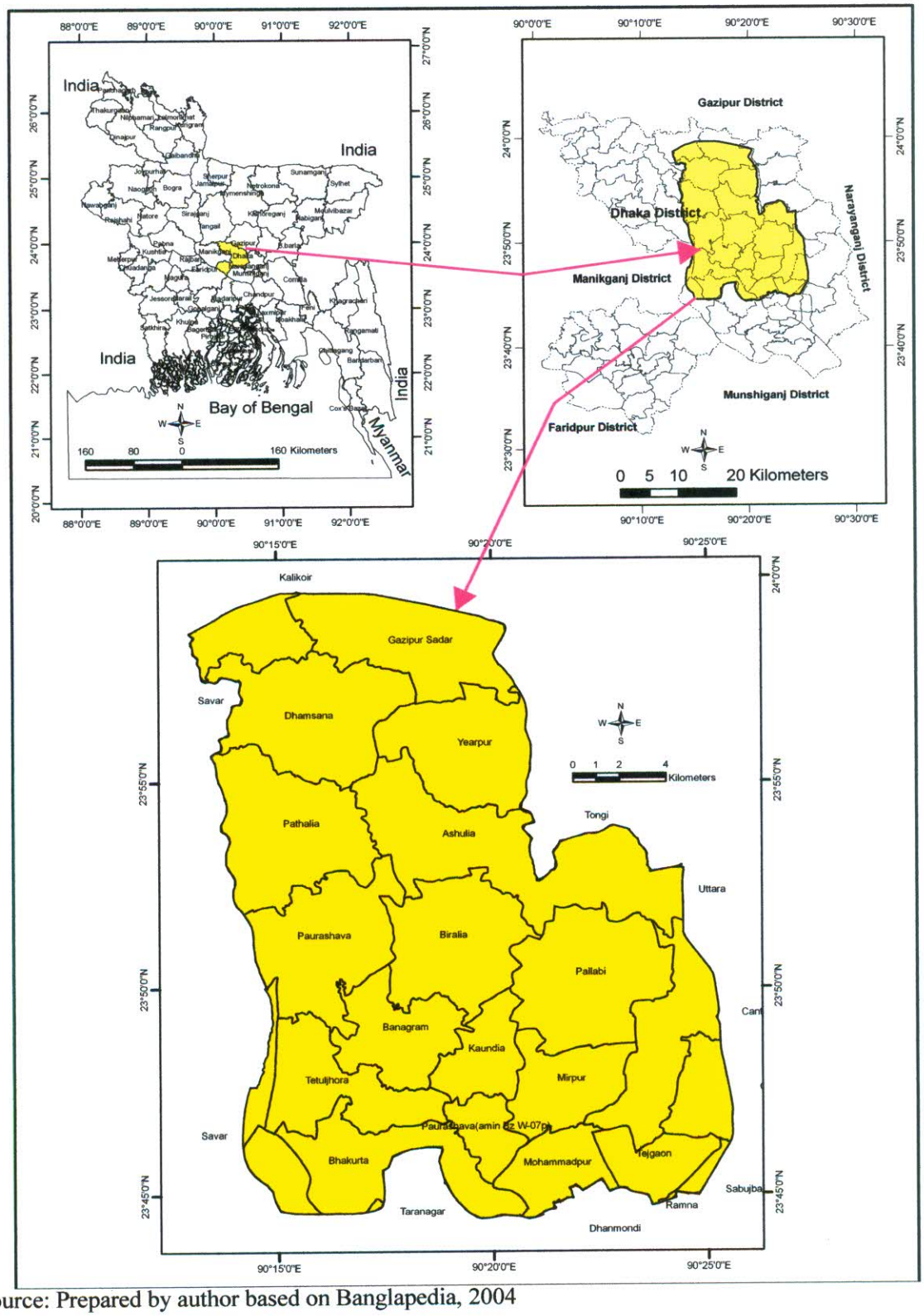
Source: RAJUK, 1997

Figure 4.1 Location of the Three Selected Area (D, E and J)



Source: Google image, 2008

Figure 4.2 Geographical Location of the Study Area



Source: Prepared by author based on Banglapedia, 2004

4.1.3 Climate

Dhaka usually experiences the characteristics of tropical monsoon climate. It is hot and humid during May to September while cool and dries during November to February. The monsoon is the rainy season ranging from the month of May to September (Nishat, *et al.*, 2000). Rainfall in Dhaka occurs from three main sources: the western depression of winter, the early summer thunderstorms known as Nor'westers and the summer monsoon. Average numbers of rainy days per month during June to August are 18 to 22. The average annual rainfall is about 2000 mm. Rainfall is rather scarce during the months from November to February. The lowest temperature during this period may drop down to about 13^0 C. On the other hand, temperature, as high as 33^0 C may occurs during the warm months of March and April. The average temperature of Dhaka is 25^0 C. Monthly evaporation varies from 80 to 138 mm. The climatic conditions of Dhaka are shown in the following **Table 4.2.**

Table 4.2 Climatic Condition in Dhaka (1990-2003)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. rainfall (mm)	11	23	64	126	335	290	377	325	293	167	31	12
Avg. Rainy days/m	2	2	5	9	14	18	23	21	17	9	3	0
Temperature ^{0}C												
Max. Temp.	26	28	32	33	33	32	31	31	32	31	29	26
Min Temp.	13	15	20	23	24	26	26	26	26	24	20	14
Mean Temp.	18	21	26	29	29	28	28	29	29	27	24	19
Humidity(%)	69	63	56	70	80	85	85	84	79	70	74	75
Evaporation (mm/m)	69	87	120	138	132	114	111	108	105	99	81	63

Source: Hoque, 2004

4.1.4 Topography

Dhaka city represents mostly flat land area with slight undulation. It comprises of Madhupur tract and recent sediment. A large part of this city is covered by low lying depression. The elevation of greater Dhaka lies between 2 to 13 above mean sea level (msl). Most of the urbanized areas lie at elevation of 6 to 8 m above msl (**Table 4.3**). The area slopes towards southeast, east and west but general slope is from the north to south east where the ground surface merges gently with the flood plain of the Buriganga River. The highest land of the city is located at Mirpur with an elevation of 13 m while the lowest is in the floodplain of Buriganga River in western part of Dhaka. The topography may be classified into the three

topographic units: high land formation (6-13 m), medium land formation (5-6 m), and lower land formation (1.5- 5 m).The land area above 8 m msl covers about 20sq. km. The land ranging from 6 to 8 m msl covers 75 sq .km. while 70 sq km. of area is below 6 m.

Table 4.3 Land elevation of Dhaka city (above mean sea level)

Land form area	Land elevation above mean sea level (meter)	Comments
1	Higher than 10.0	1 & 2 = these type of landforms considered as safe from annual flooding. 3 = this is marginally free from normal flooding. 4-6 = these type of landforms are under severe threat of flooding
2	8-10 meter	
3	6-8 meter	
	Average flood level 6.0	
4	4-6 meter	
5	2-4 meter	
6	Lower than 2 meter	

Source: FAP 8A, JICA 1992

4.1.5 Geomorphology and Land use

Geomorphology and land use relationship manifest that agriculture is the typical land use of low flood plan, depressions and valleys, whereas most of the settlements have taken place on the higher lands. The higher the land, the more dense has been the urbanization process. But not all the higher grounds visible today in the landscape, are tectonically uplifted terraces or deposited ridges; rather they are the results of land filling owing to urban expansion. Such land filling is mainly occurring on three types of landforms-on flood plains or agricultural lands, on depressions and on low terraces. However, an intrinsic adjustment between geomorphology and land use has been seen in the study area. The geomorphology of Greater Dhaka has been shown in **Table 4.4.**

Table 4.4 Percentage of area occupied by different land use on geomorphic units

Geom. Units Land use Units	Highly Urban (%)	Urban (%)	Semi Urban (%)	Rural (%)	Agricultural Land (%)	Marshy Land (%)	Open Space (%)	Water Body (%)
High Terrace	11.556	-	-	-	-	-	-	-
Dissected Terrace	-	1.57	4.38	1.95	-	-	-	-
Medium Terrace	-	11.16	-	1.44	-	-	0.15	-
Terrace Outliners	0.18	3.43	6.35	1.99	-	-	-	-
Balu Natural Levee	0.14	-	0.28	3.04	-	-	-	-

Balu Point Bar	-	-	-	-	0.05	-	-	-
Low Flood Plain	-	-	-	-	63.71	-	0.8	-
Depression	-	-	-	-	-	9.40	-	0.16
Water body	-	-	-	-	-	-	-	0.36
Rivers	-	-	-	-	-	-	-	4.90
Total	11.88	16.16	11.01	8.42	36.76	9.40	0.95	5.42

Source: Demographic Characteristics of the People interviewed, 2010.

The trend of urban in Dhaka at present reveals that the expansion is taking place along the east of the fringe areas. The overall process of change within the natural environment due to urban expansions is summarized in following **Table 4.4.**

Most of the lands filling sites in the area are located on High terrace and Medium terrace. In the land use category, these two units have been identified as highly urban and urban classes respectively. The soil report of 1965 mapped these units experiencing seasonal flooding, but the present information characterizes the unit as a flood-free zone, this is due to extensive earth-filling activities on the part of rapid urbanization that is occurred in the units, thus elevating their previous height. Information attained from local people revealed that the land filling occurred both at individual and PLDCs levels. But these land-filling are not high enough to save the sites from abnormal flooding. The situation is particularly true for the middle level terrace that includes residential and industrial areas like Mohammadpur (DCC ward nos.43&46), Pallabi thana (DCC ward nos.3&5), Uttara (DCC ward nos.1 and Turag police station area), Savar Paurashava, Amin bazaar, Ashulia and Dhamsona adjacent areas etc. Indications of future landfill on the low lands along the fringes of the urban and semi-urban land use were apparent from the higher rate of selling agricultural land. Such transactions have continuing between the farmers and urban dwellers.

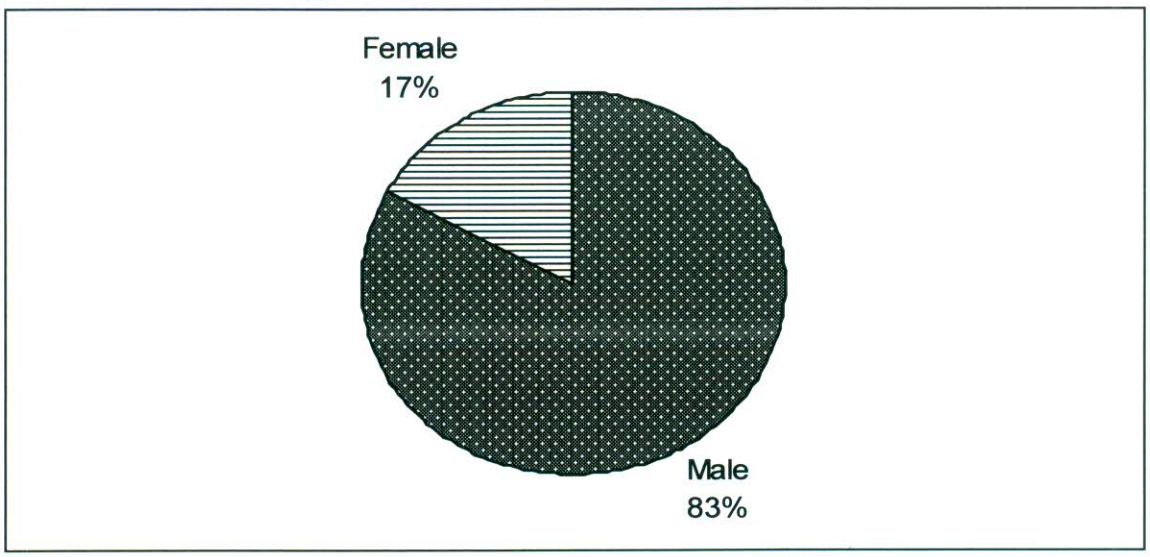
4.2 Demographic Characteristics of the Study Area

These segments capture the most important individual details of the respondent: their age, sex, occupation and level of education. Because of the nature of the questionnaire only individuals of 18 years old or above were interviewed.

4.2.1 Sex Composition

Regarding the sex composition of total respondents, about 83% were males and around 17% were females. Most of the time women were not willing to talk with the interviewers. For this reason the proportion of the interviewed women is lower than the proportion of men.

Figure 4.3 Percentage of respondents by sex

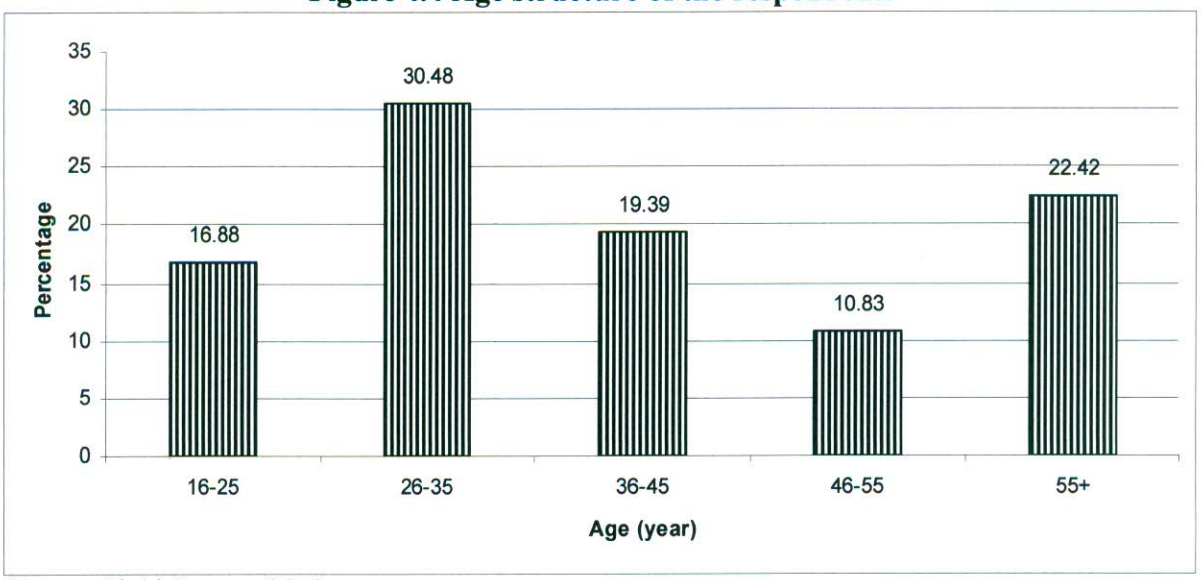


Source: Field Survey, 2010

4.2.2 Age Structure

Most of the respondents (30.48%) belonged to age group 26-35. The second major age group was 55^{+} (22.42%). The lowest number of respondents (10.83%) belonged to age group 46-55, while a slightly higher number of respondents belonged to the age group 36-45 (19.39%). The most junior respondent was 17 years old and the most senior respondent was 93 years old. The average of the respondent was about 43 years.

Figure 4.4 Age structure of the respondents



Source: Field Survey, 2010

4.2.3 Occupation

Among the respondents majority were businessmen (41%). The second major occupation of the respondents was service holder (30.48%). The lowest percentage of respondents was engaged in agriculture (14.61) and day laborers (6.05%). Only 5.29% respondents were housewife and 3.02% respondents were unemployed.

Table 4.5 Occupation of the respondents

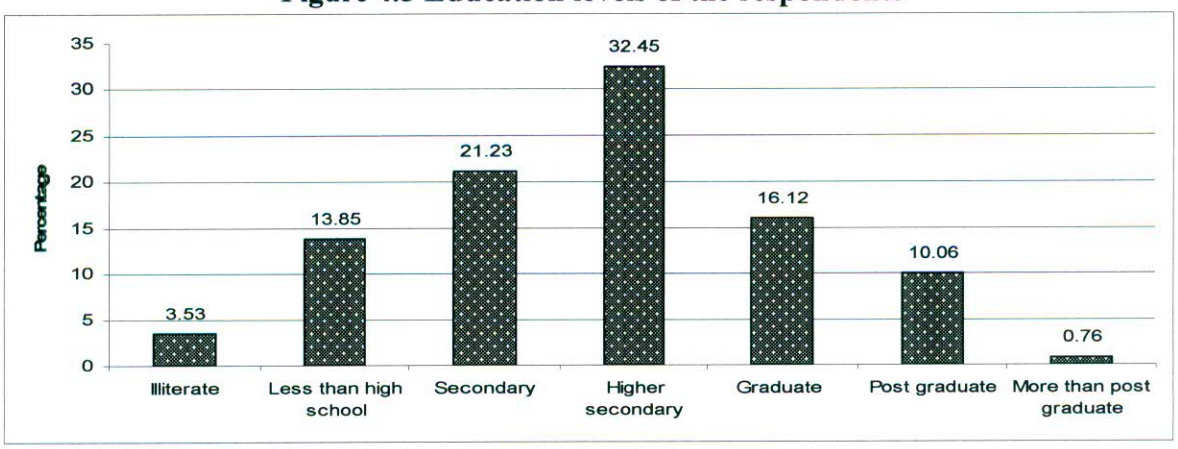
Occupation	Frequency	Percentage
Agriculture	58	14.61
Housewife	21	5.29
Day Labourer	24	6.05
Business	161	40.55
Service	121	30.48
Unemployed	12	3.02
Total	397	100

Source: Field Survey, 2010

4.2.4 Literacy and Education

Education is an important indicator of individual's quality of life. Out of the total respondents 17.2% respondents were of secondary level, while 31.5% respondents were of higher secondary level, 28.5% respondents were of graduate level and around 13% respondent were of post graduate level. Very few respondents were of illiterate but 7.9% respondents were of less than high school level. Only one respondent was more than postgraduate level.

Figure 4.5 Education levels of the respondents

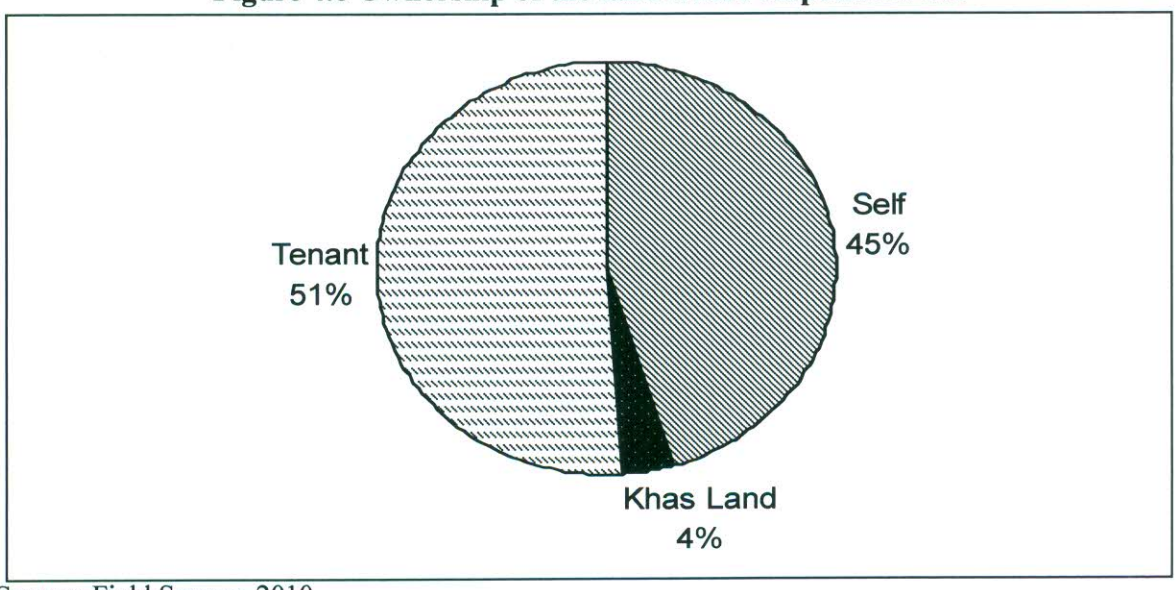


Source: Field Survey, 2010

4.2.5 Land Ownership

During interview the respondent were asked about the ownership of land where they live. Out of the total sample households 45% respondents have own house, while 51% live in rent house and only 3.67% live on *khas* land.

Figure 4.6 Ownership of the land where respondent live



Source: Field Survey, 2010

4.3 Growth of Dhaka City

Dhaka has grown from a small settlement within the confines of the river Buriganga and Dholai Khal to to-days mega city. The physical features, topography and demographic features of Dhaka city have always influenced its physical expansion. During the Mughal and British regime, political importance and trade played significant roles in the city's growth and expansion. Topographical considerations dictated the growth of the city in its different phases of existence. The evolution of Dhaka city and Savar passes through the various historical stages:

- Pre-Mughal Periods (before 1608);
- Mughal Periods (1608-1764);
- British Periods (1764-1947);
- Pakistan Periods (1947-1971) and
- Bangladesh (after 1971).

4.3.1 Pre-Mughal Period (before 1608)

The history of Dhaka in the Pre-Mughal period is lost in obscurity. The discovery of the Gupta gold imitation coins dated 7th century A.D. and an image of Harisankara dated 11-12th centuries A.D. give some ideas about the antiquity of the site and also indicate that Dhaka and some of the neighbouring districts were originally under the sway of the Buddhist kings. The Mauryas and the Guptas appear to have ruled this district till 544 A.D. After the Buddhist, the Palas and the Chandras ruled it. The earliest Dhaka is found in an inscription of Sultan Ruknuddin Barbak Shah dated 1460 and discovered from Birbhum district, but it is doubtful wherher that places may be identified with modern Dhaka (Dani, 1962). Recent discoveries of statues and images of Lord Buddha in different postures of contemplation on massive brick platforms in this place conclusively prove the existence of a thirving Buddhist heritage. Some valuable relics of Raja Harish Chandra's palace have been found at the sites of the on-going excavations of Majidpur Mauza near Savar Bazar Bus stand.

4.3.2 Mughal Period (1608 -1764)

At the beginning of the Mughal period, Dhaka became the capital of the Mughal "Subah" of Bengal when Islam Khan Chishti (1608-1613) transferred the capital here from Rajmahal and renamed it Jahangirnagar after the name of the reigning Mughal Emperor Jahangir, 1605-1627 (Dani, 1962).

During the time of Islam Khan, Dhaka expanded rapidly and in 1610, the proper city are stretched seven to ten miles along the Buriganga river and upto two and a half miles inland (**Figure 4.7A**). During this period, Dhaka was the queen of the cities of Eastern India. The northern limit of the city expended to the gateway built by Mir Jumla (1660-63). Mir Jumla's name is also associated with the construction of two roads connecting Dhaka with a network of forts built for the defense of the capital city. A road headed north to a fort at Tongi-Jamalpur and another toward the east connecting Dhaka with Fatullah, where two other defensive forts were constructed. The two roads influenced the growth of the city in these directions. In the available early records of the East India Company (1786 and 1800 A.D.) the boundary of the city is mentioned as: Barraging in the south, Tongi in the north, Jafarabad- Mirpur in the west and Postogola in the east. The expansion of the city in the Mughal period was dictated by nature, particularly highlands. As a provincial capital, Dhaka enjoyed a golden era, serving as the commercial headquarters and chief emporium for

products of Eastern Bengal. Dutch, Portuguese, French, English, and Armenians were among those who established trading houses in the 17th Century. The population of Dhaka city in the Mughal period was 0.9 million living with its 50 square kilometer area (DCC, 2004).

By the beginning of the 18th century, the capital of Bengal was shifted from Dhaka to Murshiddabad and Dhaka lost its status as a capital town. In 1765, James Rennel reported that Dhaka had an estemeted population of 450,000 and stretched nearly four miles along the Buriganga and two and a half miles deep (Ahmed, 1991). By 1765, Savar was a settlement area and had grown over a longer period of time and **Figure 4.7A** gives an idea of status of Savar in relation to Dhaka in 1765 A.D. According to Dani (1962), Savar had a Buddhist monastery. There was the 'Rajashan' of the saintly King Harish Chandra. It was also one of the scattered capitals of the Afgan rulers who treated after the advent of the Mughal rule. So, Savar has importance in archaeological and historic significance in terms of settlement development and potentialities.

4.3.3 British Period (1764-1947)

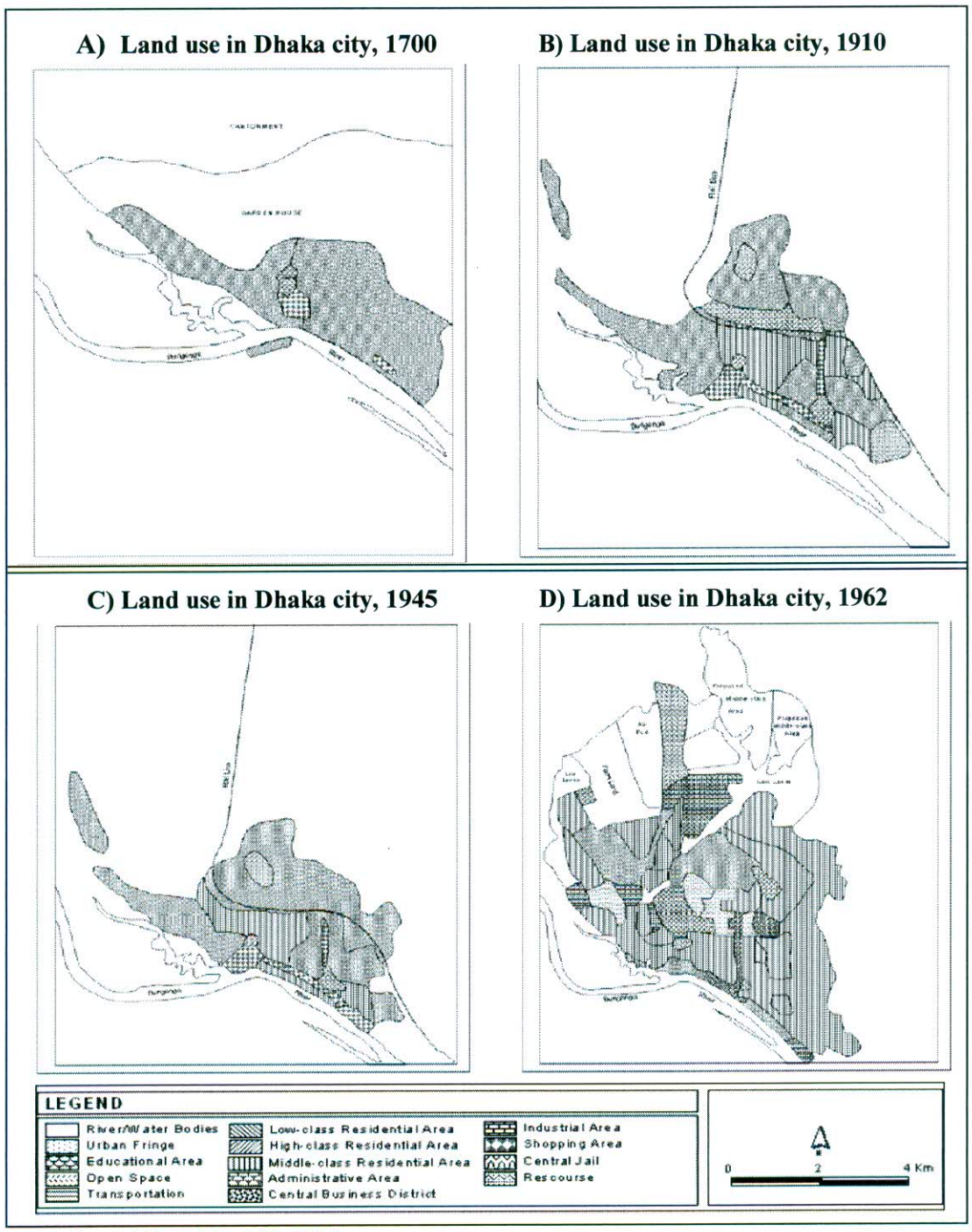
In 1765, due to the military control over Bengal, the political, military and administrative power was shifted to Calcutta and the development process in Dhaka was declined rapidly. By 1801 the population of the city including the suburbs was about 2 million while the limits of the city proper had shrunk to three and a half miles by one and a quarter miles (Ahmed, 1986).

From 1864, onward the town, the developing process which has shrunk earlier in the century, gradually extended. The northern portion of Islampur, Tantibazar, Kamarnagar, Goalnagar and Roy Saheb's Bazar, which were then lowlands, were gradually filled up by the Municipality; and the present court buildings were created after filling up the ditches then existing to the north of present State Bank Building (Dani, 1962). However, the second half of the nineteenth century marked the beginning of the physical renewal of the city. In 1857, India came under-the direct rule of the British crown and saw some development of utility services.

In 1905, Dhaka became the capital of the newly created province of Eastern Bengal and Assam, but the opposition of the Hindus led to reversal of the partition in 1911(**Figure 4.7B**) and Dhaka again lapsed into the position of district town and Calcutta became the capital of Bengal and in 1947, Dhaka again became the provincial capital of East Pakistan and the

development process took place in Dhaka and other peripheral region. **Figure 4.8C** shows the development pattern of Savar in British period. In 1947, the development process basically confined to the Savar Bazar and surrounding areas.

Figure 4.7 Historical developments and land use pattern of Dhaka city (1700-1962 A.D)



Source: Adopted from Tawhid, 2004

4.3.4 Pakistan Period (1947-1971)

Pakistan was created on the 14th August, 1947 and Dhaka was made the capital of the province of East Pakistan. Dhaka was suddenly called upon to shoulder many responsibilities (Islam, 1996). The real extent of Dhaka city in 1947 at the end of the British rule was not more than 65 sq. km, with its built limits extending from the northern bank of Buriganga River only up to Tejgaon. Its population was approximately 250,000 at that time (Islam, 2005) the needs of the officials engaged in administration, the business community and the residents grew out of the sudden on rush of people to Dhaka.

Planning continued such that open areas of the city were devoted to recreation, residences, and more commerce to cater to the ever-increasing residential needs of the new capital, the Dhanmondi area, adorned with paddy fields in the early 1950s was developed as a residential area after 1955. Till 1971, the Dhaka city was stretched from the Buriganga River in the south to Gulshan, Banani, Tongi in the north; and from Mirpur in the west to Rayer Bazar, Hazaribagh, Jatrabari and Dholaippar in the east.

During this period, the development process in Savar also took place. The transmission centre of present Radio Bangladesh, Savar Dairy Farm and Jahangirnagar University were the major developments that took place mainly along the Dhaka-Aricha Highway on the build-up lands. Further, the construction of Nayarhat and Mirpur bridges on the Bansi and Turag rivers and up gradation of Dhaka-aricha road provided better transport facilities and helped Savar to grow further in recent decades. **Figure 4.7D** shows the status of Dhaka city and Savar during the Pakistani regime.

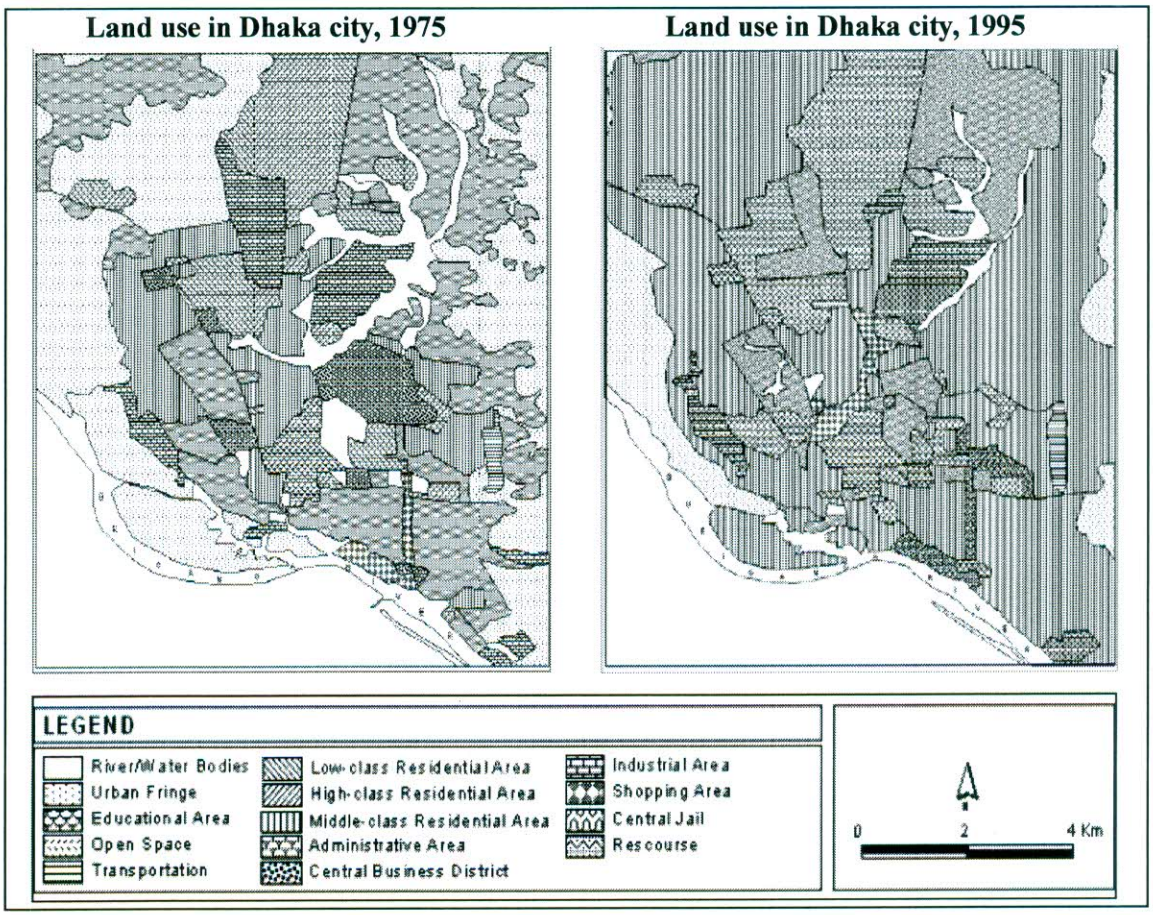
4.3.5 Bangladesh (1971 onward)

Dhaka rearranged itself again as the capital city of Bangladesh after the liberation war in 1971. It accommodates all public and private factories and industries, and commercial establishments. The significant influx and natural growth of population after the liberation war made this one of the most populated cities in the world (DoE *et al.*, 2006).

From 1974 to 1981 population of Bangladesh increased more than doubled and this rising volume was marked by the physical expansion of the city. In 1990, the total population of Dhaka city was 6 million and due to the heavy population pressure, the Dhaka city rapidly increases and now the city is extended as far as Joydebpur, Kaliganj, Sonargaon and Savar (Figure 4.8). In fact, Savar came into limelight after the independence of Bangladesh. The establishment of Gana Sawastha Kendra, Savar Cantonment, Youth Training Complex and Jatiya Smiriti Shoudha have reinforced further developments in Saver. The recent

construction of Bangladesh public Administration Training Centre (BPATC) has given an added impetus to the growth of Savar. Private industries were established along the main roads. The availability of built-up lands and infrastructural services like gas, electricity; and roads, flood free lands and expanding market are the main factor that favored in industrial growth along the main roads of Savar (**Figure 4.8**).

Figure 4.8 Development and land use pattern of Dhaka city in Bangladesh period



Source: Adopted from Tawhid, 2004

Since the 1990s, Dhaka has been on the verge of change in its urban character with vertical growth replacing horizontal expansion. Being a principal, city contributes to a great extent to the nation building process, but such role often leads to potential negative social and environmental impacts. Moreover Dhaka is growing in an unplanned way. The present trend of city development is alarming and unacceptable. Absence of policy implementation has resulted into sell-out of huger chunk of available lowlands to individuals and over ambitious

developers. In Dhaka urbanization proceeds because the planning procedure is extremely weak and slow. But the development occurred in a scattered and unplanned way.

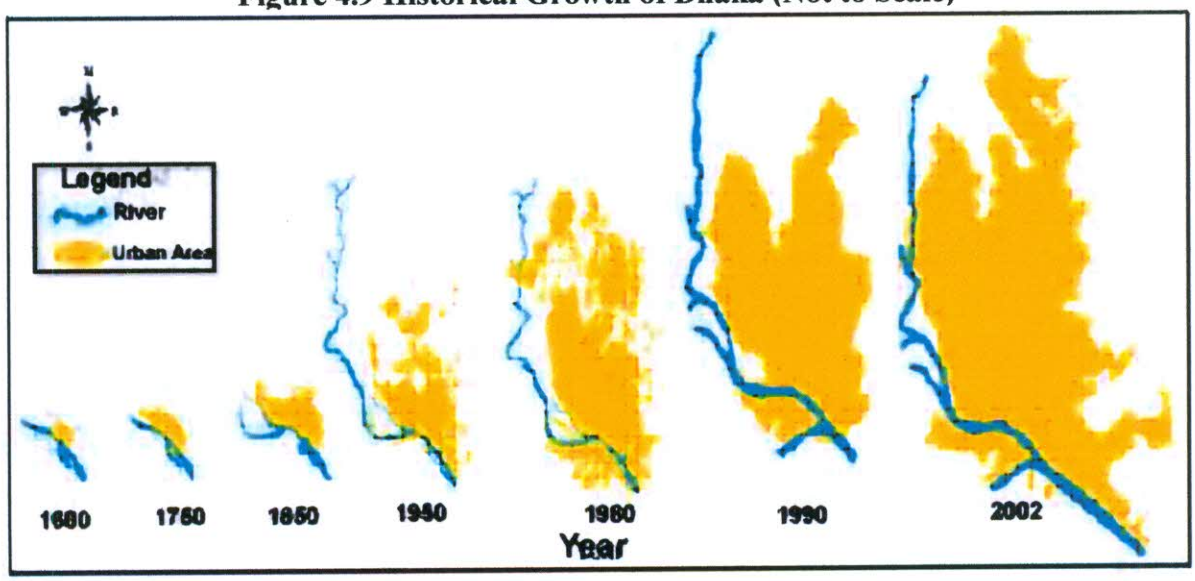
The expansion of Dhaka city in the 1950s could be described as dawdling and steady, in the 1960s the speed was picked up but in the period after the emergence of Bangladesh in 1971, it could be said to be extraordinary because of its standing as the capital of a new country. The development of Dhaka has followed the dictation of nature, rather than planned growth. The development of Gulshan, Banani, Baridhhara and Uttara was based on choosing the highlands on the main Dhaka-Tongi axis road and Mirpur on Dhaka-Savar axis road. Dhaka did not expand toward the south beyond Buriganga River, until the construction of bridges over the river Buriganga in the 1980s and 1990s. No serious effort at reclaiming land under a well-planned scheme to give the city a homogenous and cohesive growth is visible. Dhaka has grown on its own, in a haphazard manner and the topography of the area dictated the terms and direction of the growth. Since Dhaka became the capital of an independent sovereign country, the pressure on it has become enormous. The number of permanent inhabitants of the city registered a steady growth from 2 million to 10 million in 30 years (**Table 4.6**).

Table 4.6 Area and population of Dhaka city, (1600-2005)

Year	Period	Area (Sq. mile)	Population	Source
1600	Per-Mughal Period	1	Unknown	Islam, 1974
1700	Mughal period	50	9,00,000	Taylor1840
1800	British period	8	2,00,000,	Taylor,1840
1867	British period	8	51,000	Census of Bangladesh, 1901
1911	British Period	--	1,25,733	Census of Bangladesh, 1911
1947	Pakistan Period	12	2,50,000	Census of Pakistan 1951
1951	Pakistan period	28	3,35,928	Census of Pakistan, 1951
1961	Pakistan period	35	5,50,143	Census of Bangladesh 1961
1971	Capital of Bangladesh	40	15,00,000	Census of Bangladesh 1974
1974	Bangladesh period	125	1,77,2000	Census of Bangladesh 1974
1981	Dhaka Municipality	155	34,40,147	Census of Bangladesh, 1981
1991	Dhaka city Corporation Area	276	4,486,421	Census of Bangladesh 1991

2001	Dhaka city Corporation Area	276	5,378,023	Census of Bangladesh 2001
2005	Dhaka city Corporation Area	390	8,400,000	DoE *et al.*, 2006
2005	Dhaka Statistical Metropolitan Area	522 (1353 sq km)	99,12,908	DoE *et al.*, 2006

Figure 4.9 Historical Growth of Dhaka (Not to Scale)



Source: Urban Planning Department, Dhaka City Corporation, 2004

Physical expansion of the Dhaka city is governed by the number of factors. These are mentioned below:

- Capital of the country
- High growth rate of population
- All the ministries and high government offices, Embassies, and good institutions are located here
- Rural-urban migration occurred because of better opportunities for jobs and accelerated rapid and uncontrolled growth of slums and squatter communities particularly in the low lying areas
- Lack of decentralization process in National Development Programs
- Good economic return from the land
- Infrastructural development

Rural urban migration is recognized as a major component of the aerial extent of the city in Bangladesh. The governing factors for this type of migration are rural population densities,

rural landlessness, natural disasters, and less employment opportunities. Beside these factors, other important factors are the relatively more attractive opportunities for betterment of their present and future life.

4.4 Urbanization in Bangladesh and Dhaka City

The positive correlation between economic development and urbanization is well recognized. Even in many of the developing countries more than 50 percent of their GDP is derived from the urban areas although such areas contain much lower shares of national population. The roles of urban areas in the national economy are likely to be stronger in the future (Islam, 1996). In Bangladesh too, urbanization is making an increasingly higher contribution to the national economy. Besides, urbanization plays a significant role in changing the quality of taste of many people at the individual or household level. However, when urbanization or the growth of urban population and physical expansion of urban areas take place at exceptionally rapid rates, most cities and towns are unable to cope with the changing situation due to their internal resource constraints and management limitations. Many serious problems emerge under such a situation of 'over- urbanization'.

Like many other developing countries, Bangladesh has been experiencing very rapid urbanization. As a matter of fact, the rate of urbanization in Bangladesh has been one of the highest, over 6 percent annually, during the last three decades. However, the level of urbanization (i.e. percent of total population living in urban areas) is still quite low in Bangladesh compared to the average in developing countries and even lower than in India, Pakistan and Sri Lanka of South Asia. Yet, the absolute size of urban population in Bangladesh is quite high, about 23 million in 1991. Every year one million or more additional number of people is added to the urban population of Bangladesh. This number would be increasing every year in the future. By the year 2020 Bangladesh would possibly become an "urbanized" country with more than 50% of its population being urban.

The growth of urban population in Bangladesh has been taking place due to (a) high natural increase, (b) change in boundaries of urban centres or revision of definition of urban centres and (c) rural to urban migration.

The urban population will continue to increase rapidly giving the very high natural increase both in urban and rural areas. Due to worsening land-man ratio and weakening economic condition in the rural areas, the rural to urban migration rate will also remain rather high for many more years. Indeed, the already massive base population (120 million plus in 1996) of the country and its persisting high overall growth rate (2.2% annually) are leading it to an

almost impossible situation. By 2025, the country's population may even cross the 200 million mark and the urban population would be around 100 million. These are very high figures for a small country like Bangladesh, which is characterized by dwindling natural resources potentials, very low level of human Development Indicators and lower level of statecraft or management of the rural and urban environments.

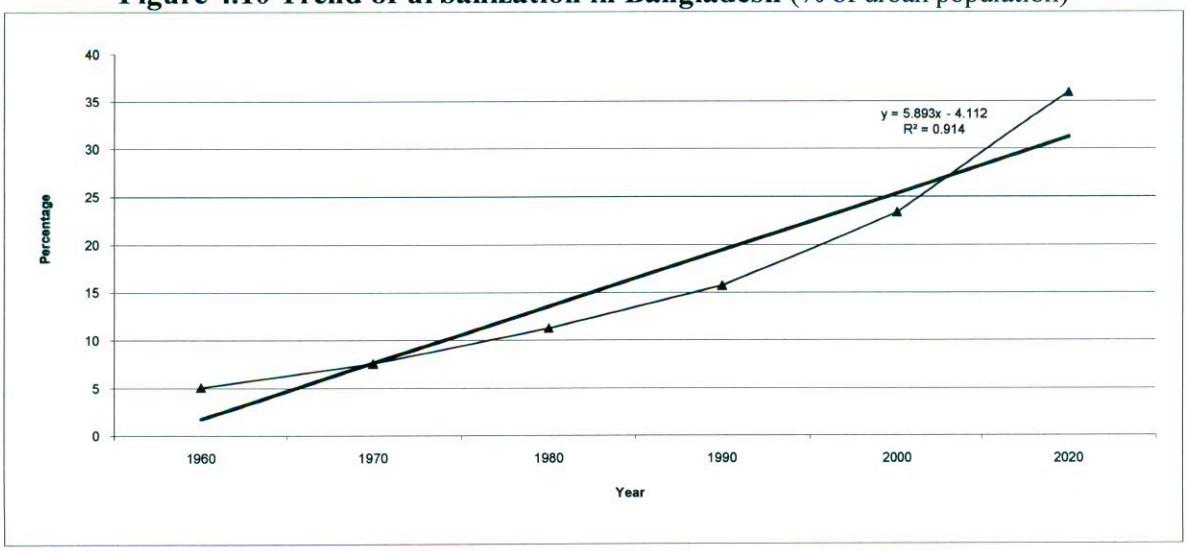
Bangladesh has experienced one of the high treats of urbanization in the last few decades. Urban population has grown at an annual rate of about 3.9 percent during 1960-1970, 4.0 percent during 1970-1980, 3.3 percent during 1980-1990, and 3.8 percent during 1990-2001 while rural population has grown at a rate of 1.04 percent during 1991-2001. Because of the large national population size, the absolute size of urban population is large at 28.8 million (BBS, 2001). With the increasing growth rate of urban population the level of urbanization in Bangladesh is also increasing (**Table 4.7 and Figure 4.10**).

Table 4.7 Level of urbanization and annual growth of some Asian countries (in percent)

Country	Level of Urbanization						Average Annual Change				
	1960	1970	1980	1990	2000	2020	1960-1970	1970-1980	1980-1990	1990-2000	2000-2020
Bangladesh	5.1	7.6	11.3	15.7	23.39	36.0	3.9	4.0	3.3	3.8	2.6
India	18.0	19.8	23.1	25.5	28.6	41.3	1.0	1.6	1.0	1.1	1.8
Malaysia	26.6	33.5	42.0	49.8	57.5	70.2	2.3	2.3	1.7	1.4	1.0
Thailand	12.5	13.3	17.0	18.7	21.9	35.1	0.6	2.5	0.9	1.6	2.4

Source: Uddin, 2004 and Report of Asian Development Bank, 1997

Figure 4.10 Trend of urbanization in Bangladesh (% of urban population)



Source: Researcher Computation, 2010

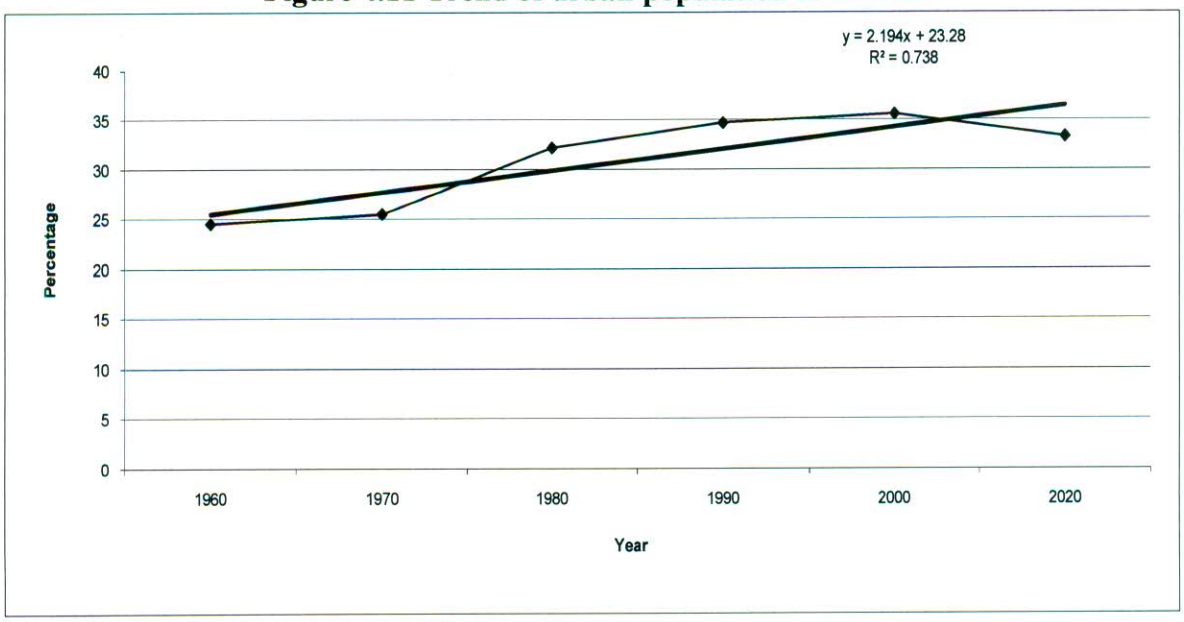
A salient characteristic of urban systems in developing countries is the concentration of urban population and economic activity in one or few larger cities. Urban concentration is, in fact, the most acute in Asia, and considers this phenomenon to be the bigger problem than the speed of urbanization itself. The percentage of a country where urban population residing in the largest urban agglomeration which is known as its primate city. In South Asia, urban population in primate city is highest in Bangladesh at 35.6 percent followed by Myanmar at 30.8 percent, Pakistan 20.1 and India 6.2 percent. In Southeast Asia urban population concentration is highest in Thailand at 54 percent followed by Philippines and Vietnam. The data in **Table 4.8 and Figure 4.11** indicate broadly varying trends in urban primacy among developing countries in Asia (ADB, 1997).

Table 4.8 Trend of urban population in Dhaka (% of urban population)

City	Year					
	1960	1970	1980	1990	2000	2020
Bombay	5.1	5.3	5.1	5.6	6.2	5.8
Bangkok	65.1	65.5	59.3	56.6	54.0	48.8
Dhaka	24.5	25.5	32.2	34.7	35.6	33.3
Karachi	16.7	19.1	21.0	20.4	19.7	17.7
Kuala Lumpur	15.9	12.4	15.9	12.6	10.8	10.1
Manila	27.2	28.6	32.9	26.9	24.6	22.5
Yangon	22.6	22.9	27.3	31.9	30.8	28.3

Source: Uddin, 2004 and Asian Development Bank, 1997

Figure 4.11 Trend of urban population in Dhaka



Source: Researcher Computation, 2010

Dhaka, the primate city, and the other metropolitan areas of Chittagong, Khulna, Rajshahi, Sylhet and Barishal dominate the urban system in Bangladesh. Among the six cities Dhaka itself contains more than half and other five largest cities together account for less than half of the total urban population of the six cities (Table 4.9). Dhaka's population has growth at an annual rate of about 15.51 percent during 1961-1974, 14.89 percent during 1981-1991 and 8.6 percent during 1991-2001 (BBS, 2001).

Table 4.9 Population of four statistical metropolitan area and six city corporations

SMA	2001	2006 (Estimated)	2007(Estimated)
Dhaka	96,72763	118,13728	122,95728
Chittagong	29,91723	35,87692	37,20437
Khulna	11,72831	13,23071	13,55354
Rajshahi	6,51062	7,37336	7,56359
City Corporations			
Dhaka	53,33571	64,79751	67,37774
Chittagong	20,23489	24,38403	25,32421
Khulna	7,70498	8,30454	8,42995
Rajshahi	3,88811	4,47031	4,59682
Barisal	1,92810	2,05166	1,95955
Sylhet	2,63197	3,94119	4,45798

Source: BBS, 2007a

Recently urban expansion is stretching into the lowland, back swamps and depressions. The following table depicts the relationship of urbanization process and geomorphologic characteristics of Dhaka city from 1955 to 1996 (**Table 4.10**).

Table 4.10 Relationship between urbanization and geomorphology during 1955-1996

Geomorphic Unit	Year				
	1955	1975	1983	1989	1996
High, medium, low Madhupur terrace and natural levee	86%	91%	94%	94%	95%
Depression, abandoned channel, point bar	14%	9%	6%	6%	5%

Source: Khan, 1997

The table mentioned above is giving a very clear indication of urban areas stretching into lower land over the time period. Because of the population growth/migration, urbanization is stretching along/towards the depression or back swamps. This process started from the mid eighties. These wetlands are very important for the ecological and environmental balance of the city.

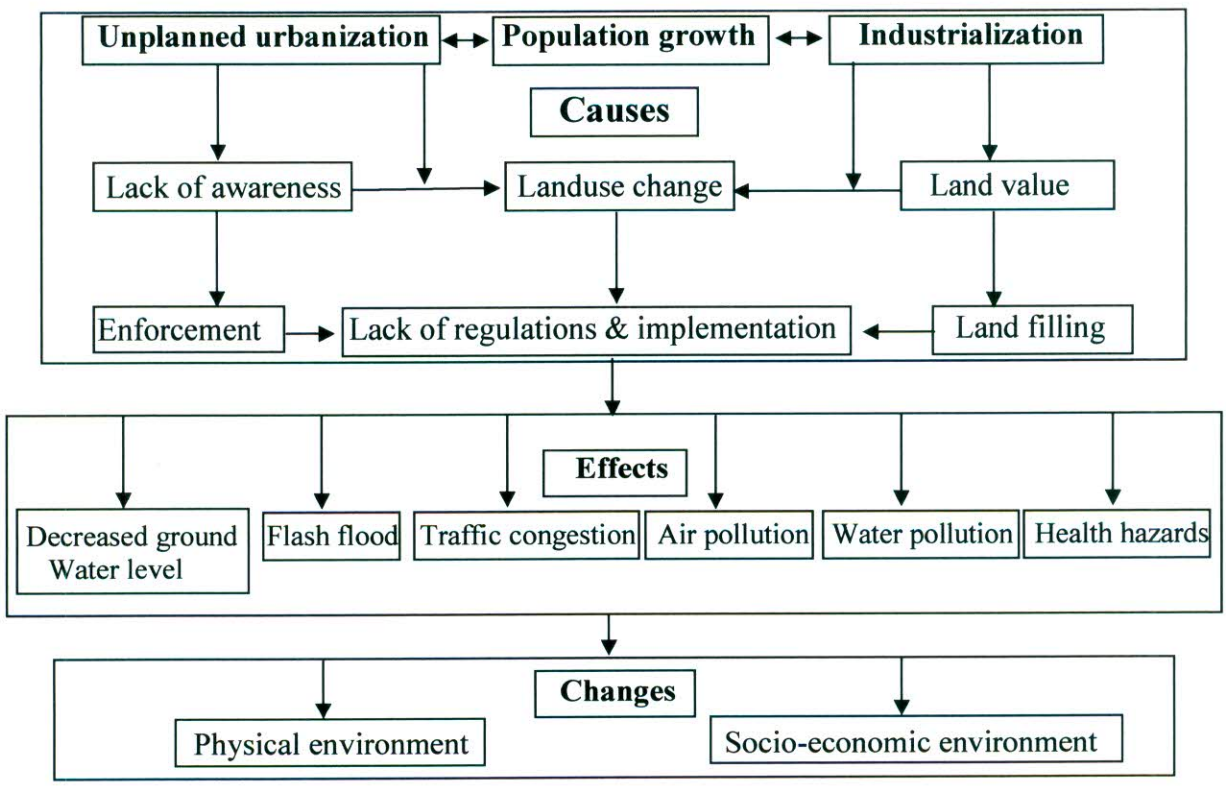
4.5 Causes and Effects on Land use Changes

The possible causes of land use/cover changes can be grouped into four categories: population, technology; political economy and structure; and attitudes and values (Turner and Meyer, 1994). So, this study gives a new experience and provides a fresh data base. Result obtained from the study supplemented by other secondary data reveals that the major causes responsible for land use changes are: rapid population growth and unplanned urbanization, industrialization, some socio-economic; and political and institutional factors (Heilig, 1997; Lambin *et al.*, 2001).

The overall environment particularly, the physical and socio-economic environments are changed due to effects of changing landuse practices. The schematic flow diagram (**Figure 4.12**) is used to describe various functions and interrelationships of each sub-component. Practice of unplanned urbanization and industrialization were remarkable converted to agricultural land, vegetation, water-bodies and wet/lowlands. As a result, the impervious area is increased in the study area as any man made object of impermeable natures that considerably diminishes the water storage capacity. 75 percent of the total urban areas are impervious in nature in Dhaka city. It contains 25 percent permeable surfaces that have not been engulfed by urbanization (Khan, 2001). The impervious areas play a significant role to aggravate water logging, reduced infiltration/subsurface flow, reduced ground water recharge, increase in the flood peak, increase in surface runoff that puts pressure on existing drainage system and some cases causing failure in drainage performance.

The industrialization are degraded the quality of urban environment. The industrial pollutants are to the river and *khals*; and caused water and air pollution. On the other hand, air, water and sound pollution are seriously hampered in human health. However, overall environment particularly, the physical and socio-economic environments are changed due to effects of changing landuse practices.

Figure 4.12 Diagrammatic model of overall function and implication of landuse changes



Field survey reflects that the rate of land use change in Dhaka city, loss of agricultural land, vegetation, water-bodies and wet/lowlands are high at the built-up areas. To find out inherent causes of land use change in Dhaka city, a field survey, as a questionnaire survey, informal interviews and open discussion have been conducted with the authorities of different concerned organizations, experts and people living in different areas in Dhaka city. The total numbers of respondent were 397 and following **Table 4.11** shows their summarized opinions about the prime causes for land use change in the city.

Table 4.11 Causes of land use change and people's perception

Causes	No. of Responses	Percentage
Unplanned urbanization	337	84.89
Population growth	251	63.22
Industrialization	243	61.21
Land value	227	57.18
Encroachment and land filling	214	53.90
Lack of public awareness	88	22.16
Lack of regulations and its implementation	139	35.01

Source: Field survey, 2010

Table 4.11 represents the causes of land use change; it appears from their respondents identified unplanned urbanization (85%), population growth (63%), industrialization (61%), land value (57%), encroachment and land filling (54%), Lack of public awareness (22%); and Lack of regulations and its implementation (35%).

4.5.1 Unplanned Urbanization

Dhaka is a major city in Asia and one of the fastest growing cities of the world. A principal reason of such a rapid growth is over concentration of maximum activities and development works in the city and little improvements in other cities, towns and villages in terms of infrastructures development and economic activities. Dhaka city has an enormous number of floating populations, which is the result of migration. People affected by the different kind of natural hazard i.e. riverbank erosion, cyclone, flood, etc. migrate towards Dhaka for their survival. Because of resource constraint and high land value it is very difficult for the government to accommodate those people. As a result illegal land encroachment has been accelerated along the bank of the wet/lowlands (**Appendix D2).**

The urbanization activities have been achieving tremendous growth of the needs of the newly independent country's capital. The city began to expand in all directions including over the wet / lowlands. Land development through filling of wetlands areas in the study area prompted urban expansion, establishment of infrastructures including road infrastructure, electricity gas and water supply etc. Urbanization enhances service facilities through establishment of residential, commercial, industrial, educational and administrative areas; in addition to that motorized road network contributes to economic development and enhancing the quality of life. The demand for land within Dhaka has increased tremendously as the mobility of urban, sub-urban and regional commuter has increased. This has initiated the ongoing development of housing through land filling in the study area.

Present management practice of development agencies in the Dhaka city is not at all systematic. Urban planning and development management in Dhaka is fragmented and uncoordinated. There are 42 agencies belonging to 22 ministries that guide and control Dhaka city. On one hand, RAJUK, the capital development authority has both urban planning and development responsibilities for Dhaka city. On the other hand, citizen services are provided and maintained by DCC. These arrangements have led to conflicts and misunderstandings among different government agencies. It appears from the opinion of the

respondent that rapid growth of population and unplanned urbanization is the main cause of land use changes. 85% respondent identified that unplanned urbanization is mainly responsible for land use changes and the effect of urban environment.

4.5.2 Population Growth

Dhaka city being the administrative, commercial and cultural capital of Bangladesh has now turned into 26th Mega City and 10th most Populous City of the world. It is the nerve center of the country. The population of Dhaka has grown from only 0.1 million in 1906 to 3,36,000 in 1951 and 10.71 million in 2001 (BBS, 2001). It is growing at an alarming rate (5.6% during 1991-2001 inter-casual periods). As per future prediction, this population will further grow to about 20 million by the year 2020 and to 25 million by 2025 (RAJUK, 1997). Dhaka city is projected to be one of the four largest mega cities in the world by next 10 years. A principal reason of such a rapid growth is over concentration of maximum activities and development works in the city and little improvements in other cities, towns and villages in terms of infrastructures development and economic activities. Improved road communication in the country further made it easy to converge on the capital for searching employment and better quality of life. High-density population as well as shortage of land causes intense densification in the existing built-up areas. Out of 397 respondents 251(63%) respondents replied that rapid population growth is the main causes of land use change in the study area. **Table 4.12** shows the population growth trend of DMA and DCC area.

Table 4.12 Population changes in Dhaka metropolitan area and Dhaka city corporation area

Year	Population (DMA)	Growth rate (DMA)	Population (DCC)	Growth rate (DCC)
1974	19,50252	-	-	-
1981	34,58602	8.5	-	-
1991	733,40000	7.8	44,86421	-
2001	111,62000	8.2	53,78023	3.77
2016	155,69000	8.33	80,00000	1.02

Source: BBS, 2001 and RAJUK, 1997

Extreme unplanned growth in and around Dhaka is showing a high degree of congestion and over crowding and malfunctioning of the traffic system. High-rise buildings are springing up. Many of such buildings tend to serve commercial purposes. Business activities are found in 'greater or lesser degree all along the roads' and pavements but 'intensify at the cross-roads.'

Photograph 4.1 Fast growing "Concrete Jungle" tells the tale of and unplanned city

Source: http://www.thedailystar.net

The city exhibits a very high density 'human population' with inadequate space to live and much lesser road infrastructures to move. The rapidly growing urban population in Dhaka and its outskirts is enhancing environmental pollution posing 'problems to human health and threatening the general quality of life'. **Photograph 4.1** illustrates the increased built-up area in Dhaka city.

4.5.3 Industrialization

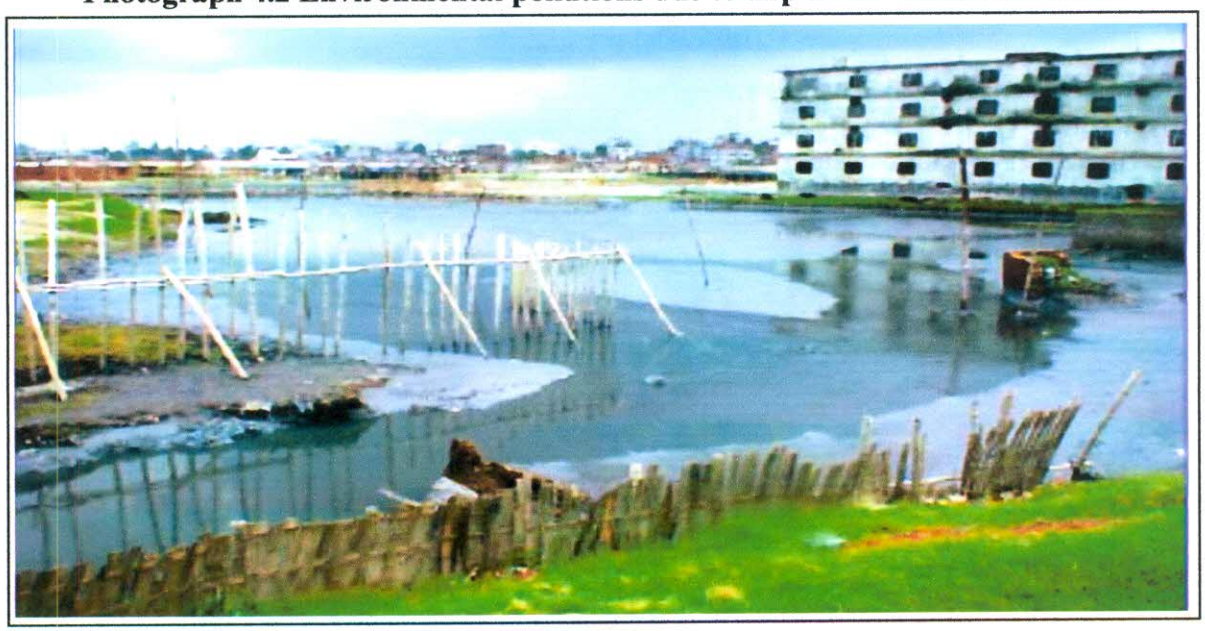
According to field survey, 61% respondents mentioned that industrialization is the important factors of land use change in the study area. Dhaka has rapidly been developed with a large number of industrial and commercial establishments, formal settlements, roads and highways and growth of real estates. Most of these development activities were carried out in an unplanned way and many of them were established illegally in the Turag, Balu and Buriganga River. The same practices are continued with all the lakes and water bodies (e.g. ponds, ditches etc) in the city due to encroachment and illegal filling up of wet/lowlands by the local muscle power.

After independence, a large number of industries were established in the study area. Nearly 2000 garments industries have been established all over the city starting during the early 1980s. However, after the independence, the number of total industries has increased to about 1200 (IGES, 1998). Of this jute, tannery, dyeing and textiles, chemicals and pesticides,

battery, petroleum refinery, distillery, plastic, brick manufacturing etc. were established in a rapid and unplanned manner in different places of Dhaka city (Siddiqui *et al.*, 2004).

Industrialization is not only causes of land use change but also main factors of environmental pollution. The national pollutions profile shows that the unplanned industrialization is responsible for large percentage of pollution loads in the country. The following table (**Appendix B1**) shows that 12 highest polluting industrial sub-sectors contribute more than 85% for three of the pollutants considered (toxic chemicals to land, toxic metals to water, and SO_2); more than 70% for two more pollutants (toxic chemicals to air and BOD); and more than 50% of the sixth pollutant (total particulates).

Photograph 4.2 Environmental pollutions due to unplanned industrialization



Source: Field visit, 2010

Ashulia, Uttara and Amin Bazar area has been built-up with a mixture of large industries, which might be the main source of air and water pollution in the city, especially the SPM concentration which has already exceeded the International Standard. The high concentration of tanneries in the main source of water, air and soil pollution often creates problems for the people living and working in that area. The numerous industries established in Uttara, Tongi, Ashuli and Savar EPZs area may be responsible for the localized pollution of air and water.

4.5.4 Land Value

Land value in the study area of Dhaka has been increasing for a long period. Before 1970s, land value of the city and its peripheries increased slowly. After the 1970s, land value of the areas had increased due to demand for urban land. The values varied in landing on locations and sites and classifications of land. The average value of an acre (0.405 ha) of land in 1974, suitable for both cultivable and housing, was about Tk. 0.1 million. This value increased fourfold in 1981, and tenfold in 1990 (RAJUK, 1990). The study has identified some physical factors that influence the land price in Dhaka. These include the type of neighborhood (planned/unplanned), width of the main road, width of access road, surface quality of the road, distance of the main road from the area, duration of water logging and distance of the marketplace and the nearest health facility.

According to a study, Dhaka City has seen the unusual rise in the land price due to a lack of land compared to the demand. The study says real-estate companies have had land development and housing projects all over the city driving up the land price, as they compete with each other for a single piece of land. The 1980s, mainly different actors like the PLDCs, housing cooperatives, individual households and land brokers operated in the land market. The government's development in the land market was almost absent, but in an indirect way, it was participated market supplying residential, commercial and industrial plots. These companies engaged local *dalals* to purchase land for their meets through negotiation with private landowners. The land values of the study area are shown in the **Table 4.13**.

The study says that the shift in land use from residential to commercial purpose knocks up the price further. 'The growth rate of land price of Amin Bazar area (Mohammadpur, Adabor, Kallyanpur, Gabtali and Amin Bazar union) were higher during 1960 to 2010, which was 4000%-6000%. In recent years, the land price in Mohammadpur has broken the previous records due to a fierce competition among the developers.'

The study found only one area in the city, Uttara area (Harirampur union), where the land price had been rising faster long before the Independence (between 1947 and 1966). Land prices at Harirampur union increased by 50-100% before Independence and by 2000%-3000% after Independence. And the area closest to Ashulia Bazar and the Ashulia-Tongi Bypass in the vicinity of Ashulia union experienced a marked rise in land value during the given period; while the rural area experience a lower level of land value is too high because of their industrial importance.

For instance, during 1960-2010, Uttara area (Hrirmpur union) and Amin Bazar area, an urban experienced a rapid increase of land value-by about 3000% and 6000% respectively; while,

Ashulia union, a rural area experienced a relatively slow increase in land value- about 1875%. **Table 4.13** shows the spatial pattern of land value change in the study area during 1960 to 2010. It is seen in the table that the land values differ greatly from place to place and are influenced by the location of given land in relation to the accessibility routes and proximity to Dhaka city and the core administrative and commercial areas of Amin Bazar, Uttara and Ashulia, and the availability of flood free lands.

Table 4.13 Land value change pattern in the study area Ashulia-Uttara-Amin Bazar during 1960-2010

Area	Land value (in '000Tk/decimal)			% of Changed land value		
	1960	1991	2010	1960-'91	1991-2010	1960-2010
Ashulia area						
High land	0.3-0.5	50-100	5,00-10,00	190	10	1875
Medium land	0.15-0.2	10-15	2,00-3,00	71	20	1429
Lowland	0.10-0.15	3-5	50-60	32	14	440
Uttara area (Harirampur union)						
High land	0.4-0.6	50-100	10,00-25,00	150	23	3000
Medium land	0.2-0.3	15-20	5,00-10,00	70	43	2800
Lowland	0.1-0.2	5-10	50-100	50	10	500
Amin Bazar area						
High land	1.0-1.5	3,00-5,00	50,00-100,00	320	19	6000
Medium land	0.5-1.0	2,00-3,00	30,00-40,00	333	14	4666
Lowland	0.2-0.5	50-100	2,00-10,00	300	11	2286

Source: Field Survey, 2010

Note: **High land means**: Road side resident and commercial and flood free land;
Medium land means: cultivable and vegetated land; and lowland means: water-bodies, *Khals, doba* and flood porn areas.

4.5.5 Encroachment and Land filling

Most of the natural drainages of Dhaka city disappeared or are in way to lose their existence due to illegal encroachment. According to 54 percent of respondents, encroachment on the rivers, lake and *khals* /drains through unauthorized construction and solid waste, and the lack of regulations to prevent encroachments making the drain ineffective to drain are run off. Dhaka metropolitan city is bounded by Tongi khal on the north, the Turag and the Buriganga Rivers on the west and as the Balu River on the east. A good number of khals criss-crossing the city, have some of their out falls in these rivers and are playing a very significant role in the drainage system of the city area. During 60s, there were around 50 khals in Dhaka City and their length was 256 km. But due to the encroachment, presently there are only 26 khals and their length is 125 km (The Daily Star, June 2, 2010).

Wet/lowlands encroachment is very common practice in Dhaka city and surroundings. The first step of encroachment is to build structures along the banks of wetlands and further out on the wetlands itself. To do this, rows and bamboo posts are positioned and fixed on the water-body bed along the bank and extending into the main body of the wetlands. Then huts and shops are built on these stilts. The owner of these structure then start reclaiming land by earth fills and dumping garbage. Rivers are being encroached upon deliberately filled up and are being held as private property (Khuda, 2001). **Photograph 4.3** shows the sign of illegal encroachment on lowlands in Ahulia area.

The wet/lowlands around the Dhaka city like Ashulia are degrading for rapid urbanization. The developers are filling the low lands of Ashulia to build apartment complexes. The real estate companies have started the process of land buying from the middle of 2001.

Photograph 4.3 Lowland encroachments the area of Ashulia

Source: Field visit, 2010

Sometimes they create pressure on the landowner to sell their land to the developers. In many cases it has been found that the landowners have got only the contract money, in spite of passing many years after contract they didn't get the full price of their land. It has been found from field observation that there is an about 10 percent area that has grabbed under the control of Developer Company. The developers are filling the lowlands by earths and sands and these sands are spreading over the surrounding lands. As a result productivity of these lands is decreasing. Besides this many brick manufacturing industries are present there due to low price of soil and good convenience for the transportation of bricks to Dhaka.

There is another aspect of encroachment, which is done by PLDCs in the study area. A good number of land development companies are involved in land encroachment activities. Among them, some companies are big and powerful in terms of financial and political prowess. Each company maintains its tentative boundary adjacent to the project. These companies try to occupy all the lands including wetlands within their tentative boundary. If it is private owned land they try to purchase land applying different techniques, which are: attractive false offers to the land owners, make false case against land owners, and if it is public owned land ('*khas land*') they try to fabricate the land records in collaboration with some dishonest officials of different public agencies and politicians who work for the illegal activities. Sometimes they encroach the '*khas*' land and lake with the help of local muscleman **(Appendix D1).**

Land filling

Filling in wet/lowlands occurs when earthen or other miscellaneous material is used to fill in the area of a wetland and to raise the final elevation of the site (Nakashima *et al.*, 1994). Topographically Dhaka does not have continuous highland. This highland is already occupied by man's activities. Now the city expansion is stretching towards the low-lying areas, which is vulnerable to annual internal and external flooding. Due to the construction of embankment in the western part of the city the urbanization process has speed up in this low-lying areas using land filling methods **(Photograph 4.4)**. Frequently, this is done to provide new sites for buildings, infrastructure alignments, and for disposal of garbage and waste.

Photograph 4.4 Land filling in the Turag river

Source: Field Visit, 2010

Land filling by PLDCs

The Private Land Development Companies (PLDCs) implement housing projects in low lying areas with their own style ignoring the existing laws, restrictions and even they are not sincere and co-operative with government agencies. They are always looking for loopholes and default of laws and acts as well as weakness of authorities. The PLDCs flout laws and fill-up low-lying areas by carrying sand/earth from other areas using country boats and engine boats. The regulatory bodies in this context are not always eager to enforce law effectively. The PLDCs have filled up hectare of low-lying land on the city fringe areas flouting government directive and laws.

Photograph 4.5 Lowlands and flood flow zones are filling-up rapidly for housing development

Source: Field visit, 2010

Allegations run high as the PLDCs are motivated primarily in making high profits and are often involved in fraudulent land transaction. In this process of development, they almost ignore the master plan provision, existing policies and provisions of Town Improvement Act 1952 and Building Construction Act 1953.The PLDCs tendency is to start land collection and filling those first, and they create pressure to the authorities concerned from influential corners to obtained approval of the project. The massive land filling activities in the low-lying areas have now become a deep concern to experts, professionals and environmentalist.

The filling-up of vast areas in Ashulia, Banashree, Aftabnagar, Meradia, Baunia, Badda, Amin Bazar and Hatirjheel, known as water catchments, increase the hazards of water logging that swamp much of the city. The Dhaka Master Plan has clearly marked these areas for flood retention and the Wetland Conservation Act, 2000 bars land development in water bodies. According to the Conservation Act, no one has the right to develop wetlands, flood flow zones or catchments. But the developers and land owners have occupied and filled the areas.

4.5.6 Public Awareness and Education

In general, most people of Bangladesh are poor and illiterate. A large number of people of Dhaka may still be unaware about the environment, how it gets polluted and why it should be protected. There is serious lacking of public awareness about the necessity of natural environment. According to Akash and Singha (2003), slum dwellers are living in an unhygienic condition and polluting through regular activities i. e. burning of biomass, unsanitary practices etc. Lack of awareness and services have identified as major cause behind it. People don't understand the effect of drainage blocking and filling of natural drainage, low lands, wetlands etc. Therefore, they don't hesitate to throw solid waste on to the roads and drains and their poverty encourage them to fill the natural water bodies as well as destroy the ecological habitats. Not only the general people but also the Government Authority sometimes occupies the wetlands, retention areas, *khals* etc to save the cost of land acquisition for development works like roads and so on. Thus, lack of public awareness and education increases the environmental problem in Dhaka City. According to 42 per cent respondents, through public awareness and education programs, it is possible to maintain the natural environment systems properly, therefore, reduce the environmental degradation and improve the environmental situation.

4.6 Pressure Levels in the Study Area

There are many pressures in the study area, such as housing, job opportunities, transportations and water are of very high level and food, environment, health, solid waste, crime, recreation and energy are of high level (**Table 4.14**).

Table 4.14 Level of pressure in the study area

Sectors	Pressure Levels
Housing	Very High
Job Opportunities	Very High
Transportations	Very High
Water	Very High
Electricity	Very High
Environment	Very High
Solid Waste	High
Food	High
Health	High
Crime	High
Recreation	High

Source: Adopted from Saleheen, 2010 and Field Survey, 2010

Housing

Size of city influences residential pattern, private or community households, or government and semi-government bodies. Housing can be considered to be one of the prime pressure problems of Dhaka. Majority of the residents do not have any land in the city. They live in the city as tenants or in the slums and squatters. For most households, accommodation costs in the cities are usually higher than in smaller cities. The poor people are deplorable in general. A recent survey on the slum population of the city shows that at present nearly 3.5 million people are now living in 4966 slums of the city.

Job Opportunities

Dhaka, as a mega city needs to be looked after, and is doing well in terms of government spending. A substantial amount of government exchequers is being spent on it. It is believed that as far as the job opportunities go, large-city meant that both rich and poor were treated rather better than their cousins elsewhere.

Transportation

For the study area it is more than 20 percent of urban household income is spent on transportation. For better facilities one-fourth of the city infrastructure investment needs required for transport. Despite some positive sector involvement in transport infrastructures in Dhaka, little has achieved through the city corporation's budget. The city has a total road

network of about 3000 kilometers. Only 25 percent of these roads are either major or primary roads. Structural policies on: (a) infrastructural expansion (b) structural de-concentration and (c) land use control should be taken for transportation on Dhaka.

Water

Currently not over 60 percent of the general people is connected to WASA's piped water supply system and another 30 percent indirectly to by households with connection and the remaining population depends on water from private wells and surface water. Authorities responsible for water supply in the city should think about a "ready-to-run decisions-supporting tools" for planning and implementing sustainable water management for the city.

Electricity

Electricity is not available in most of the houses. It is by far the best utility services, the residents of Dhaka get. Still, there are some places were inadequate supply of electricity prevails. Because of the national electricity deficiency, DESA can not supply the required electricity the city needs. As a result load shading is a common feature of city life.

Environment

The study area suffers badly from air pollution. However, air pollution is not only a function of size. Dhaka suffers because it is a populous city, has vast numbers of cars, and suffers from temperature inversions in winter. Air quality of the study area has improved substantially in the recent past due to the removal of two-stroke engine baby taxis. The key measures for improving air quality of the city are (a) introduction of Compressed Natural Gas (CNG) based vehicles, (b) introduction of unleaded gasoline from 1st July of 1999, (c) notification of lubricant standards on 1st January, 2001, (d) banning of buses older than 20 years and trucks older than 25 years in Bangladesh from 2002, (e) banning of imported reconditioned cars older than 5 years, and (f) banning of operation of commercial trucks in Dhaka city during day time (8 am to 10 pm).

Food

Evidence on malnutrition is there but it is lower than in the rural areas. Sometimes urban pressure has made life more expensive for the poor people in the city. The cost of food in the city is higher than in smaller cities.

Health

Health care in the study areas is generally much better than in the rest of the country. There are more hospitals and doctors per head than in smaller cities because there is a much higher level of private healthcare provision. However, health conditions are not better in slums, where one-fourth of the population of the city live. Now public health experts are beginning to believe that the advantages of urban life in Dhaka does not reflect dramatic decline in living standard for huge number of urban poor people.

Solid Waste

Generation of solid waste in the urban area has increased significantly over the past years in relation to rising consumption. Those of higher socioeconomic status typically generate greater volumes of waste in comparison to the poor. Most of urban solid waste originates from a wide range of residential, industrial, agricultural, institutional, municipal and commercial sources. The composition of the solid waste has changed in the past few decades with a decrease in organic waste and an increase in non-organic waste (e.g. plastic, paper, and cans). Despite the poor levels of service, solid waste management is still the single largest expenditure of the city corporation.

Crime

It has been observed that the rapid growth of Dhaka and the cramming of their increasingly impoverished inhabitants into restricted areas has undermined sociability and increased the level of violence occurring in conflicts. The evidence is clear that the incidence of crime is higher in big cities than in smaller towns, and in urban than in rural areas. The social and economic costs of crime are greater for big city residents than for others. It can also be argued that more crime in Dhaka is a direct result of city size.

Education

It is for sure that in the field of education, Dhaka is the best in country but still suffers from high degree of inadequacy from primary level to higher education. Although almost all the prestigious institutions in secondary, higher secondary and higher education both in public and private are located in the city, almost all of them are overcrowded. Most of the 4966 slums, where 3.5 million people live, have no schools. It is obvious that the literary rates show marked difference between Dhaka and other cities of the country.

Recreation

There can be little doubt that the major city of a country should have a much wider array of leisure facilities. There should be more open parks, cinemas and theatres, more varied and higher-quality shopping facilities, and a wider range of clubs of all types. Dhaka lacks in much respects about its recreation facilities. The civil society had to demonstrate to obtain open spaces for the city. The poor, as usual, gets a little share to these facilities.

4.6.1 Governance for Dhaka city

From above discussions it can be said that due to quick and unprecedented growth of population within a short period of time, Dhaka city is almost deficient in all the urban sectors. Coordinated planning and good governance can bring a positive condition. The present corporation consists of a group of people and is defined under country law, and has specific rights and responsibilities. It is very difficult to coordinate at least 17 departments, which deal with the city problems like water supply, law and order, electricity, transport, housing, telephone, sewerage, road construction, education, environmental pollution, keeping official records, such as birth and death and public health. In recent past all the mayors of Dhaka and Chittagong had tried to convince their respective governments about this concept. The civil societies like BAPA through a seminar on 1 May 2005 suggested the formation of metropolitan government (city government) for ideal urbanization and effective running of the mega city, Dhaka. The government must also think and evaluate the current situations of city administration of our country and take steps to reform their responsibilities by forming city government in a stepwise manner which ensure success.

Now the analyses about land use change pattern, land use change trend, major land use change areas and comparative land use change trend in selected areas is necessary for further development of the thesis, so it'll be discussed thoroughly in the next chapter.

Chapter 5

Land use Change Pattern and Trend

Chapter 5

Land use Change Pattern and Trend

Land use change is a common reflective phenomenon connects human socioeconomic development activities with nature. With the emergence of industrial revolution land use has been changed extensively reflecting industrialization and dynamic human interaction with nature. Gradual increase in population increase across the world created a need for more employment generation that added the change further and the speed of change accelerated significantly during the last century. However, consequences of land use changes on environment and its resource have taken place into consideration when environmental degradation and hazards are observed in different countries due to unplanned and inappropriate development activities. In order to address the consequences of land use change on environment such as resources depletion, environmental quality, loss of prime agricultural lands, destruction of important wetlands and loss of aquatic resources, deforestation and habitat loss every nation has taken different policies and plans to overcome those.

In Bangladesh, before 1953, there was no regulatory authority and regulations to develop the urban areas in appropriate and sustainable manner so that environmental degradation can be minimize in an optimal level. Town Improvement Act, first of its kind in East Pakistan, was promulgated in 1953. As per the Town Improvement Act 1953, Rajdhani Unnayan Kartripakkha (RAJUK[1]) is the legitimate authority to prepare land use plan and accordingly oversee and monitor the all sort of development activities and growth of Dhaka city. The main goals of RAJUK are to ensure a planned development; promote healthy urban environment, reduce congestion and crowd, and prevent development of conflicting-land use. At present it is said that the goal of RAJUK is to initiate sustainable development of Dhaka city. Other than this there is no specific land use policy for the city.

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[1] The RAJUK; Rajdhani Unnayan Kartipakkha- the hight level statutory metropolitan city development authority under the Minstry of Works. The Town Improvement Act, 1953 and the Building Construction Act, 1952 gave power to the RAJUK to plan, build and take legal action against nonconforming land uses and contravention of building construction regulation in the area under the jurisdiction. Before 1987, it was known as the Dhaka Improvement Trust (DIT).

These chapters discuss land use change pattern as a result of the impact of expansion of unplanned urbanization. Its impacts on the environment are also taken into consideration. Therefore, an attempt has been made in this chapter to analyze the pattern of land use change occurred during 1960-2008 to see the trend of land use of the city. Considering the nature and diversity of land uses, eight major land use categories are identified in the study area, which are:

- Built-up
- Bare soil/landfill
- Cultivated land
- Vegetation
- Water-bodies
- Wet/lowlands
- Transport and communication and
- Others

5.1 Pattern of Land use Change

5.1.1 Global Land use Change Pattern

Land use changes reflect the history of human economic activities, and perhaps might reflect the future human economic activities. They are linked with economic development, population growth, technology and environmental change. The rates of land use change often parallel to population growth, whereas they generally diminish locally with increased economic development (Houghton, 1994). Land use change can be considered from two perspectives: the intended and the unintended effects. The purpose of deliberate land use change is to increase the local capacity of lands to support the human enterprise, but many land use practices instead reduce this capacity and deleterious the local and regional effects of environment.

The magnitude of land use change varies with the time period being examined as well as with the geographical area. Moreover, assessments of these changes depend on the source, the definitions of land use types, the spatial groupings, and the use of data sets. A few indicative figures are given here to show salient changes in major uses of land. **Table 5.1** presents the magnitude of change in each of the three major land use types distinguished as percent of total in 1980 for land area of each regional group and for the world as a whole.

Table 5.1 Global and regional land use change in the regional grouping area, 1700-1980

	Total land use change in 1700 to 1980 (mill. ha)	Total land area, 1980 (mill. ha)	Land use change in 1700 to 1980 as % of total 1980 land area
Europe		487	
Forest	-18		-3.70
Grassland	-52		-10.70
Cropland	+70		+14.37
North America		1935	
Forest	-74		-3.82
Grassland	-125		-6.46
Cropland	+200		+5.16
Latin America		2060	
Forest	-296		-14.27
Grassland	+159		+7.72
Cropland	+135		+6.55
Africa and Middle East		3635	
Forest	-308		-8.47
Grassland	+43		+1.18
Cropland	+265		+7.29
Asia		2074	
Forest	-250		-12.05
Grassland	-63		-3.03
Cropland	+313		+15.10
USSR and Oceania		3151	
Forest	-218		-6.9
Grassland	-34		-1.08
Cropland	+253		+8.03
World		13342	
Forest	-1162		-8.71
Grassland	-72		-0.54
Cropland	+1236		+9.26

Source: Adopted from Grubbler, 1990 Note: (+) or (-) sign indicates direction of change

Changes in the uses of land which cause major concern are associated with conversion to and from cropland as well as with forest clearance. **Table 5.2** presents data on global land areas converted to regular cropping and developed and developing areas of different ecosystems converted to cropping, respectively.

Table 5.2 Global land areas converted to regular cropping, 1960, 1920 and 1978

(in 10,000 km^2)

Regions	Cropped area			Net change		
	1860	1920	1978	1860-1920	1920-1978	1860-1978
Developed regions						
USA/Canada	760	2,372	2,357	1,612	-15	1,596
Europe	1,200	1,406	1,417	206	11	217
USSR	810	1,690	2,319	880	629	1,509
Ocenia	40	191	591	151	400	551
Total	**2,810**	**5,659**	**6,684**	**2,849**	**1,025**	**3,874**
Developing regions						
Africa	630	799	-	159	905	1,064
Asia	2,110	3,025	1694	915	1,429	2,344
Latin America	170	571	4454	399	834	1,233
Total	**2,910**	**4,395**	**1405**	**1,473**	**3,168**	**4,694**
World Total	**5,720**	**10,054**	**7553**	**4,322**	**4,193**	**8,515**

Source: Adopted from Williams, 1990

5.1.2 Land use Pattern in South East Asian Countries

The land use information compiled and provided by the FAO is the only available data that facilitates any time series analysis of land use changes across countries. Based on the above information, World Bank (1999) analyzed the land use changes by classifying the land area into three categories: (a) arable land, (b) permanent cropland and (c) other land. Though an analysis based on World Bank classification provided a broad understanding on land use pattern, it was reclassified the categories differently to suit the purpose of analysis. For this purpose the FAO's electronic data files, SOFA 2001 (Table 5.3) was considered and obtained the data on area under forests and pastures. Based on this information, land uses were classified into three categories: (a) arable area and permanent crops, (b) forest and pasture land and (c) land not available for cultivation. The first category includes the arable land defined by FAO and permanent cropland, excluding forest and pasture land. The second category includes area under natural or planted stands for trees and pastureland. The last category includes uncultivated land, grassland not used for pasture, barren land, built-up areas-residential, recreational and industrial lands, and areas covered by roads and other fabricated infrastructure.

This revised classification scheme to understand the changes in the land use pattern has significant relevance for the present analysis so as to capture the impact of population pressure on land cover changes, attempted in the next section. I shall examine below the changes in the land use pattern in the Southeast Asian Countries during the period between 1972 and 1998 **Table 5.3.**

The data on the table show that the land use patterns are changing in the Southeast Asian Countries between the seventies and the nineties. The share of arable land and permanent crops (that represent the extent of crop cultivation and its expansion) increased steadily from 16.58% to 21.28% between 1972 and 1990. During the nineties, it remained almost unchanged at 21%. The share of forest and pasture area that accounts for 56.67% by 1998 has marginally declined from its earlier position of 62.07% by 1972. The share of land not available for cultivation (that represents the non-agricultural use of land) showed a marginal increase from 21.34% to 22.38% between 1972 and 1998 with minor fluctuation during the eighties.

The table also indicates major differences in resource endowments and uses among countries. According to the data for the year 1998, in Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar and Philippines about 50% and above of the total area is accounted by forests and pastures. The share of arable and permanent cropland occupied the dominant position in Thailand (40%). 'Land not available for cultivation' accounted for a lion share to the total land area in Singapore (98.36%) and Vietnam (46.11%).

Table 5.3 Trends in land use pattern in South East Asian Countries (1972-1998)

(% to the Total Land Area*)

Country	Years											
	1972			1980			1990			1998		
	Arable Land** and Permanent Cropland*** (%)	Forest and Pasture Land (%)	Not Available for Cultivation (%)	Arable Land** and Permanent Cropland*** (%)	Forest and Pasture Land (%)	Not Available for Cultivation (%)	Arable Land** and Permanent Cropland *** (%)	Forest and Pasture Land (%)	Not Available for Cultivation (%)	Arable Land** and Permanent Cropland*** (%)	Forest and Pasture Land (%)	Not Available for Cultivation (%)
Indonesia	14.35	74.38	11.26	14.35	71.54	14.11	17.65	68.94	13.41	17.11	67.87	15.03
Vietnam	18.97	42.93	38.10	20.18	37.60	42.22	19.61	29.91	50.47	22.27	31.62	46.11
Philippines	25.48	54.65	19.87	32.29	45.12	22.59	33.14	49.97	16.89	33.54	49.90	16.56
Thailand	28.87	41.59	29.53	35.82	33.64	30.54	44.24	30.82	24.93	39.88	29.95	30.17
Myanmar	15.88	49.48	34.64	15.24	49.30	35.46	15.31	49.82	34.87	15.43	49.82	34.75

Malaysia	13.79	65.11	21.10	14.61	65.16	20.23	21.00	68.56	10.44	23.15	68.58	8.27
Cambodia	10.59	78.06	11.34	11.73	77.84	10.44	21.50	77.75	0.75	21.57	77.61	0.82
Laos	2.90	66.29	30.81	2.99	62.98	34.03	3.68	62.39	33.93	3.69	57.95	38.35
Singapore	18.03	4.92	77.05	13.11	4.92	81.97	1.64	4.92	93.44	1.64	0.00	98.36
Brunei	2.28	86.53	11.20	1.52	86.53	11.95	1.33	86.53	12.14	1.33	86.53	12.14
TOTAL	16.58	62.07	21.34	17.97	58.69	23.34	21.28	57.33	21.39	20.95	56.67	22.38

Source: FAO Year book, SOFA 2001

***Total land area** refers to the total geographical area of the country.

****Arable land** includes temporary crops (double cropped areas are counted only once), temporary meadows for mowing, kitchen gardens and land temporally fallow (less than five years).

*****Land under permanent crops** refers to land cultivated with crops that occupy the land for long periods.

An analysis of trends in land use pattern between 1972 and 1998 based on the combined data of the Southeast Asian Countries indicated a steady increase in the share of arable and permanent cropland from 1972 to 1990 and thereafter remained unchanged; the share of forest and pasture land declined steadily from 62% to 57% between 1972 and 1998.

The trends in land use pattern across countries indicated divergence. They are:

- In Vietnam, Malaysia and Philippines, the share of arable and permanent cropland increased steadily during the reference period, whereas, there was no change in it in Myanmar; and, steady decline in Singapore. In Cambodia and Indonesia, it increased up to mid-eighties and thereafter unchanged; in Laos, it increased up to early eighties and thereafter, remained unchanged; and, in Brunei the share declined during mid-seventies and remained unchanged from mid-eighties onwards.
- The share of forest and pasture land declined steadily in Thailand and Laos; increased marginally during eighties and remained unchanged further in Malaysia; and it remained unchanged throughout in Cambodia, Brunei and Myanmar. In Singapore, the share of forest and pastures declined sharply from nineties; and in Indonesia, Vietnam and Philippines, its share declined during mid-seventies and remained unchanged thereafter.
- The share of area 'not available for cultivation' increased steadily in Singapore, Indonesia and Laos during the entire period. On the contrary, in Cambodia, Malaysia and Philippines, it declined steadily. In Thailand and Myanmar, this share remained unchanged. In both Vietnam and Indonesia, it increased initially up to the mid-eighties, and thereafter remained unchanged.

The above changes in land use pattern in the Southeast Asian Countries raise certain important questions. What is the linkage between population growth and land use pattern? To what extent, the land use changes are shaped by population pressure? Why differential pattern of land use is observed in the Southeast Asian Countries? This aspect will be discussed in the next section.

5.1.3 Land use Pattern in Bangladesh

The distribution pattern of land use is one of the most important criteria of the development of human settlements and the quality of habitat environment therein. The use of land varies according to the human resource and the socio-economic needs of the inhabitants, and is variable with the dynamic nature of the society and hence its needs (Sultana, 1989).

Bangladesh is essentially an agrarian society still though there is a tendency of strong shift towards urbanization. Agricultural economy directly and indirectly controls the socio-economic system of the country. In rural and urban areas, land use is related to a certain combination of factors, such as, socio-economic classes by tenancy structure, agricultural practices, the laws of inheritance etc. and is classified according to the functions the land is generally put into use, such as land in agriculture, settlements and associated infrastructures and land with settlements, such as roads, orchard/trees, water-bodies etc. The present land use in Bangladesh is shown in **Table 5.4** and **Figure 5.1.** The category 'not available for cultivation' also includes housing and related human settlement and infrastructures.

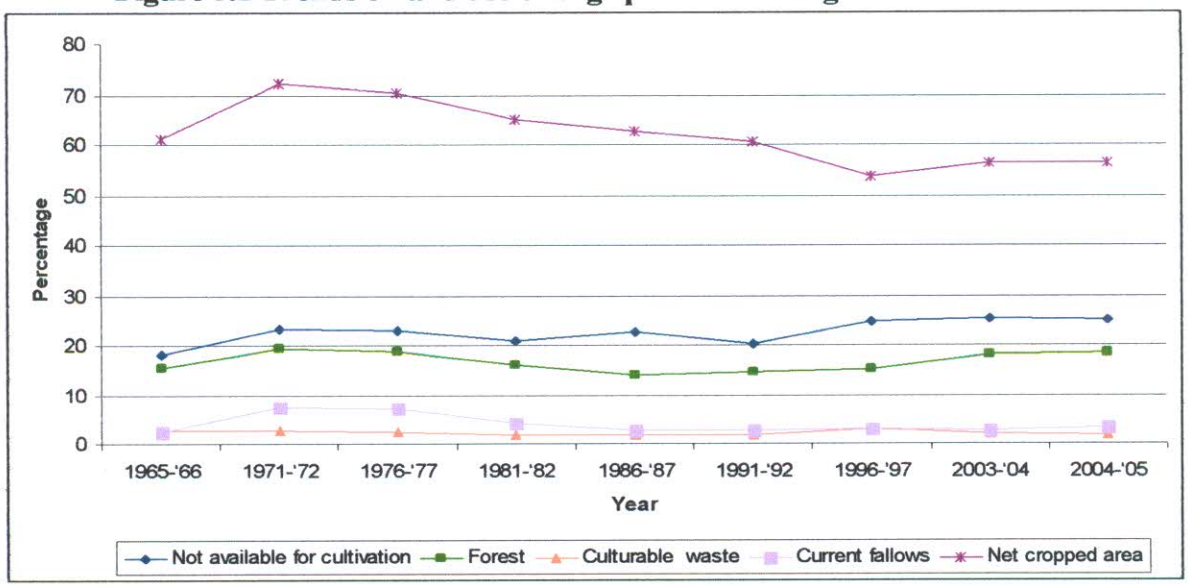
Table 5.4 General land use pattern in Bangladesh, 1965-2005 (Percentage)

Year	Not available for cultivation	Forest	Culturable waste*	Current fallows**	Net cropped area	Total cropped area*** ('000acres)
1965-'66	18.06	15.43	2.81	2.43	61.27	27,403
1971-'72	23.31	19.55	2.61	7.46	72.32	28,169
1976-'77	22.86	18.80	2.28	7.25	70.55	28,979
1981-'82	20.95	16.23	1.87	4.14	64.99	32,638
1986-'87	22.71	14.07	1.87	2.76	62.72	34,882
1991-'92	20.18	14.63	1.87	2.79	60.53	35,785
1996-'97	24.9	15.2	3.0	3.1	53.8	34,086
2003-'04	25.46	18.27	2.09	2.77	56.49	35,111
2004-'05	25.03	18.42	1.90	3.32	56.54	34,827

Source: BBS, 1989, 1999 and 2007

Note: * Cultivable waste is the area suitable for cultivation but lying fallow for more than one year.
**Current fallow is the area already brought under cultivation but not cultivated during the year.
***Total cropped area is the sum of the net cropped area and the area shown more than once.

Figure 5.1 Trends of land use change pattern in Bangladesh 1965-2005



Source: Table 5.4

Table 5.4 and Figure 5.1, an analysis of trends in land use change pattern between 1965-'66 to 2004-'05 based on the combined data of the Bangladesh Bureau of Statistic indicates a steady increase in the 'not available for cultivation' land from 18% to 25%, forest area 15.43% to 18.42% and Current fallows 2.81% to 3.32% from 1965-'66 to 2004-'05 and thereafter remains unchanged; the Culturable waste decreased from 2.81% to 1.90% and Net cropped area declined steadily from 61.27% to 56.54% between 1965-'66 and 2004-'05.

5.1.3 Land use Pattern in Dhaka City

Land use in Dhaka may conveniently and generally be classified into five categories: cultivated, forest, cultivable fallow, fallow and non-accessible land for cultivation. With the growing population and their expanding needs in various sectors, land use pattern have changed and "the area not available for cultivation" is increasing which includes land that is mainly urban, rural settlements and industrial land. As a result the net cropland and forestland is decreasing.

However, the present status of Dhaka city demonstrates that the development of the city did not succeed to fully meet the requirements of a mega city. Absence of adequate parks, open water bodies and drainage system has degraded the quality of living in the city in many ways.

Table 5.5 Land use distribution in DIT master plan, 1959

Land use	Occupied Area (ha)	(%)
Housing and ancillary uses	2367.61	20.1
Industry	366.80	3.4
Central business	99.60	0.9
Commerce	133.60	1.3
Warehousing and storage	157.08	1.5
Provincial Government center	40.49	0.4
Government areas	184.62	1.7
Education and institution zone	382.38	3.6
Main roads	319.83	3.1
Railways and Railway land	177.73	1.6
Steamer Station and Bus station	10.53	0.1
Open space	541.70	5.1
Cemeteries	45.75	0.4
Cantonments (part only)	393.12	3.7
Major reclamation (part only)	1524.69	14.4
Water areas (rivers and land liable to flood)	3801.21	38.7
Total	**10,560.73**	**100**

Source: DIT Master Plan, 1959

The above trends in land use change are quite well marked in the study areas. In Uttara, the land use is characterized by a mixture of urban and rural uses. Although the study area is adjacent to the planned areas of the Uttara model Town, rural characteristics predominate. One of the important reasons for this is the restrictions imposed on building construction by the RAJUK for the possibility of future extension of the Uttara Model Town towards the west. For the reason, many of the urban services have not yet been extended to Uttara area.

Table 5.6 shows the general land use of Uttara and Savar area. It is observed that due to the higher elevation of land in scattered places, as characteristic of the Madhupur terrace topography, most part of the area is covered by groups of homesteads in isolated locations. Besides, the main connection roads, a large number of narrow unpaved/non-metallic roads provide access to the human settlements and other non-farm activity areas. Previously, the entire area was rain fed agricultural area, particularly in the highlands. Presently, the highlands are mostly used for residential and non-farm uses. The changes in land use during 1974-'88 and 1974-'90 are depicted in **Table 5.6**. Overall, it may be seen from the table that

the area under human settlement has nearly doubled during this period. But by far the highest change was registered in case of land under housing and land speculation and commercial users. These were at the cost of cropland, orchards and water-bodies.

Table 5.6 Land use changes in Uttara, 1974 -'88 and Savar, 1974 -'90

(Area in percentage)

Land Uses	Uttara			Savar		
	1974	1981	1988	1974	1981	1990
Settlement	3.74	4.08	6.88	4.56	6.86	11.96
Land speculation	-	0.27	3.96	0.12	0.30	1.16
Cropland	63.57	57.08	50.31	61.31	59.62	52.07
Orchards	1.91	1.80	1.75	11.26	9.32	7.14
Commercial	0.15	0.19	0.62	0.19	0.23	0.37
Industrial	-	1.31	1.50	1.16	1.37	1.79
Fallow land	-	5.00	10.00	11.37	10.93	14.92
Water-bodies	26.21	26.25	20.94	2.35	2.27	2.13
Roads	2.25	2.69	2.89	1.19	2.36	3.99
Others	2.44	1.33	1.15	6.49	6.74	4.47

Source: Alam, 1989 and Hasan, 1991
Note: Uttara sampling area, 3465 ha and Savar area, 27973 ha

During 1974-'90, a marked transformation in land use pattern has also been observed in Savar. **Table 5.6** presents the land use condition of Savar. For this study area, land use transformation is characterized by the increased use of land under residential and related along the Dhaka-Aricha highway, close to the access routes, along the selected stretches of the Bansi river, Savar bazaar, and thana headquarters. While the changes in agricultural land use were in the form of non-crop farms (poultry and some orchards), and most importantly, transformation of farm lands to non-farms uses, such as, residential, industrial and commercial units, housing complexes (real estate business) and various land speculations. Such a trend in the land use changes led to the sharp increase in land value per unit area. Overall, the land use transformation along the major transport network in Savar, till now, indicates potentials for expansion in other areas.

It may be noted in the **Table 5.6** that the trend of change in non-farm land uses is faster/higher in Savar compared to Uttara. This is because of higher land value and scarcity of build-able land in the latter as well as restrictions imposed upon building construction by the RAJUK. Such restrictions have been imposed upon Savar only in 1990.

There are two types of land ownership in Dhaka city- *firstly*, the privately owned land *secondly*, the government owned land. Ministry of Land (MoL, 1982) has conducted a study on urban land ownership in Dhaka city in 1981. This study has observed that the distribution of land for use in various purposes is anomalous. Areas under private ownership are mainly uses for residential purposes. No sufficient studies have been conducted on the use of publicly owned vacant land in Dhaka city. A survey carried out by the Ministry of Land had figured out that there were about 500 acres of land which had remained vacant or unused for the purposes for which these land were initially acquired (Das, 1992). Most of these areas are now used as slums or for illegal and non-profitable purposes **(Table 5.7).**

Table 5.7 Land use distribution in greater Dhaka city, 1990

Land use	**Occupied Area (ha)**	**(%)**
Residential area	6,050	22
Commercial	550	2
Industrial	275	1
Institutional	1,100	4
Roads	1,650	6
Other urban	1,650	6
Agriculture	12,650	46
Water	3,575	13
Total	**27,500**	**100**

Source: JICA, 1991, 1992

5.2 Interpretation of Maps and Images

This maps and images were used only the parts of the study area. The topographic maps of 1960 (scale 1: 50,000) were used to generate land use/cover types. Landsat TM image and topographic map of 1991 and Google image of 2008 were employed in this study to produce land use/cover categories of 1991 and 2008 respectively. Both ArcGIS and CartaLinx software were used to device land use/cover classification in a multi-temporal approach.

A modified version of the Anderson Scheme Level I (Anderson *et al.*, 1976) was adopted to study the land use/cover change. This system proposed multilevel land use/cover type's classification of which Level I classes can be mapped from Landsat data or from high altitude air photo/imaging.

Eight separable land use/cover types have been identified in this study as built-up, bare soil/landfill, cultivated land, vegetation, water-bodies, wet/lowlands, transportation and communications and others. These are shown in the following **Table 5.8**.

Table 5.8 Present land use/cover classification scheme in the study area

Land use /cover types	Description
Built-up	Residential, commercial and services, industrial, socio-economic infrastructure and mixed urban and other urban
Bare soil/landfill	Exposed soils, landfill sites, and areas of active excavation.
Cultivated land	Agricultural area, crop fields, fallow lands and vegetable lands.
Vegetation	Deciduous forest, mixed forest lands, palms, conifer, scrub and others.
Water-bodies	River, permanent open water, lakes, ponds and reservoirs.
Wet/lowlands	Permanent and seasonal wetlands, low-lying areas, marshy land, rills and gully, swamps.
Transports and communications	Transportation, roads and air port.
Others	Brick fields and unidentified soil.

Source: Field Survey, 2008

5.3 Land use Change Pattern in the Study Area

Land use change pattern of Dhaka city is more or less mixed type like other cities of Bangladesh. The spatial patterns of land use changes in the study area for 1960, 1991 and 2008 are shown in **Figures 5.3**, **5.4** and **5.5**. In 1960, wet/lowlands, cultivated land and water-bodies were the dominant land use types, and the direction of urban expansion (herein referred to as the built-up category) was northward. In 1991, the built-up category replaced most of the water-bodies and land depressions within the city as well as the cultivated land along the peripheral zone. Between 1960 and 1991, when road transportation from Dhaka to the hinterland was improved by the construction of bridges over the rivers (Islam, 1996), urban expansion extended further to the north, northwest and to the west. Consequently, the area of cultivated land and water-bodies declined markedly during the period 1960 to 1991 (Islam *et al.*, 2009).

In 2008, the patterns of Land use change revealed that Dhaka started to expand in all directions, primarily at the expense of vegetated and wet/lowland areas. The rate of urban

encroachment on other land uses increased significantly following the preparation of a new Master Plan in 1995 and the development of infrastructure (Siddiqui *et al.*, 2004).

The nature of urban expansion in the study area may also be associated with other factors such as topography, land use, and transportation. Close examination of the change detection statistics revealed that approximately 5783 ha of the urbanized area in Dhaka were previously cultivated area, wet/lowlands, and water-bodies between 1960 and 1991. Conversely, 6585 ha of the newly urbanized areas were previously cultivated area, vegetation, water-bodies and wet/lowlands during the period between 1991 and 2008 (**Appendix B2**). Generally, two factors were observed to have promoted urban growth: (1) increased economic activity associated with the establishment of economic zones (e.g. export processing zone) and (2) redefinition of the metropolitan area. Between 1960 and 1991, reclassification of urban areas as well as infrastructural development played a crucial role in the expansion of urban areas. For instance, the north-westward and southward expansion of the city occurred in response to construction of a flood embankment in 1991 and a bridge on the Buriganga River in 2001. The spatial characteristics of built-up areas have also been shaped up by the construction of a number of transportation routes in the same period, as understood from historical map analysis and field visit. The expansion to the east and north-east led to the development of unplanned suburbs in the lowlands and agricultural areas that were previously located in those areas (FAP 8A JICA, 1991).

Table 5.9 Analysis of the land use change pattern in the study area, 1960-2008

Land use categories	1960 area (ha)	1991 area (ha)	2008 area (ha)	1960-1991 area changed (ha)	% of changed area	1991-2008 area changed (ha)	% of changed area	1960-2008 area changed (ha)	% of changed area
Built-up	6,083	11,866	18,451	5783	95.07	6585	55.49	12368	203.32
Bare Soil/ landfill	1,083	2,420	2,090	1337	123.45	-330	-13.64	1007	92.98
Cultivated land	13,404	10,395	8,050	-3009	-22.45	-2345	-22.56	-5354	-39.94
Vegetation	7,615	5,418	2,589	-2197	-28.85	-2829	-52.21	-5026	-66.00
Water-bodies	3,725	3,196	2,068	-529	-14.20	-1128	-35.29	-1657	-44.48
Wet/lowlands	8,982	5,829	4,732	-3153	-35.10	-1097	-18.82	-4250	-47.32
Trans. and comm.	429	2,185	2,692	1756	409.32	507	23.20	2263	527.51
Others	147	159	796	12	8.16	637	400.63	649	441.50

Source: Analysis from the land use map, 1960, 1991 and 2008

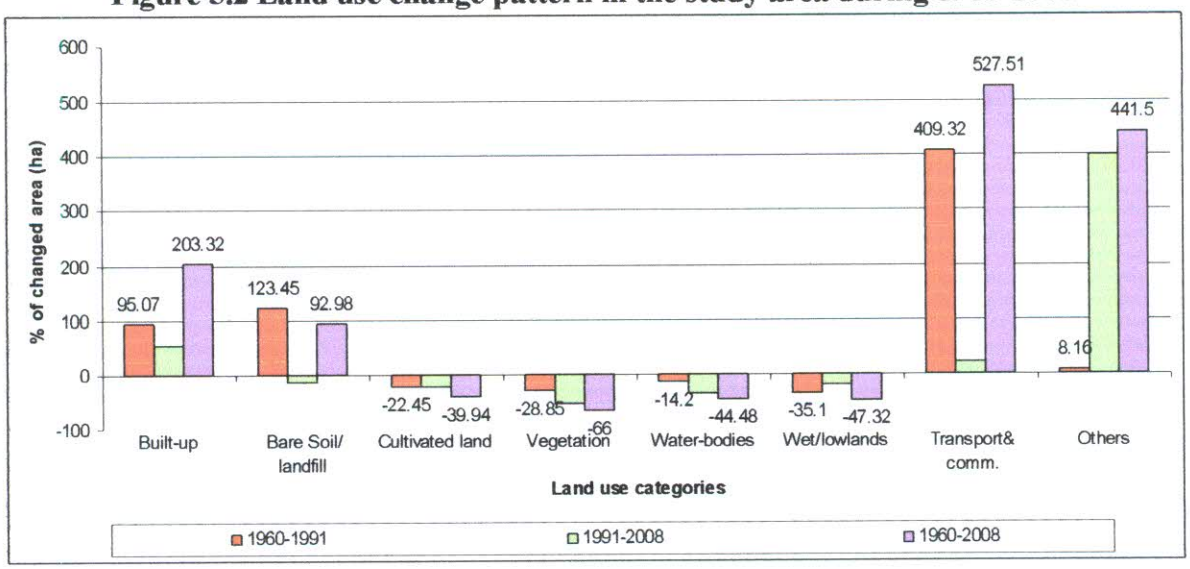
Note: (+) or (-) sign indicates direction of change

Spatial analysis of land use change patterns of Dhaka city and Savar area revealed that urban growth followed certain directions between 1960 and 1980s depending on the growth elevation. Historically, the direction of urban expansion of Dhaka has greatly been constrained by the low elevation of lands, surrounding rivers and risk of flooding. Thus major development was on the high and medium terraces usually not liable to inundation. The interpretation of the 2008 land use/cover maps however indicates that Dhaka is being started to expand in all directions, specifically to north-west, south-east and northern trends by filling up water bodies and lowlands. Three sectors, namely, public, private and individual households, are responsible for rapid land use/cover change in Dhaka. Poor coordination among the organizations is equally accountable to the quick loss of natural covers (Dewan *et al.*, 2008).

Analysis of the land use change trends in study area over time revealed a considerable increase in the built-up areas over the study period. Built-up areas were increased by 5783 ha between 1960 and 1991(**Table 5.9**).

The GIS analysis also revealed that the area occupied by water-bodies decreased by 14.20%, wet/lowlands by 35.10%, vegetation by 28.85% and cultivated land by 22.45% between 1960 and 1991. Another significant change was the decline in wetlands and vegetation from 1991 to 2008. In 1991, cultivated land occupied 22.56%; vegetation 52.21%, water-bodies 35.29%, wet/lowlands 18.82% of the total study area. But by 2008, these areas had declined to 39.94%, 66%, 44.48%, and 47.32% respectively. Conversely, built-up and transport and communication areas were increased in size by 55.49% and 23.20% in the period from 1991 to 2008 (**Figure 5.2**). A rapid increase in others category of land use (400%) was also observed in this same period. It is also revealed from the analysis of above mentioned maps and images during 1960 to 2008; the cultivated land area was decreased to 39.94%, vegetation area 66%, water-bodies 44.48% and wet/lowlands 47.32%. At the same time conversely built-up area was increased to 203%, bare soil/landfill area to 93%, transport and communication area to 527% and others type of land use category increased to 441.50%. The decline of vegetation and wet/lowlands was caused due to intensification of urban development in the study area, particularly through the process of suburban development. As shown in **Table 5.9** and **Figures 5.3**, **5.4 and 5.5**, there has been a marked change in land use over the 48 years' study period.

Figure 5.2 Land use change pattern in the study area during 1960-2008



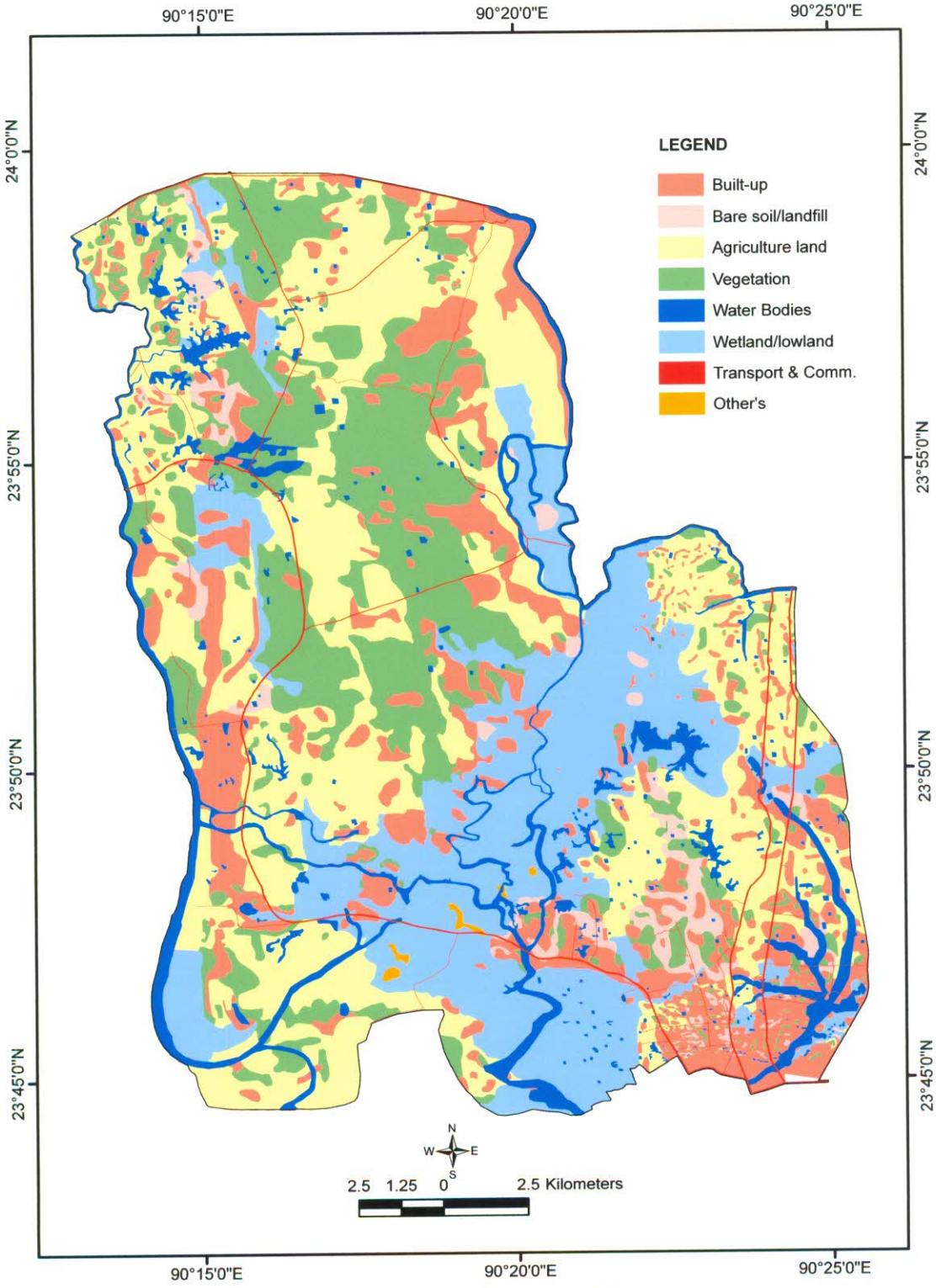
Source: Field survey, 2010

5.3.1 Land use Change Pattern in the Study Area in 1960

From the analysis of land use/cover map, 1960 **(Figure 5.3)** it was observed that in 1960, the total area of built-up were 6083 ha, bare soil/landfill 1083 ha, cultivated land 13404 ha, vegetation 7615 ha, water-bodies 3725 ha, wet/lowlands 8982 ha, transports and communication 429 ha and others area were only 147 ha which was 14.67%, 2.61%, 32.33%, 18.36%, 8.98%, 21.66%, 1.04% and 0.35% of the total area respectively **(Appendix B2)**. It is mentioned that in 1960, cultivated area was the highest land use types (32.33%), and others area were the lowest land use types (0.35%), wet/lowland areas were the second highest (21.66%), third highest was vegetation 18.36% and fourth highest land use types were built-up area, 14.67%.

Most of the lands are used in these areas for development purpose. The city was limited within the area of 35 sq. mile in the bank of Buriganga River. Most of the roads are earthen and brick concealed built. At that time most of the built-up areas were used in residential purposes. Although Dhaka was renowned as commercial center of Bangladesh, the percentage of the land of commercial use was comparatively low. The BEPZ industrial area of the study area was not established at that time. This area was used as an agricultural land. For being lack of structural development, the percentage of undeveloped land was high.

Figure 5.3 Land use map in the study area, 1960



Source: Prepared by researcher based on topographical map, 1960

5.3.2 Land use Pattern in the Study Area in 1991

From the interpretation of land use/cover map 1991 **(Figure 5.4)**, built-up area was found to be the dominant user of land, which occupied 28.61%. Cultivated land uses occupied 25.07% of the total area, which was the second user of land. Other uses related to human uses were transportation and communication 5.27%, bare soil/landfill 5.84%, vegetation 13.06%, water-bodies 7.71%, wet/lowlands 14.06% and others 0.38% **(Appendix B2)**. Various new development activities in land use were seen in 1991 compare to 1960. Various institutions were developed surrounding roads and highways.

Because of the location of Dhaka city, its communication facilities and as a commercial center, the people migrated to this city from different parts of the country. As a result, population of this city grew at a high rate and for this, built-up land use was high. By this time BEPZ industrial area was established in the study area. It indicates that some cultivated lands are converted into industrial use of land. In the same way, various wet/lowlands, cultivated land and water-bodies were converted to use bare soil/landfill, residential, government and non-government institutions and industry etc.

5.3.3 Land use Pattern in the Study Area in 2008

It is observed from the land use map of 2008 **(Figure 5.5)** that the residential uses are the predominate type of land development, accounting for 56.02% of the total developed area of the city, followed by built up 44.49%; transports and communication 6.46%; and bare soil/landfill 5.04% and second largest area is cultivated land 29.06% out of total area, 11.41% of the wet/lowlands, vegetation 6.24%, water-bodies 4.99% and the lowest area used in others purposes is only 1.92% of the total area **(Appendix B2)**. It is revealed that here built-up areas cover the largest land use/cover types of study area.

Comparing the results from 1960-1991 it is evident that in 1960 the area surrounding the Dhaka city was completely covered by built-up area. From the interpretation of classified land use/cover map 1960-1991, the aerial extensions of different features are observed. **Table 5.9** indicates that the study area were increased or added built-up area around 5783 ha and transport and communication area was 1756 ha from 1960 to 1991, while the decrease or losses of the areas was wet/lowlands 3153 ha, cultivated land 3009 ha, vegetation 2197 ha and water-bodies 529 ha in the same period. It is clearly visible that in 1991 built-up areas were the largest piece of converted land cover area, i.e., 5783 ha (out of 95.07% total built-up area).

Figure 5.4 Land use map in the study area, 1991

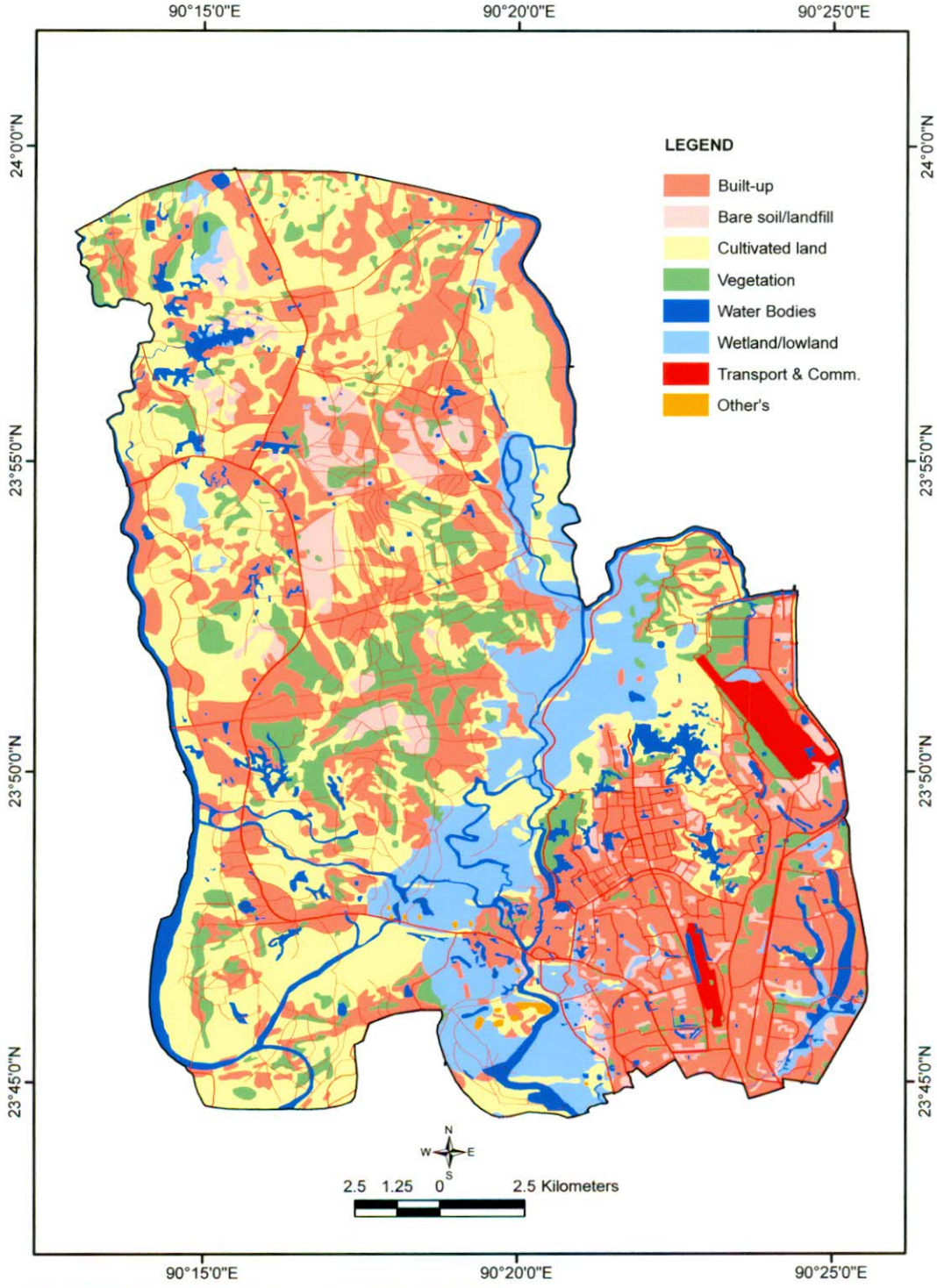
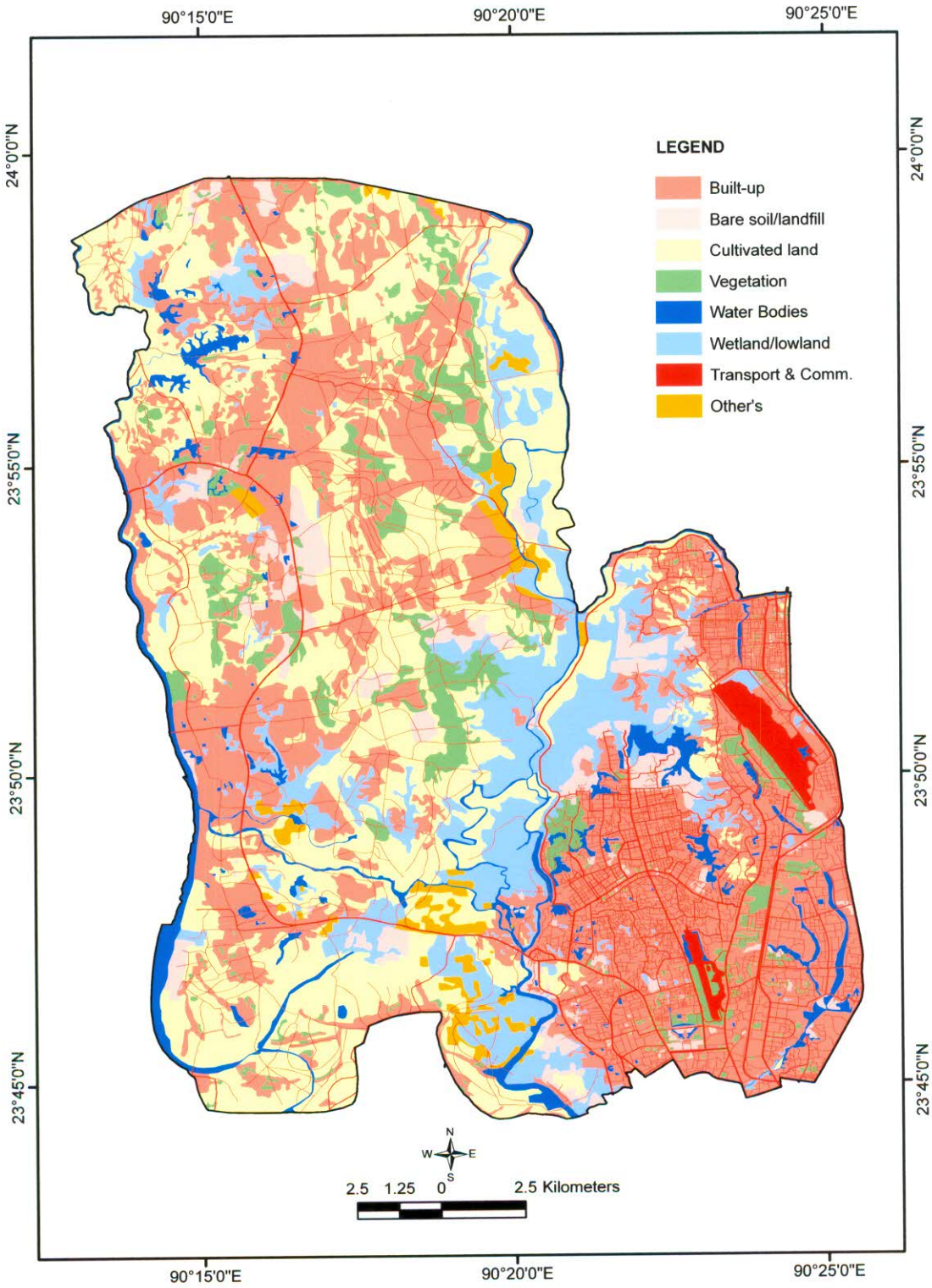


Fig :Landuse Pattern of a part of Dhaka City and Savar area, 1991

Source: Prepared by researcher based on Landsat TM image, 1991

Figure 5.5 Land use map in the study area, 2008



Source: Prepared by researcher based on Google image, 2008

Similarly, this can be clearly observed on comparing the classified images of 1991 and 2008 where it seems to be an explosion of Dhaka city infestation on the western and eastern sides of the study area thus reducing the agricultural land, vegetation and wet/lowlands to a considerable extent of built-up area.

It can be noticed in 2008 image that it was even possible to identify two different densities of Dhaka city which are classified as land use change as shown in **Figure 5.5**. During this span of 17 years there has been some dynamic change in the environmental degradation that has contributed to this rapid spread. It can be clearly noticed from the multi-temporal series of images from 1960 to 2008 that the area under agriculture land, vegetation and wet/lowlands has been drastically decreased.

5.4 Major Land use Change Areas

In the study area, possible causes of land use/cover changes can be grouped into six categories: population, unplanned urbanization, industrialization, lack of awareness, land value and lack of regulations and its implementation. So, this study gives a new experience and provides a fresh data base. Result obtained from the study supplemented by other secondary data reveals that the major factors responsible for land use changes are: excessive pressure of population, unplanned urban expansion of settlement and industrialization; and some socio-economic and political factors. Land use change pattern of the study are in 1960, 1991 and 2008 has been interpreted from different satellite images and topographic maps presented in **Figures 5.7**, **5.9**, **5.11** and **Appendix B3**, **B4 and B5.**

From the analysis of land use change maps of 1960, 1991 and 2008, it is identified that the rapid land use change areas in Location Quotient (LQ) method were selected partially within the study area. Three changed areas have selected in such a way that covers almost all categories of land use in the study area. The three selected areas are: (i) Ashulia Area (Ashulia union, Part of Yearpur and Birulia union); (ii) Uttara and Harirampur Area (Part of DCC ward-01 and Harirampur Union) and (iii) Amin Bazar Area (DCC ward; 9, 10, and a part of 8, 11, 12, 43, and 46, and Amin bazar union and a part of Kaundia, Banagram, Bhakurta and Tetuljhora union).

5.4.1 Ashulia Area

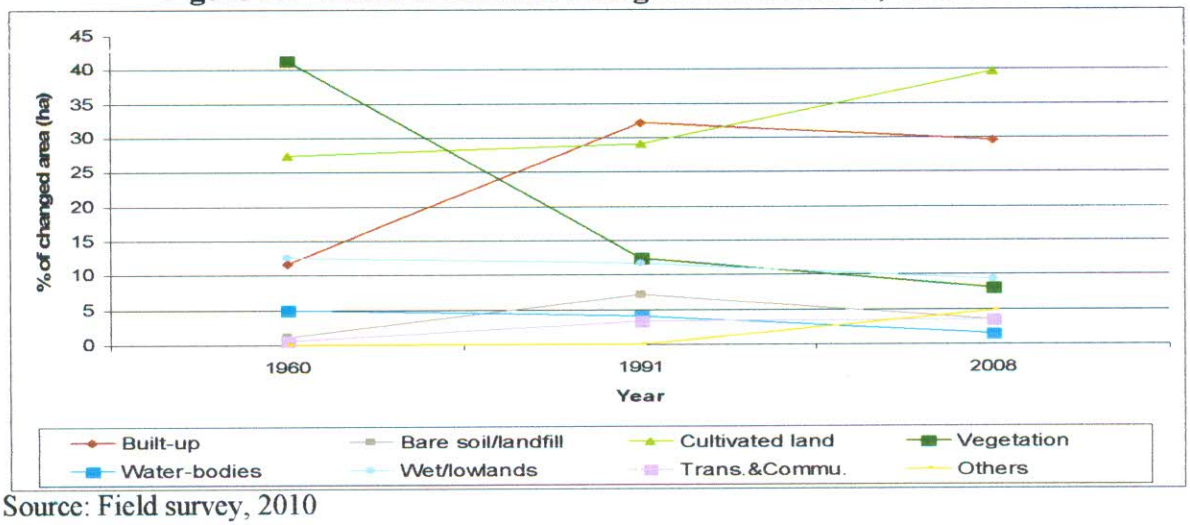
The area covers from Ashulia union and a part of Yearpur and Birulia union to the present Dhaka established areas in the east. The area is low-lying cut across by Turag and its Khals and is designated by the structure Plan as Flood Plain. There have been many housing and industrial development schemes by private sector, especially in the Ashulia, Jirabo, Katgara, Kuturia and Doshaid Bazar, and Ashulia Model Town area on the south of Ashulia EPZ Road. Some of these have received development permit from RAJUK and others authority. This will have considerable negative effect on environment.

Analysis of the land use changes in study area over time revealed a considerable increase in the built-up areas over the study period. Built-up areas increased by 934 ha between 1960 and 1991(**Figure 5.7).**

Table (**Appendix B3**) represent the trends of land use change area of Ashulia occupied by vegetation decreased by 69.91%, water-bodies by 19.89 % and wet/lowlands by 7.23% between 1960 and 1991. Another significant change was the decline in bare soil/landfill 50.52%, water-bodies 61.57%, vegetation 34.80% and wet/lowlands 21.43% from 1991 to 2008.

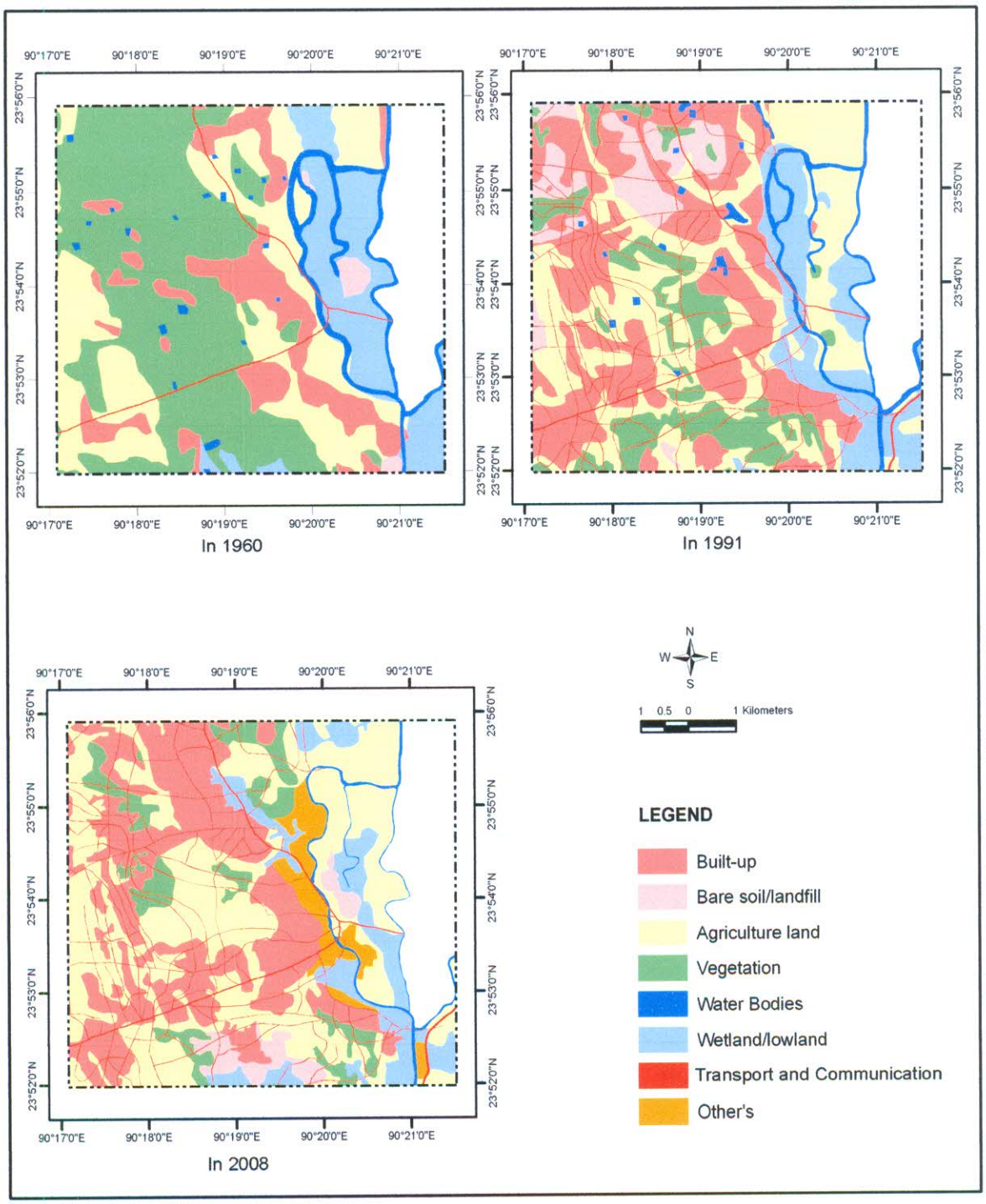
Figure 5.6 shows that in 1991 build-up area occupied 32%, bare soil/landfill 7%, vegetation 12%, water-bodies 4% and wet/lowlands occupied 12% of the total study area. But by 2008, these areas had declined to 8.40%, 50.52%, 34.80%, 61.67% and 21.43% respectively. Conversely, only cultivated land and transport and communication areas were increased in size by 31.69% and 2.65% in the period from 1991 to 2008 (**Appendix B3**).

Figure 5.6 Trends of land use change in Ashulia area, 1960-2008



Source: Field survey, 2010

Figure 5.7 Land use change of Ashulia area (1960-2008)



Source: Prepared by researcher based on figures 5.3, 5.4 and 5.5

It is also revealed from the analysis of above mentioned maps and images that during 1960 to 2008 the vegetation area decreased to 8.04%, water-bodies 69.21% and wet/lowlands 27.11%. At the same time conversely built-up area increased to 152.75%, bare soil/landfill area to 220.15%, cultivated land 44%, and transport and communication area to 446%. The decline of vegetation and wetlands was caused due to intensification of urban development in the Ashulia, particularly through the process of suburban development.

5.4.2 Uttara Area

The study area covers the north-west part of Uttara and Harirampur union and its adjacent lowlands are one of the selected areas. Uttara is located at the centre of spontaneous developed areas of Uttar khan and Dakshin khan in the east. It is low lying and undeveloped in its western borders at the Hazzrat Shahazalal Internation Airport (former Zia International Airport). The low lying undeveloped areas of the west will be available for development when the area will be flood free, but given the city center and labour opportunities it is expected that development will remain slow during the UAP planning period.

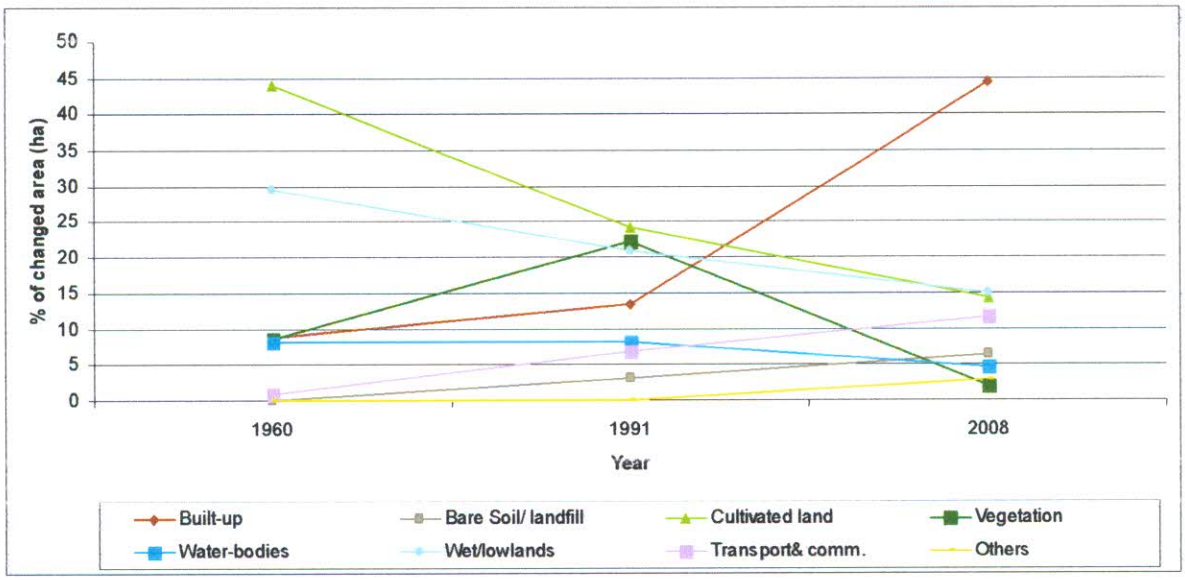
The planned area of Uttara is capable of densification even after undeveloped have been fully developed. The proposed extension of Begum Rokeya Sarani up to proposed eastern bypass through Uttara and Harirampur area will provide the area with additional access facility. The Savar(EPZ)-Ashulia-Uttara-Eastern Bypass (on Balu embankment) presently under construction will connect the area with Savar and eastern fringe.

The study area, Uttara and Harirampur area covering 1390 hectares, is shown in **Figure 5.9**. From the above discussion it is evident that coverage of cultivated land, vegetation and wet/lowlands in these areas are gradually decreasing from 1960 to 2008 and built up and transport and communication area are highly increasing from 1960 to 2008.

Table **(Appendix B4)** represent the trends of land use change area of Uttara and Harirampur area are occupied by cultivated land decreased by 45.13% and wet/lowlands by 28.70% between 1960 and 1991. Another significant change was the decline in cultivated land 40.50%, vegetation 91.50%, water-bodies 43.65% and wet/lowlands 28.70% from 1991 to 2008. In 1991, **Figure 5.8** shows that the cultivated land 24%, vegetation 23%, water bodies 8% and wet/lowlands occupied 21% of the total study area. But by 2008, these areas had declined to 67.35%, 77.98%, 42.69% and 49.17% respectively **(Appendix B4)**. Conversely,

only build up and transport and communication areas were increased in size by 403.16% and 1942.52% in the period from 1960 to 2008. The decline of cultivated land, vegetation, water-bodies and wet/lowlands was caused due to intensification of urban development in the Uttara and Harirampur area, particularly through the process of suburban development and environmental degradation.

Figure 5.8 Trends of land use change in Uttara area, 1960-2008

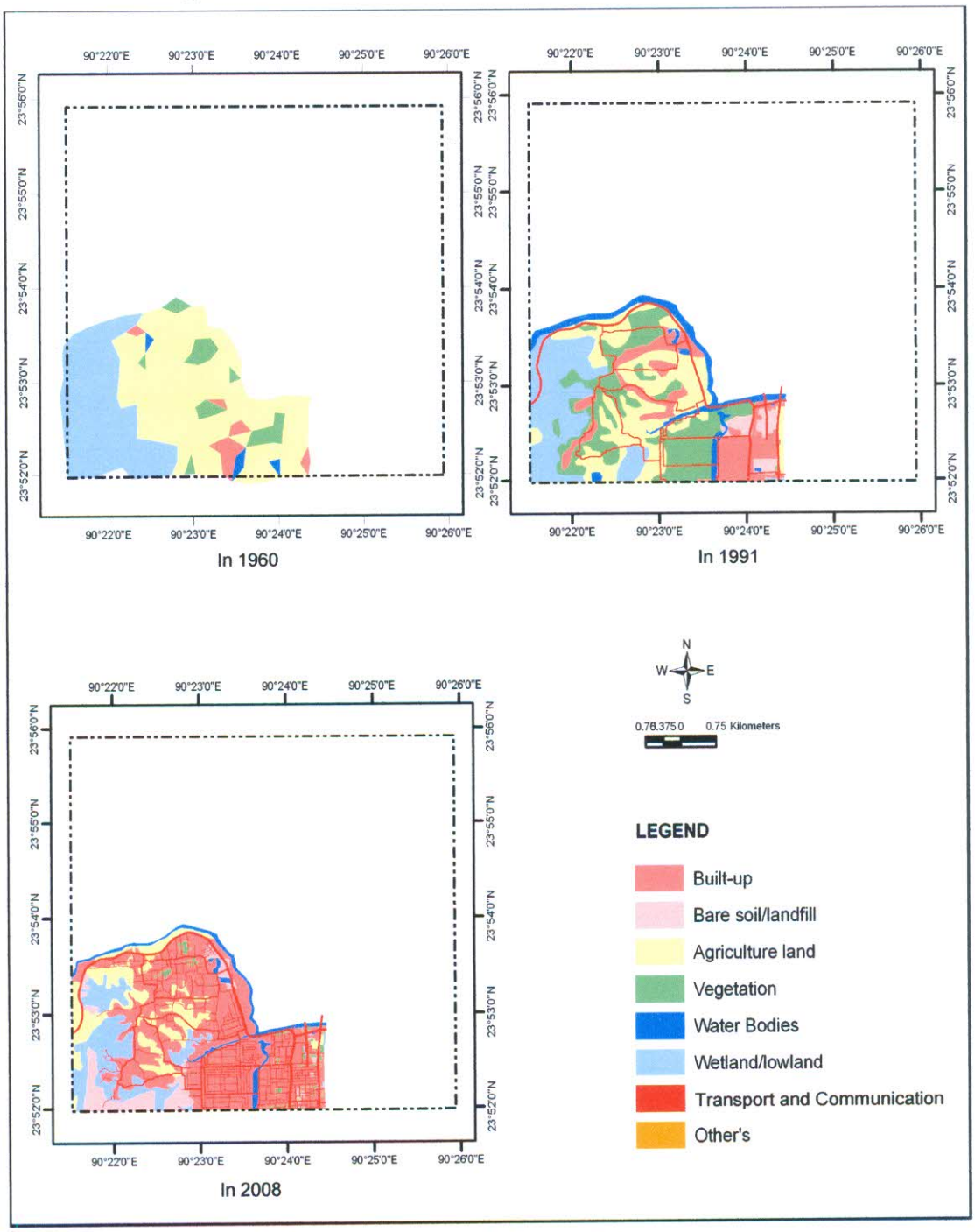


Source: Field survey, 2010

5.4.3 Amin Bazar Area

The study area covers from the western suburbs of urban Dhaka and it's divided into several sub areas. North-east (Shyamoli, Adabar and Mohammadpur) part of the area may be considered as planned residential and the north-west (Gabtali, Kallyanpur, Pirerbag, Paikpara and Lalkuti) as spontaneous residential and areas west of Shyamoli ring road are developing as spontaneous residential areas. There are large concentrations of slums on the western embankment. Amin Bazar, a low lying and fast growing area, is located on the bank of the Turaq river and inhabited mostly by poor and low income people. Due to its close proximity to old Dhaka, the area has gradually developed through land fill on flood plains of the river Turag. There have been many housing development schemes by private sector, especially in the Amin Bazar area on the south of Dhaka-Aricha road. Some of these have received development permit from RAJUK. This will have considerable negative effect on environment.

Figure 5.9 Land use change of Uttara area (1960-2008)



Source: Prepared by researcher based on figures 5.3, 5.4 and 5.5

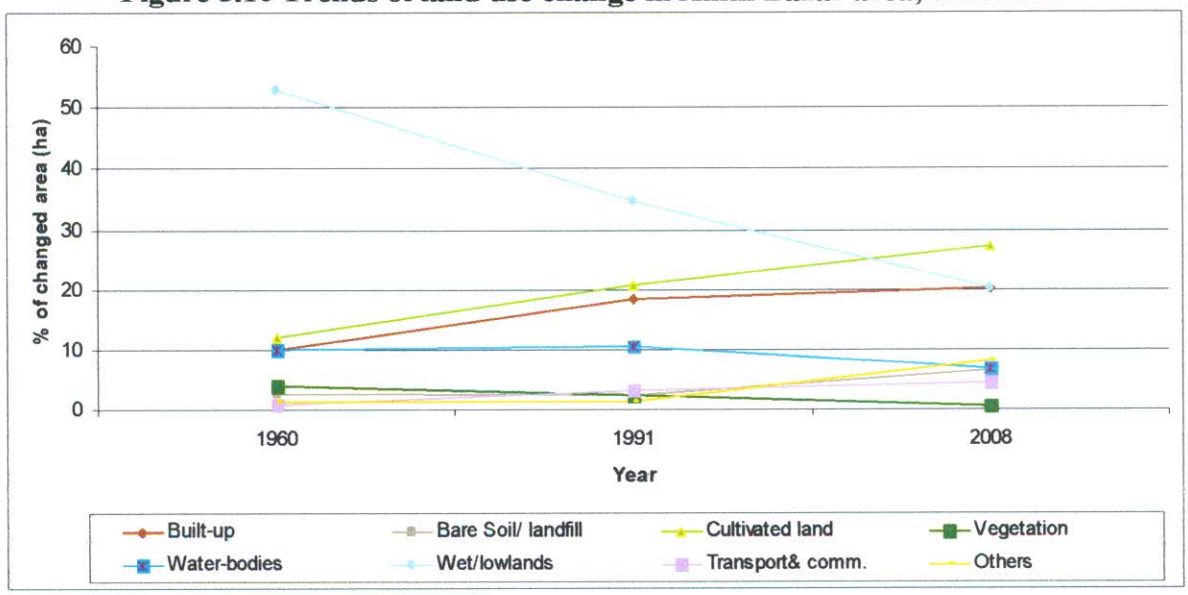
The western suburbs contain a number of slums, squatter and spontaneous settlements. While providing affordable housing for a large number of low income people, these areas substantially lack basic access and utility services. They are, for a large part, densely populated with temporary and makeshift housing cramped on small irregular plots. The areas often are flood prone. Developments in the west to Shyamoli Ring Road (Adabar) in fact encroached into the Kallyanpur retention pond area, which reduces the impact of the pump station and therefore may result in flooding elsewhere.

The study area, Amin Bazar is a part of DCC area and covers 4478 hectares **(Figure 5.11).** In 1960, along the river of this area were mostly wet/lowlands (57%), 1991 few built-up areas were grown up near the Amin Bazar and Gabtoli area converted from the wet/lowlands area. From the analysis of Google earth image, 2008 it is revealed that built-up area covers 22%; landfill area covers 7%, and water-bodies' covers 7% and wet/lowlands covers 22%, though the wetlands (water bodies and lowlands) are the dominant **(Appendix B5)**. If the present trend of built up and cultivated land, and transport and communication coverage continue, the vegetation, water bodies and wet/lowlands coverage will be the lowest amount.

The analysis of Table **(Appendix B5)** also revealed the trends of land use change, that the area of Amin Bazar area occupied by vegetation decreased by 37.53%, bare soil/landfill by 14.81% and wet/lowlands by 56.57% between 1960 and 1991. Another significant change was the decline in bare soil/landfill, cultivated land, water bodies, vegetation and wet/lowlands from 1991 to 2008. In 1991, **Figure 5.10** shows that build-up area 18.38%, bare soil/landfill 2.30%, cultivated land 20.63%, vegetation 2.41%, water-bodies 10.48% and wet/lowlands occupied 34.56% of the total study area.

But by 2008, these areas had declined to vegetation 2%, water-bodies 4% and wet/lowlands 15% respectively. Conversely, build-up area, bare soil/landfill, cultivated land and transport and communication areas were increased in size by 2%, 5%, 7% and 2% in the period from 1991 to 2008 **(Appendix B5)**.

Figure 5.10 Trends of land use change in Amin Bazar area, 1960-2008

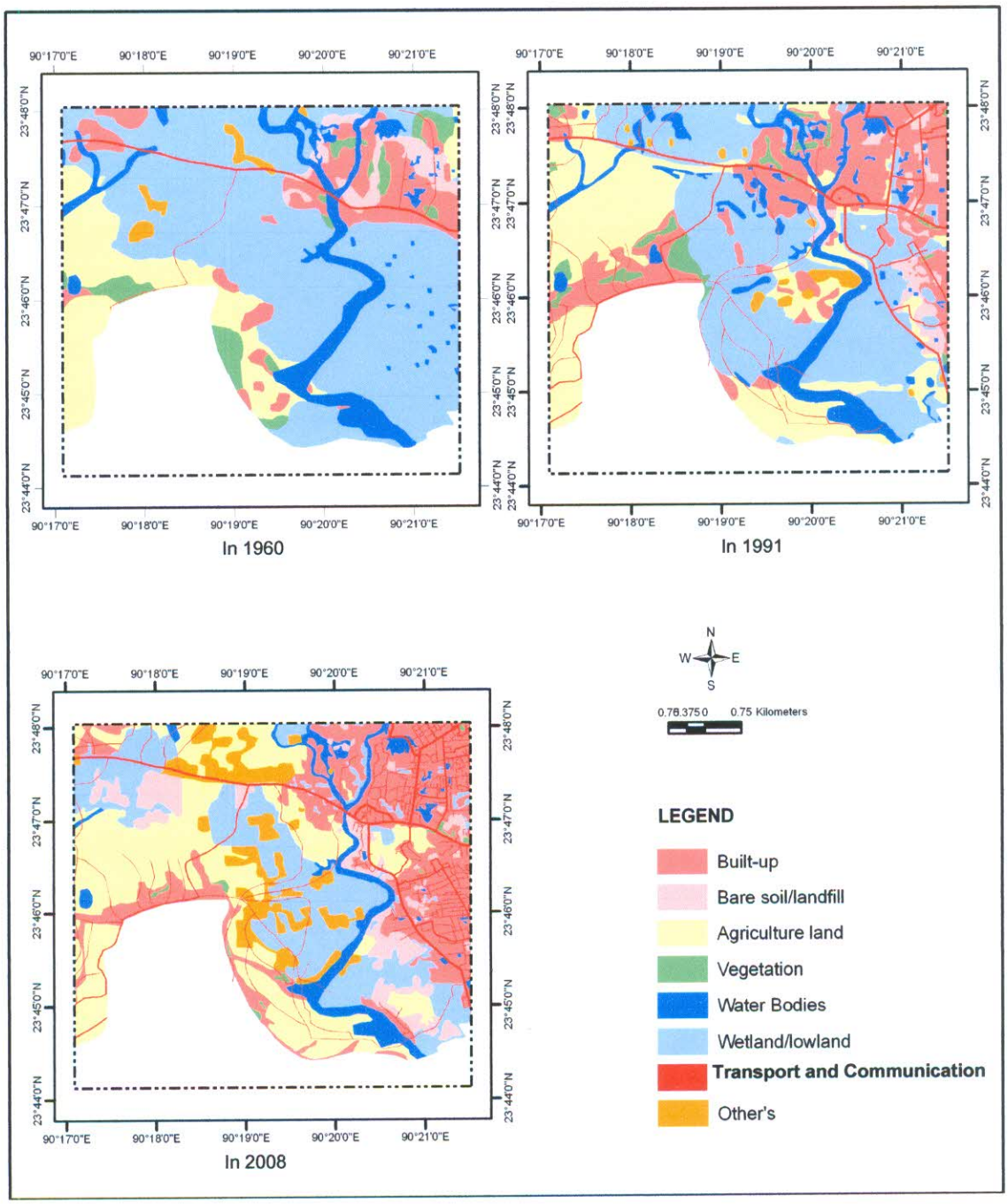


Source: Field survey, 2010

It is also revealed from the analysis of above mentioned maps and images that during 1960 to 2008 the vegetation area decreased to 89.66%, water-bodies 35.52% and wet/lowlands 61.95%. At the same time conversely built-up area increased to 104.74%, bare soil/landfill area to 142.56%, cultivated land 126.49%, and transport and communication area to 408.94% **(Appendix B5)**. The decline of vegetation, water-bodies and wetlands was caused due to intensification of urban development in the study area, particularly through the process of suburban development and decrease of environment quality.

From the analysis of land use pattern of these above changed wet/lowland areas (Turag River and Amin Bazar area, Uttara west part and Ashulia low lying area) it is revealed that the wet/lowlands of Turag River and Amin Bazar area are mainly converted into housing development and commercial purposes, and the wet/lowlands of western part of Uttara area are mainly converted into landfill for residential and industrial purposes, and agricultural land, vegetation and the wet/lowlands of Ashulia area are being mainly transformed to built up areas. From above result it is concluded that the trends of changing pattern of cultivated land, vegetation and wet/lowland is primarily converted into landfill areas then it is used as any kind of informal purpose and finally converted to built-up areas.

Figure 5.11 Land use change of Amin Bazar area (1960-2008)



Source: Prepared by researcher based on figures 5.3, 5.4 and 5.5

5.5 Comparative Land use Change Pattern and Trend in Selected Three Areas

During the period of the study, a marked transformation in the existing land use changed has been observed. Such transformation has been possible because of the increased uses of land under residential and related uses along the Ashulia EPZ Road, Dhaka-Aricha Highway and Tongi-Ashulia Road, close to the access routes, along the selected stretches of Turag River, Amin Bazar area, Ashulia area, North-west part of Uttara, and Mohammadpur Ring Road, western suburban and road with Embankment area. While the changes in wet/lowlands converted to landfill and agricultural land use were in the form of non-crop farms (Brick Kilns and some orchards), and most importantly, transformation of farm lands to non-crop farm uses, such as residential, industrial and commercial units, housing complexes (real estate business) and various land speculations. Such a trend in the land use changes has led to the sharp increases in land value per unit area. Overall, the land use transformation along the Dhaka-Aricha Highway in Amin Bazar, Ashulia EPZ Road in Ashulia area, and Tongi-Ashulia Road in Uttara North-western area indicates a trend similar to the 'ribon development' but with increased potentials for expansion in other areas, wet/lowlands and cultivated land are likely to be encroached upon in near future.

Table 5.10 Trends of land use change pattern in the selected three areas, 1960 -2008

(% of changed area)

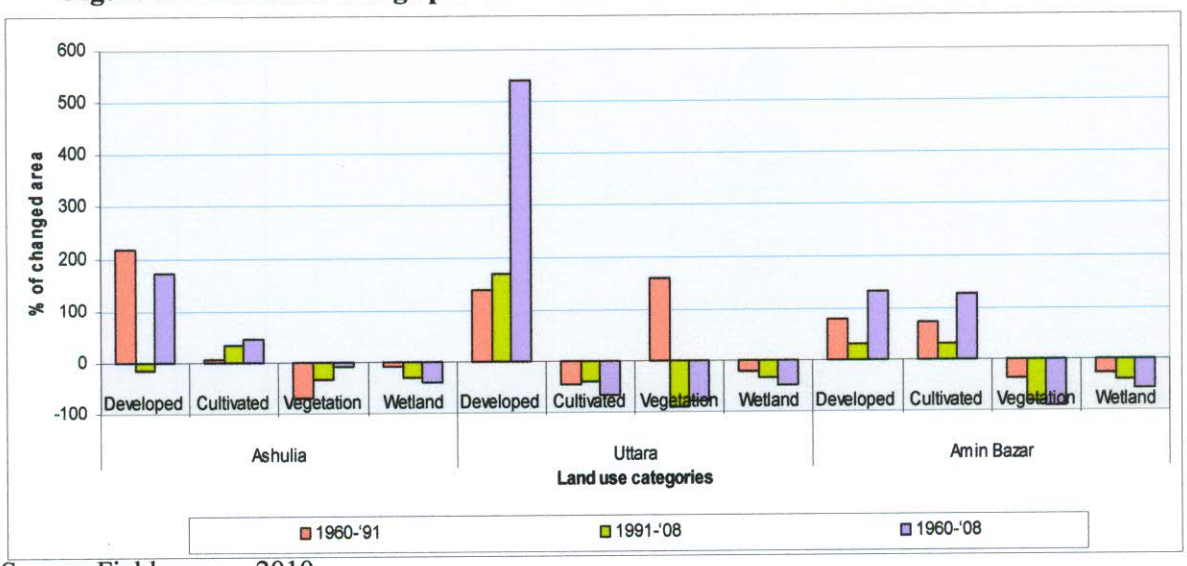
Year	Ashulia				Uttara				Amin Bazar			
	Developed Area*	Cultivated land	Vegetation	Wet land**	Developed area	Cultivated land	Veget-ation	Wet lands*	Developed area	Cultivated land	Veget-ation	Wet lands*
1960-'91	218.2	5.61	-69.9	-10.8	138.6	-45.1	159.2	-22.2	78.32	73.15	-37.5	-28.3
1991-'08	-14.5	31.69	-34.8	-31.5	168.4	-40.5	-91.5	-32.9	30.01	30.80	-83.4	-41.1
1960-'08	172.0	44.11	-8.04	-38.9	540.4	-67.4	-78.0	-47.8	131.8	126.5	-89.7	-57.8

Source: Analysis from table 5.11, 5.12 and 5.13

Note: *Developed area refers to built up area, bare soil/landfill and including transport and communication area; ** Wetlands mean water-bodies, lowland, *khal*, cannel and ponds.

It is found from the **Table 5.10** that developing areas in Ashulia, Uttara and Amin Bazar have gradually increased from 1960 to 2008. It is significant that developing area has increased 218.2% in Ashulia during 1960 to 1991; on the other hand during 1991 to 2008 developing area has decreased 14.5% in the same area. As a result considering overall features developing area has increased 172% in 1960 to 2008. Whereas developed area at Uttara has increased gradually without any disturbing. It is highly significant here that 540.4% has increased in Uttara from 1960 to 2008 **(Figure 5.12)**.

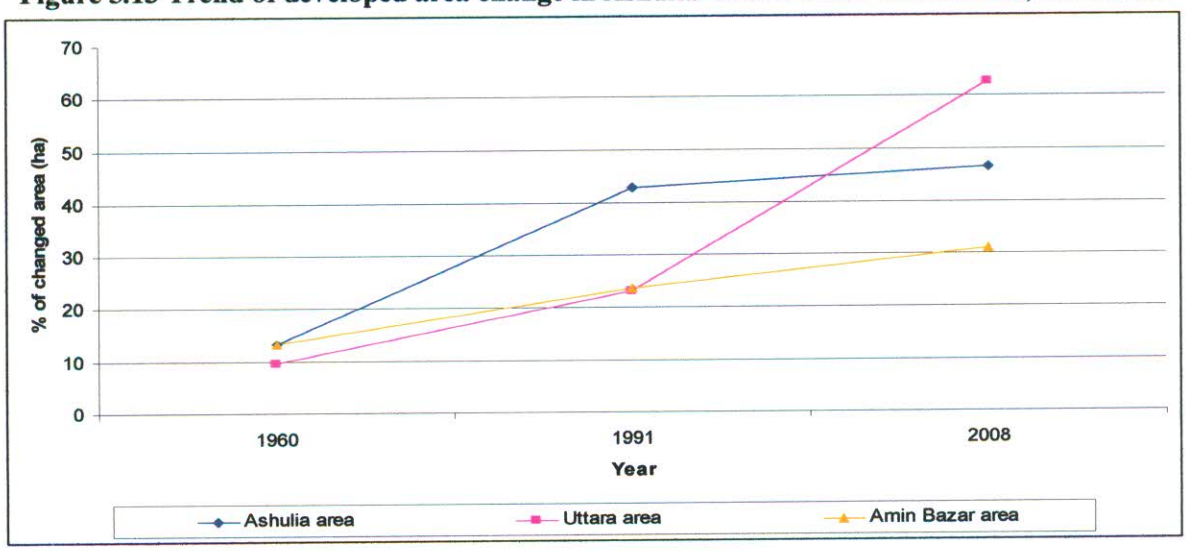
Figure 5.12 Land use change pattern in Ashulia-Uttara-Amin Bazar areas, 1960-2008



Source: Field survey, 2010

On the other hand the trend of developed area in Amin Bazar is usual/ normal as showed in the **Figure 5.13** from the same period.

Figure 5.13 Trend of developed area change in Ashulia-Uttara-Amin Bazar areas, 1960-2008

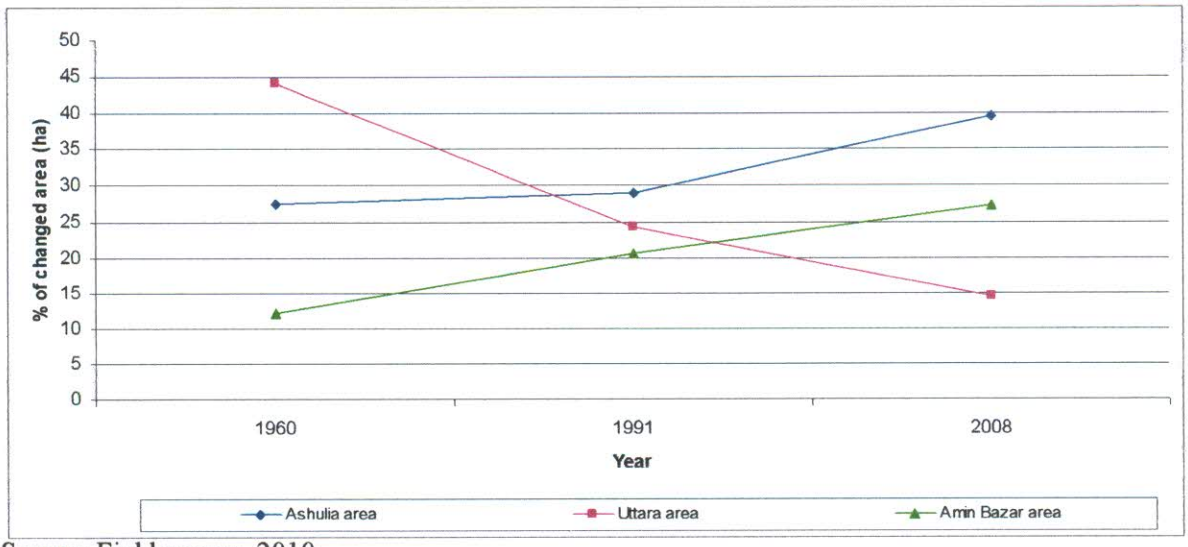


Source: Field survey, 2010

Though cultivated land area has been decreased due to urbanization, it is observed contrary features, in Ashulia and Amin Bazar that means cultivated land has increased. Behind this there are different causes found through investigation during field survey that cultivated land is acquired for development purposes, which forced to shift agriculture to the vegetated and wetland area caused 44% and 126.5% increase of cultivated area in Ashulia and Amin Bazar

from 1960 to 2008. In contrast cultivated land has decreased 67.4% at Uttara from the same period **(Table 5.10 and Figure 5.14)**.

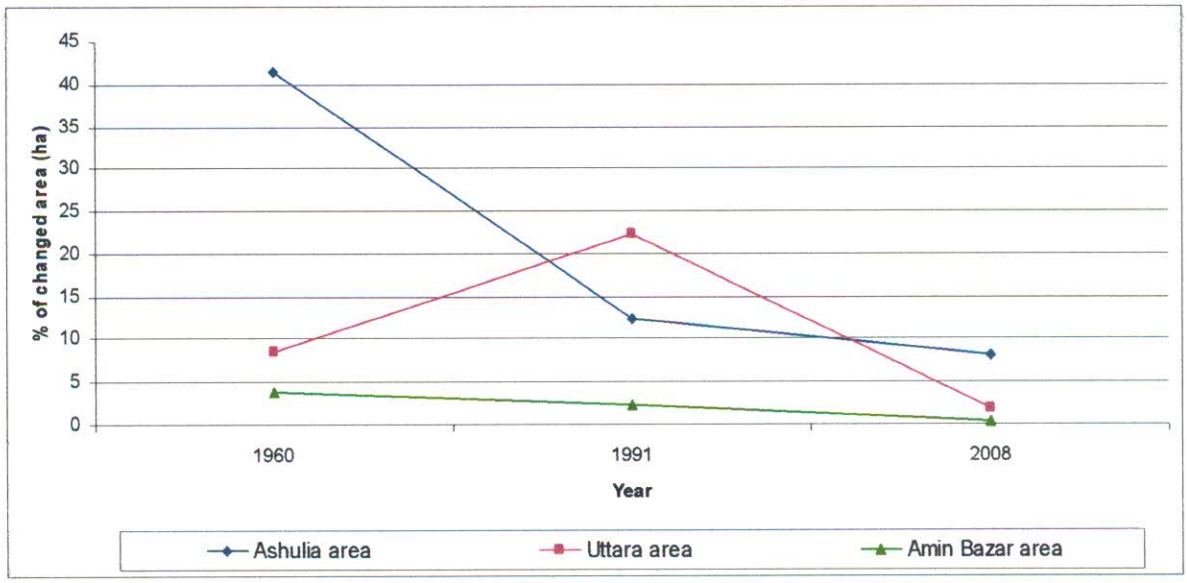
Figure 5.14 Trend of cultivated land change in Ashulia-Uttara-Amin Bazar areas, 1960-2008



Source: Field survey, 2010

It is found that vegetated land has decreased gradually in the study areas but in Uttara vegetated land had increased 159.2% in 1960 to 1991, which is not seen in any other areas. However vegetated land has decreased in study areas as shown in the **Table 5.10 and Figure 5.15**.

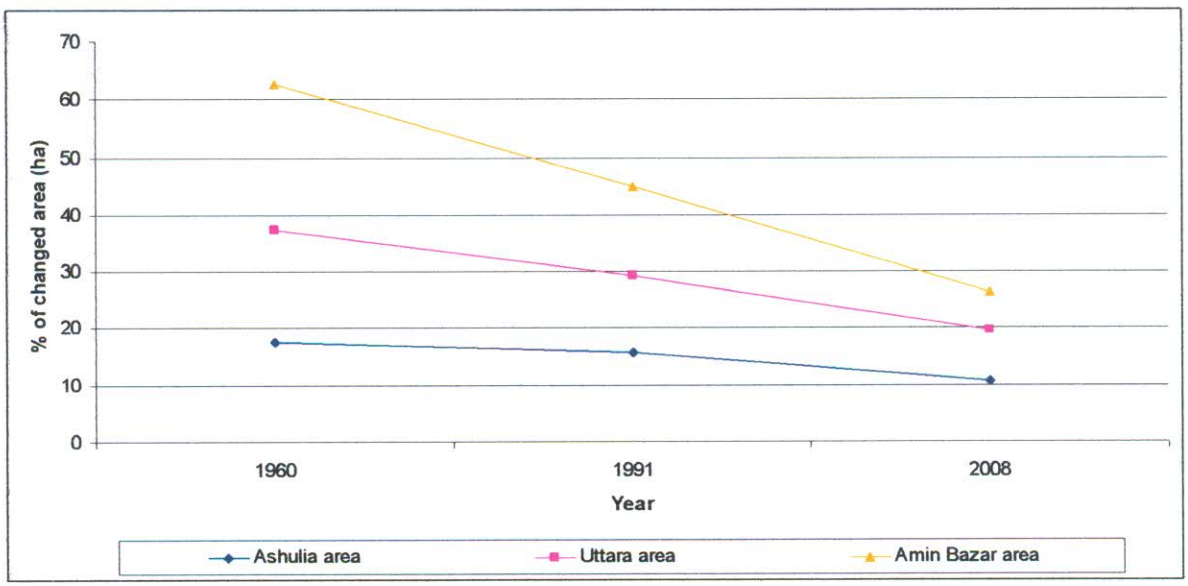
Figure 5.15 Trend of vegetated land change in Ashulia-Uttara-Amin Bazar areas, 1960-2008



Source: Field survey, 2010

It is observed from the table and during field survey that wetland has been decreasing due to unplanned urbanization and industrialization through encroachment and land filling **(Figure 5.16)**.

Figure 5.16 Trend of wetland change in Ashulia-Uttara-Amin Bazar areas, 1960-2008



Source: Field survey, 2010

It is found from the above discussion that urbanization process is rapidly intensifying in Uttara than Ashulia and Amin Bazar areas. If the present rate of urbanization in Uttara continues there would be hazards that might force to leave the area by letters. On the other hand, there would be environmental hazards if the present rate of urbanization process continues to be taken before creating any environmental disaster.

Hereby, the next chapter deals with a selection of models of land use change, change detection using land change modeler, transition probability matrix and prediction using Markov chain analysis according to the modeling and accuracy assessment.

Chapter 6

Land use Change and Modeling

Chapter 6
Land use Change and Modeling

Generally, land use change (LUC) is the modification of a piece of land. This change is based on the need and purpose of the land, which is not necessarily only the change in land cover but also changes in intensity and management (Verburg 2000; cited in Soepboer, 2001). Land use/land cover changes are critical issues due to their link with the loss of biodiversity and impact in human life as a result of unexpected change. Because of their enormous impact and implications, the International Geospehere-Biosphere Program (IGBP) and the International Human Dimension Program (IHDP) initiated a joint international program of study on land use/land cover change (LULCC). They commended the necessity of improved understanding, modeling and projections of land dynamics from global to regional scale and focusing particularly on the spatial explicitness of processes and outcomes (Geoghegan *et al.*, 2001).

The spatial setting of landscape elements is characterized by the combination of both biophysical and human forces (Fernandez *et al.*, 1992). In temporal scales of decades, human activities are basic factors in shaping land use change. Some of them are due to specific management practices and the rest are due to social, political and economical forces that control land uses (Medley *et al.*, 1995). The landscape is dynamic in relation to spatial, structural and functional patterns. The purpose of land use change simulation modeling is to describe, explain, predict, assess impact, and to evaluate hypothesis (Briassoulis, 2000). Due to fast changing nature of land use/cover the phenomena has become more important due to its integration with environmental linkage. The land-man-resource triangle is becoming more and more intensive to result/impact/create pressure on environment. The whole system works on wide range of components. Some components are very sensitive and act as unknown catalytic agents to the change. So, studying the change is a complex matter and is more complex to predict its future change. That is the area this chapter is going to deal with.

There have been many methods to see time-series analyses, surface change trend analyses or extrapolation that often gives good results. Due to coming of modern simulation technologies it is becoming more and more manageable. One such effort was initiated by the Clark Lab's

IDRISI system. They have developed various modules to analyze such changes and prediction. Land Change Modeler (LCM) for ecological sustainability is oriented to the pressing problem of accelerated land conversion and the specific analytical needs of biodiversity conversion (IDRISI Andes Manual 2006).

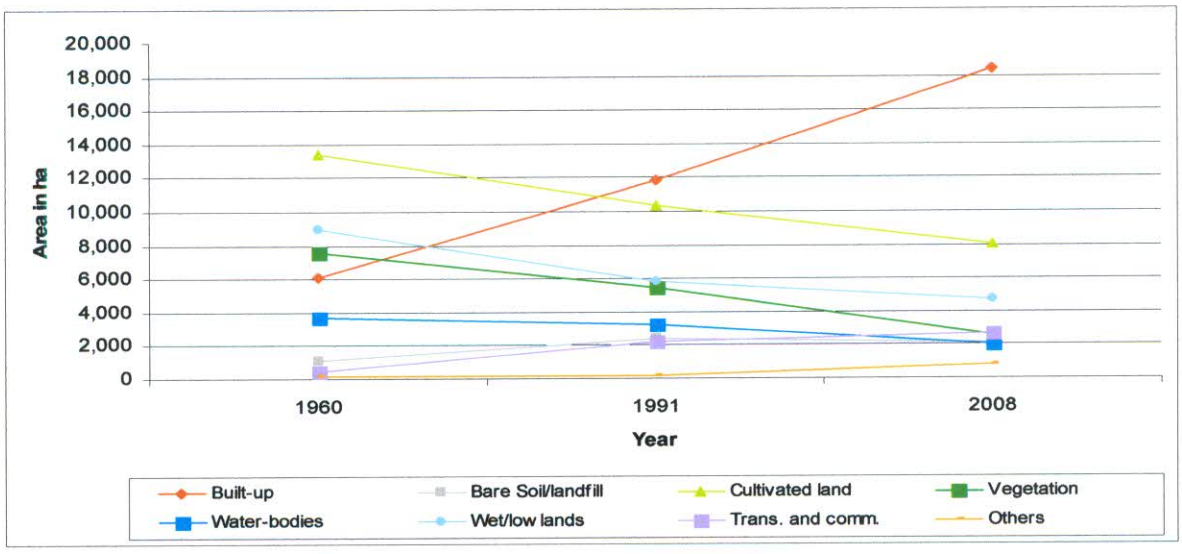
6.1 Land use Change in the Study Area, 1960 to 2008

Land use change reflects transformation of its nature, forms and its functions. Thus the conversion of a piece of cultivated land into settlement or to other use is a form of irreversible transformation. Again the conversion of the same piece of cultivated land into vegetations land is also a type of transformation. But such type of transformation is not irreversible as the utility of the land may be reverted to agriculture again if owner desires to. Thus in this context cultivated land, vegetation and lowland change may be considered as a change of form and utility of land which is supposed to be converted to built-up area at or near the surface. When the cultivated, vegetation and lowlands are drained out and used for other purpose like settlements, it can be said that, the cultivated, vegetated and lowlands are changed into built up areas. From the maps and image interpretation of different time phases, it is observed that, the cultivated land, vegetation, lowland and water bodies as well as other features are constantly changing. During the study period (1960-2008) there has been extensive development activities in the study area and Dhaka city has been expanded at these two directions significantly. So, change is supposed to be vivid over there.

6.1.1 Land use Change Analysis

From the classified image, the area of each land use class was computed (**Table 5.9 and Figure 6.1**) and compared statistically if there are differences between the images. **Figure 6.1** shows the changes in area (increase or decrease) for most of the classes. Agricultural, vegetation and wet/lowland have clearly decreasing trends while built up, bare soil and transportation and communication have clearly indicated increasing trends. And the other classes show slight changes.

Figure 6.1 Land use change trends within 1960-2008

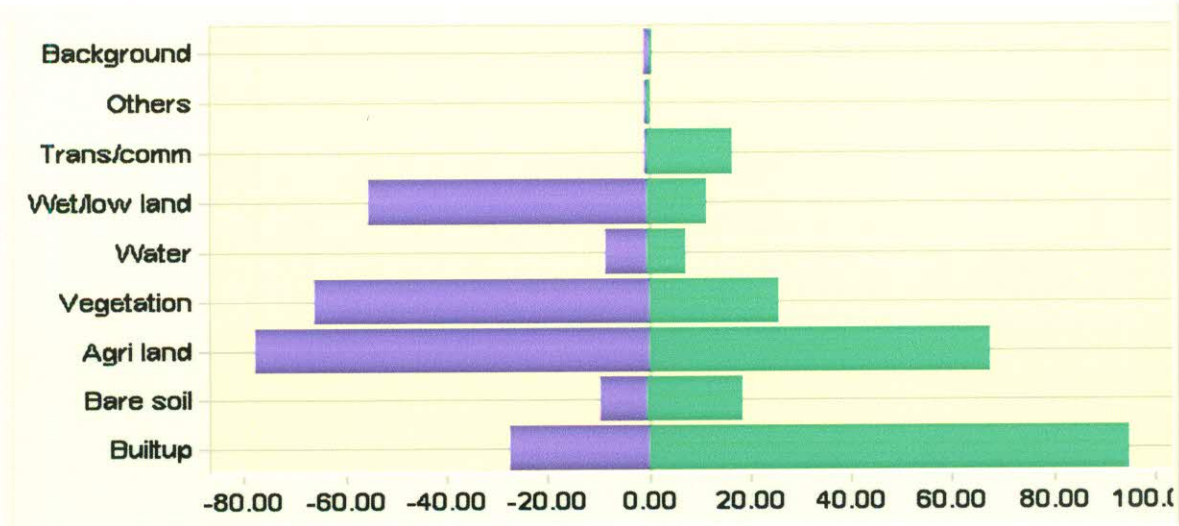


Source: Field survey, 2010

6.2 Change Detection using LCM

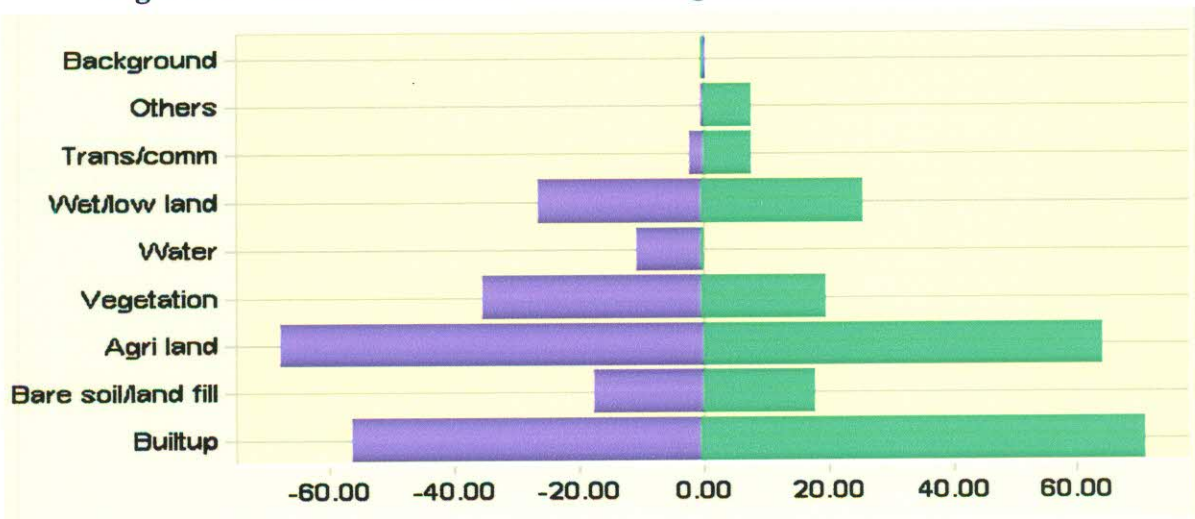
Land Change Modeler (LCM) was used to analyze the land use/cover changes between various classes during the period 1960-1991 (**Figure 6.2**) and 1991-2008 (**Figure 6.3**). The basic principle used in the module are to evaluate the trend of the change from one land use category to other, the impact of influencing factors such as roads and different types of visible and invisible infrastructures, and finally predict (short and long term) the land use pattern based on the previous change trend. There are of course several modules already developed such as Markov Chain Analysis, Time Series Analysis, Geomod etc., but Land Change Modeler (LCM) is, at the moment a widely used ecological modeling tool commonly used by the IDRISI system (Clark University based RS and GIS software). This is still under experiment, but bears a lot of potentiality. The module works on Neural Network and needs to reach accuracy greater than 70%. Accuracy depends much on influencing (driving) variables. Though researches on influencing variables were very limited and sufficient accuracy might not be expected, the level of accuracy obtained in the present study was accepted to used as temporarily functional, but of course not exclusive. The land use change was assessed through evaluation of gains and losses by classes. Most of the classes have both gains and losses, with the exception to water bodies which show losses only.

Figure 6.2 Gains and losses of land use categories between 1960 and 1991



During the period from 1960 to 1991, agricultural land lost 76.51% and gained 68.45%, with a net loss of 8.06%. And in the 1991-2008 periods the same category lost 78.31% and gained 63.72%, with a net loss of 14.59%. Vegetation lost 67.53% and gained 25.34 % in 1960-1991 with a net loss of 42.19 %. And in the 1991-2008 periods the loss was 36.28% and the gain 19.36% with a net loss of 16.92%. Wet/lowlands lost 57.45% and gained 12.53 % in 1960-1991 with a net loss of 44.92 %. And in the 1991-2008 periods the loss was 23.57 % and the gain 24.85% with a net gain of 1.28%. There was no change in of water bodies in the area during the period 1960-1991, but the area of water-bodies was lost during the period 1991-2008.

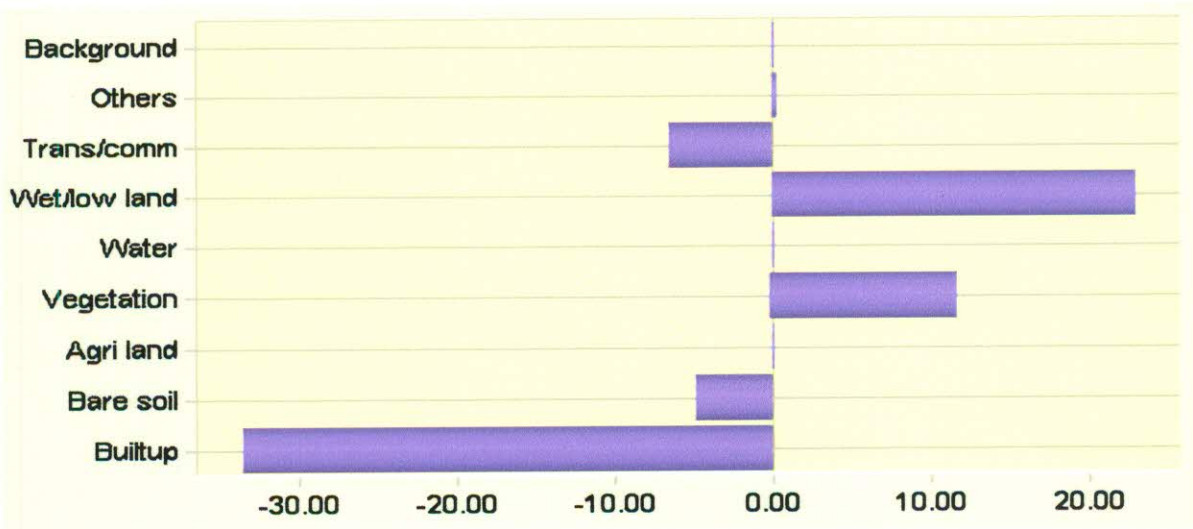
Figure 6.3 Gains and losses of land use categories between 1991 and 2008



On the other hand, built up area was lost about 27.61% and gained 93.58% with a net gain of 65.97 % during 1960 to1991. Moreover, during 1991-2008 periods the loss was 56.42% and the gain 71.26% with a net gain of 14.84%. And during the period 1960-1991, bare soil/landfill category's net gain was 10.58% and transport and communication gained 18.24%. During 1991-2008 periods there was no change in the area in case of bare soil/landfill, but the area of transport and communication gained 8.36%.

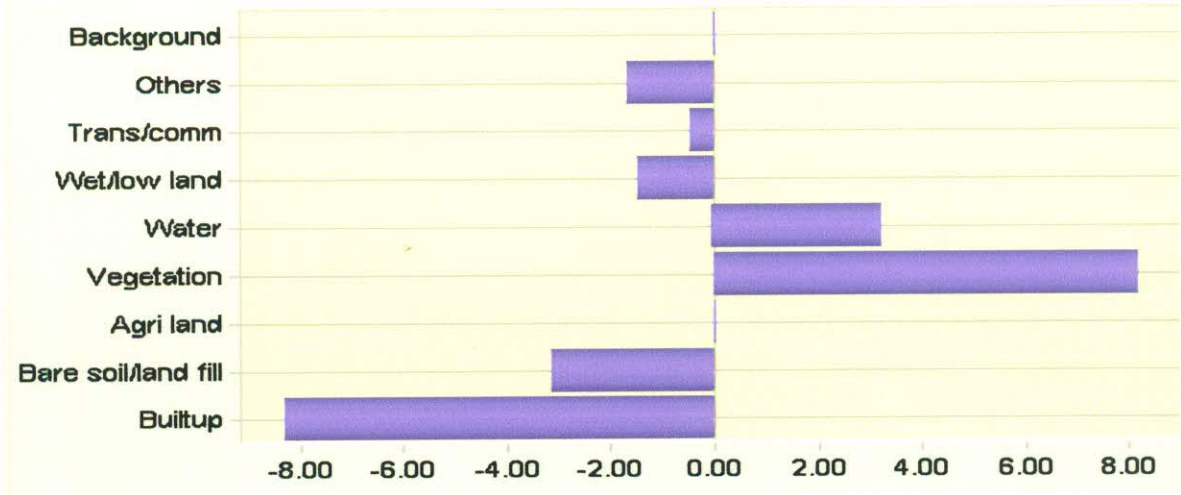
Net change analysis has been used to visualize the interclass change in detail; to see from which class the gained area came and to which class went in to. This gives a complete picture of the dynamic change of the land use classes. The analysis for agricultural land, vegetation, wet/lowlands, built up area and bare soil/landfill using net change contribution analysis which is given in **Figures 6.4 to 6.13.**

Figure 6.4 Contribution to the net change in agricultural land (1960-1991)



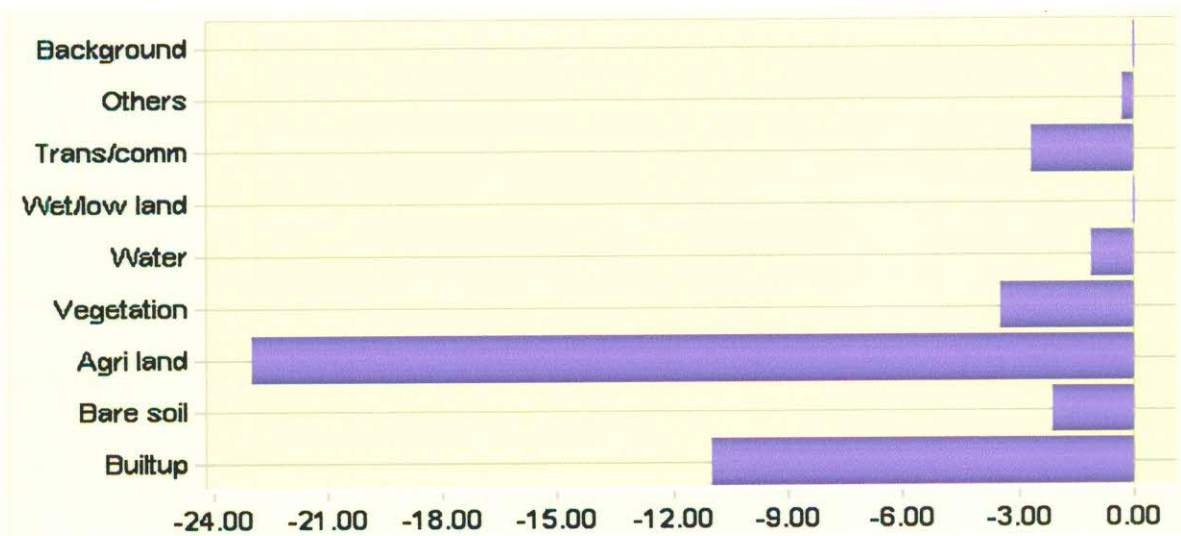
From the **Figure 6.4** it can be noticed that the agricultural land has changed mainly to build- up areas (33.14%) and a minor proportion to transport and communication (6.21%) and bare soil (4.15%). Agricultural land has gained from wet/lowlands (23.37%) and vegetation (12.03%) during 1960-1991. And in the periods 1991-2008, agricultural land was gained from vegetation (8.02%) and water-bodies (3.21%) and lost to built-up area, bare soil/landfill, wet/lowlands, transport and communication and others area shown in the **Figure 6.5.**

Figure 6.5 Contribution to the net change in agricultural land (1991-2008)



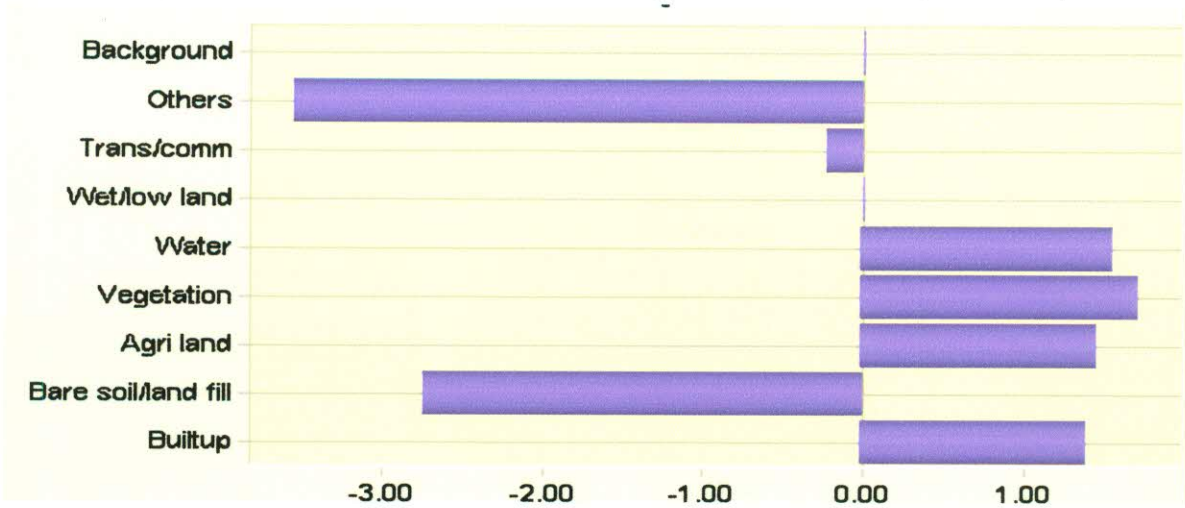
In wet/lowlands there was no gain during the period 1960 to 1991. It has been converted into all other land use classes during this period shown in **Figure 6.6**. And the proportional losses were agricultural land as 22.65%, built up area as 10.88%, vegetation as 3.46%, bare soil/landfill as 2.09%, transport and communication as 2.89% and water-bodies were 1.34% respectively.

Figure 6.6 Contribution to the net change in wet/lowlands (1960-1991)



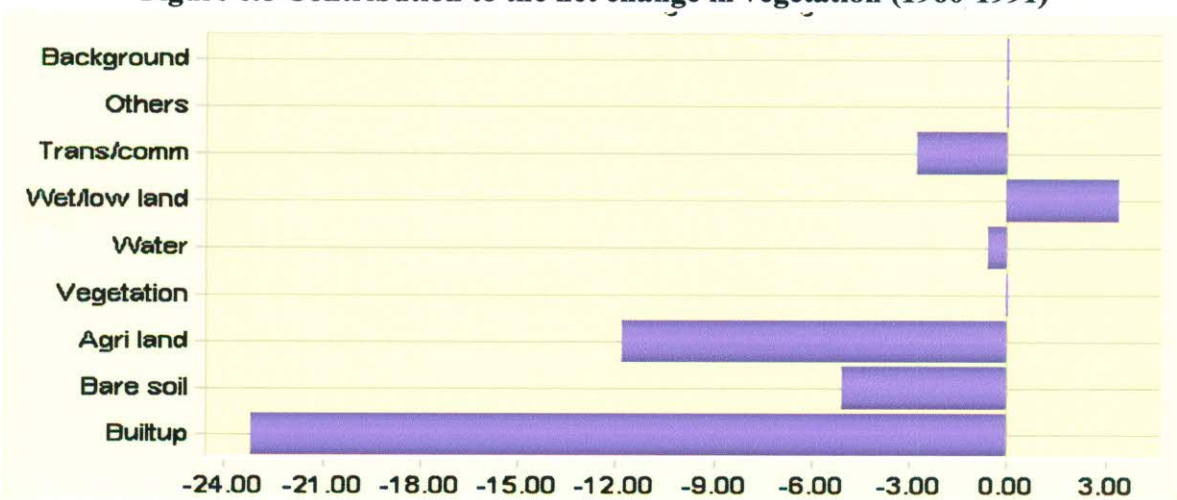
During the period 1991 to 2008, wet/lowland area converted into vegetated land, water-bodies, agricultural land and built-up area converted more than 1%. At the same time wet/lowlands area lost to bare soil/landfill as 2.73 % and others land as 3.65%, as shown in the **Figure 6.7**.

Figure 6.7 Contribution to the net change in wet/lowlands (1991-2008)



The vegetated land only gained from wet/lowlands area as 3.16% during the period 1960 to 1991. And it lost to all other classes such as: built-up area as 22.85%, agricultural land as 11.92% and bare soil/landfill as 4.58%, and a small proportion has lost into transport and communication purposes, which was only 2.87%, shown in the **Figure 6.8**. As a result vegetated land had no gain during that period, which ultimately turned into deforestation.

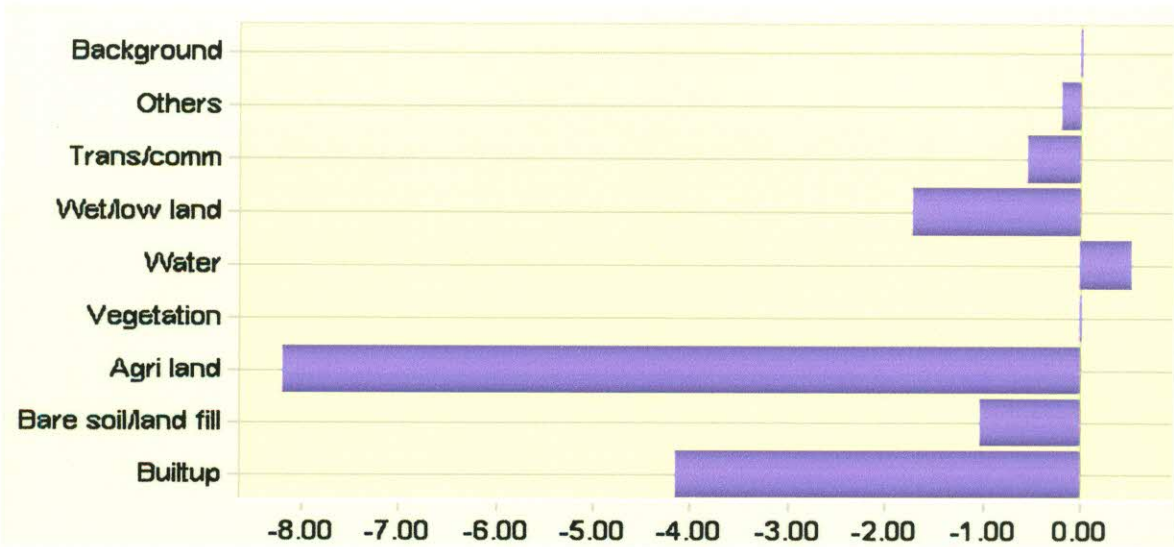
Figure 6.8 Contribution to the net change in vegetation (1960-1991)



During the period 1991 to 2008, 8.25% vegetated land has been converted into agricultural land, in case of built-up area it was 4.12%, for wet/lowlands it was 1.67%, and a minor portion has been converted into bare soil/landfill, transportation and communication and others areas (**Figure 6.9**). There was no gain in the vegetated land in the same period; only 0.62% gained from water-bodies was not significant enough. As a result the area experienced

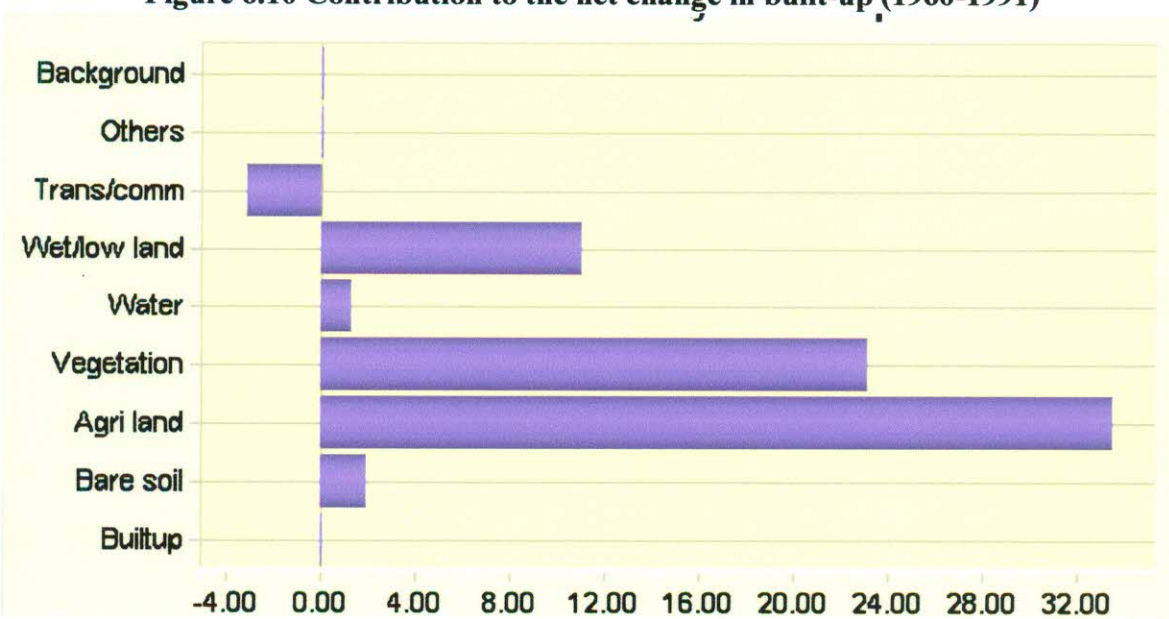
environmental degradation gradually resulting in deforestation for the unplanned urbanization and industrialization.

Figure 6.9 Contribution to the net change in vegetation (1991-2008)



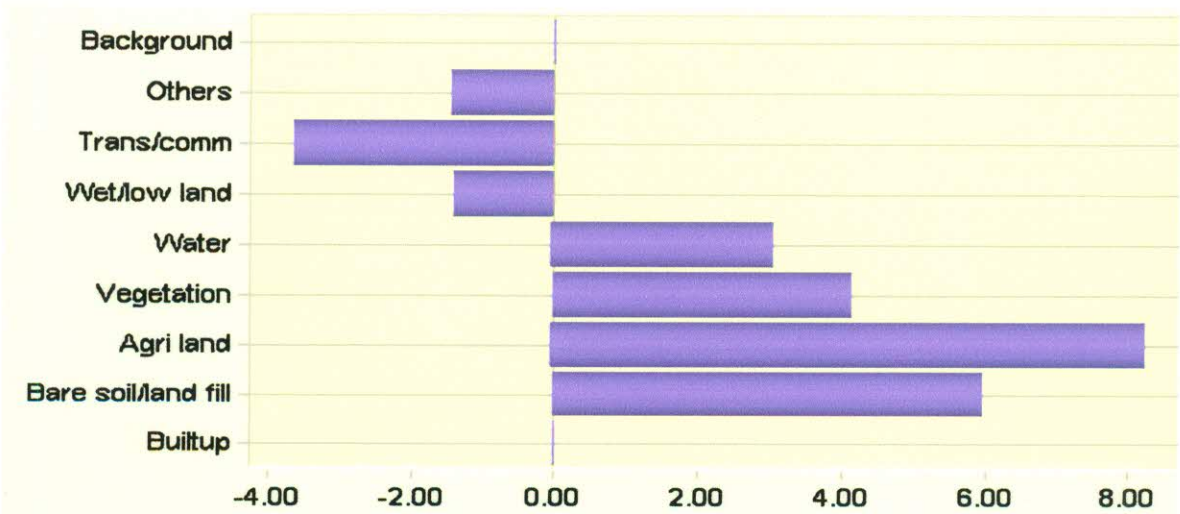
The built-up area gained from all land use classes during the period 1960 to 1991. It gained 33.87% from agricultural land, 23.47 % from vegetation, and from wet/lowlands 11.62%. A small proportion was converted from bare soil and water-bodies and the area was lost into transport and communication purpose shown in **Figure 6.10**.

Figure 6.10 Contribution to the net change in built-up (1960-1991)



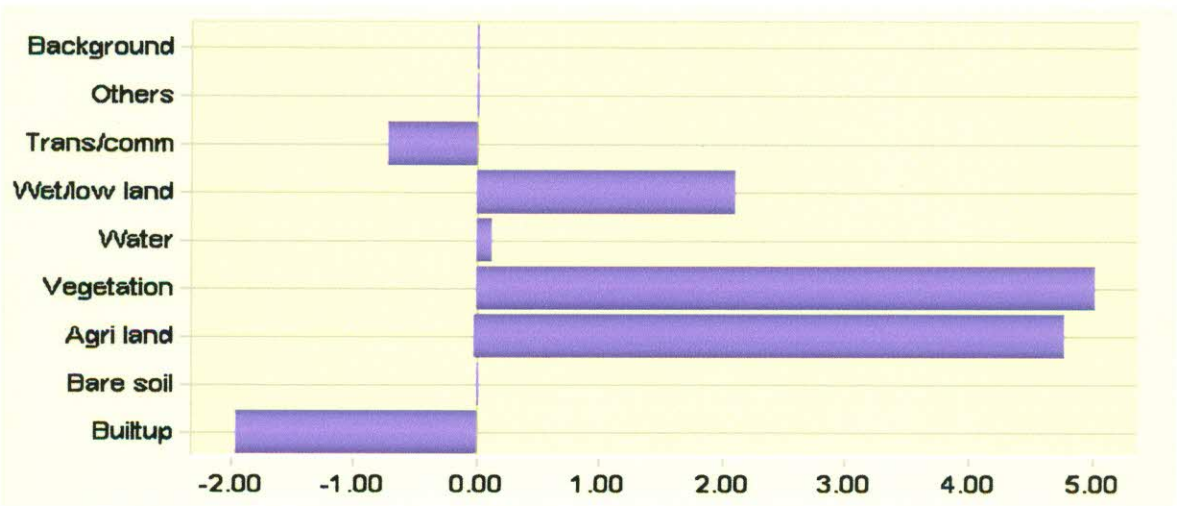
On the other hand, built-up area lost to agricultural land as 8.36%, to bare soil/landfill as 5.98%, to vegetation as 4.05% and to water bodies as 3.05% during 1991 to 2008 **(Figure 6.11)**. In the same periods built-up area was lost mainly to transport and communication (3.68%) and a minor proportion of loss was seen from wet/lowlands and others area. Now-a-days built-up area is increasing day by day for unplanned urbanization, industrialization and rapid growth of population. As a result the urban environmental quality is being destroyed.

Figure 6.11 Contribution to the net change in built-up land (1991-2008)



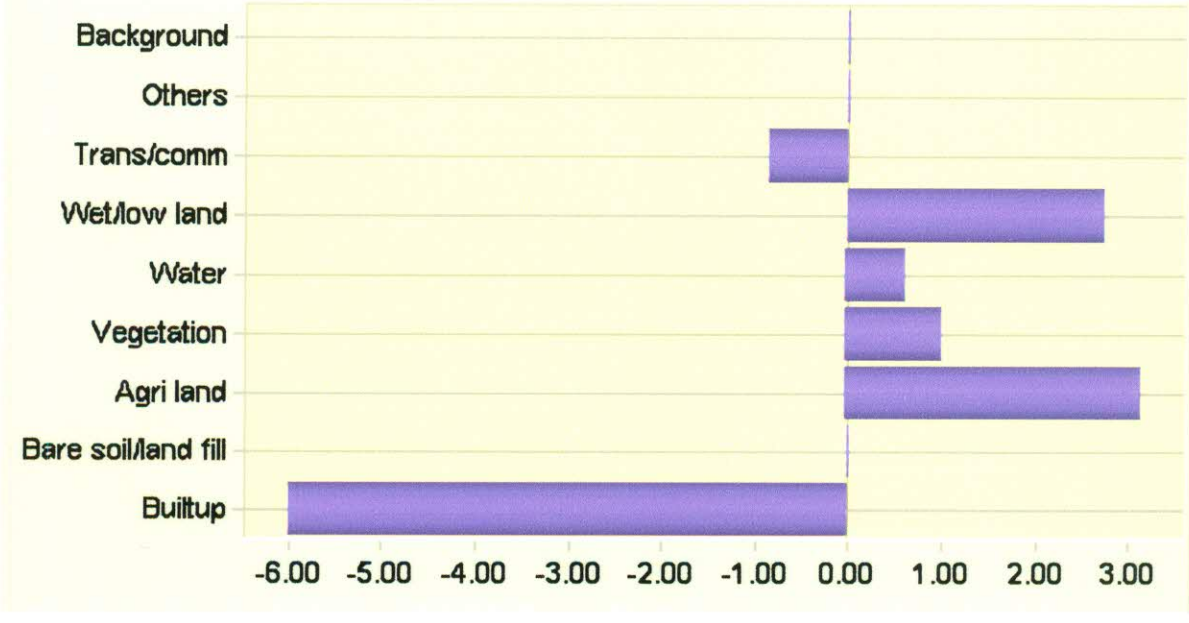
During the period from 1960-1991, bare soil/landfill has been gained from vegetation (5.04%), agricultural area (4.85%) and wet/lowlands area (2.06%) and a small proportion was lost into the built-up area (1.99%) and transport and communication purpose shown in the **Figure 6.12**.

Figure 6.12 Contribution to the net change in bare soil/landfill (1960-1991)



Similarly, as seen in the **Figure 6.13,** bare soil/landfill area, has been gained into agricultural land 3.17%, wet/lowlands 2.85%, and a small proportion was gained from vegetation and water-bodies in 1960-1991. In the period from 1991-2008, bare soil/landfill has been lost mainly to build-up area 6.0% and a small proportion was to transport and communication purpose.

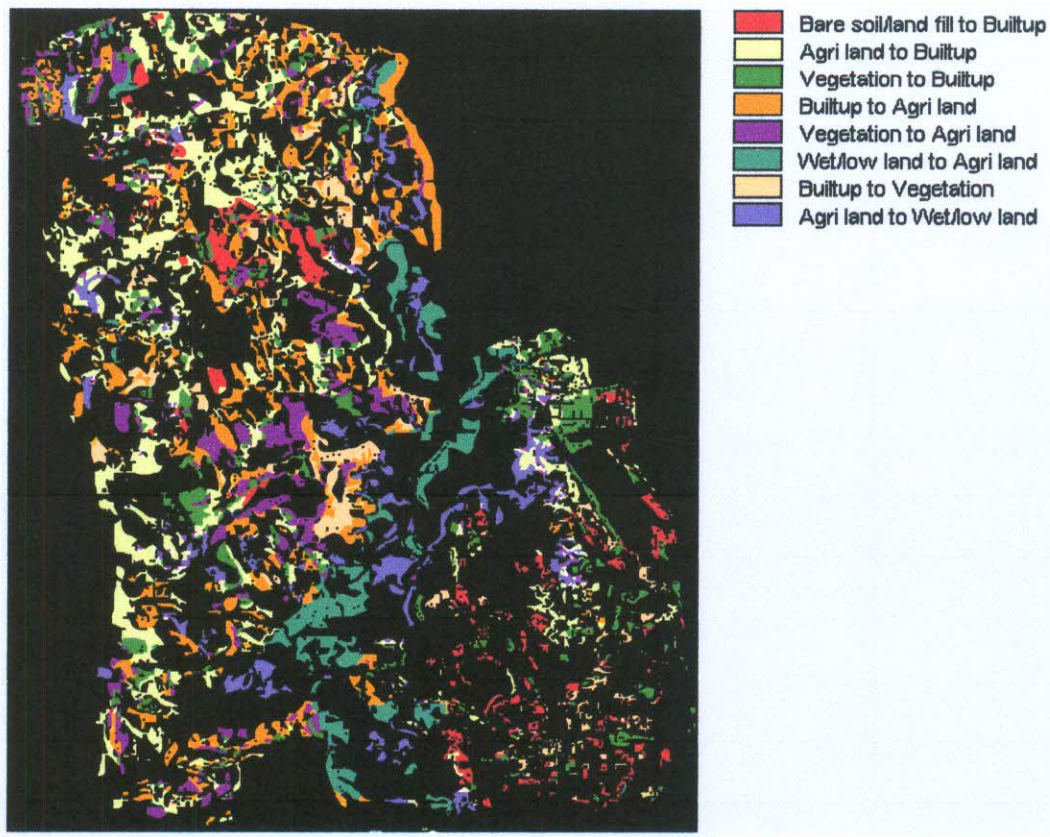
Figure 6.13 Contribution to the net change in bare soil/landfill (1991-2008



On the other hand, built-up area has gained from agricultural land, vegetated land and wet/lowlands in 1960-1991. During the period 1991 to 2008, built up area gained from bare soil/landfill, agricultural land and vegetated land (**Figure 6.13**). And a small proportion was lost to agricultural land, vegetated land and built-up areas.

Figure 6.14 shows a pictorial representation of significant changes and summarizes the various land use/cover classes that has undergone transitions from one to another during the period from 1991 to 2008. Bare soil/landfill, agricultural land and vegetated area were converted into built-up area, built-up area converted into agricultural land and vegetated area, vegetation and wet/lowland area converted into agricultural land and a small part of agricultural land converted to wet/lowlands.

Figure 6.14 Combined land use change map of 1991 and 2008



For the classes of land use change analyzed above (built-up area and seasonal agricultural land) several reasons are responsible. *First*, the seasonal agricultural land is a rotating system, where lands were used for crop production and then left for the recovery for a certain period of time. During the recovery period, it remained as a bare soil and then passes to wetland or vegetation land as a natural succession. *Second*, most of the wetland and vegetated lands are still under a condition to facilitate the farming work before the cultivation or to renew green evaluation for livestock grazing. *Thirdly*, some wetland areas with declined vegetated area or the vegetation cover of built-up area can be recovered and the class is changed to wetland. *Fourth*, forest is used to local residents as fuel and the empty places are used for agricultural and built-up purposes. *Fifth*, some changes represent an error in image classification, as there are difficulties to adequately separate the seasonal agricultural land, built-up area and wet/lowland in some areas depending on the conditions of the class and the season. Even though the images used in this study belong to the same season (dry) whereas some differences in vegetation phonology can be observed.

6.3 Modeling

Land use change modeling helps to understand the process of continuing urbanization and can also be of value in informing policymakers of possible future conditions under different scenarios. Land use change models can therefore be defined as tools to support the analysis of the causes and consequences of land use change (Verburg *et al.,* 2004). Recent inventories of operational models for land use change are numerous. Briassoulis (2000) offers a very extensive discussion of the most common land use change models and their theoretical backgrounds. Waddell and Ulfarsson (2003) and Verburg et al., (2004) present more concise overviews that focus on the future directions of research in this field, whilst more detailed, technical information on the actual models is provided by Agarwal *et al.*, (2002) and the U.S. Environmental Protection Agency (U.S. EPA, 2000). We will refrain here by classifying existing models, but rather discuss a number of characteristics that can be used to differentiate the most common modeling approaches.

One of the most important distinctions refers to static as opposed to dynamic models. Static (or cross-sectional) models directly calculate the situation at a given point in time, whereas dynamic models work with intermediate time-steps, each of which might become the starting-point for calculating the subsequent situation. Dynamic modeling, therefore, takes possible developments during the simulation period into account, providing a richer behavior and the possibility to better mimic actual spatial developments.

6.3.1 Land use Models

Land use models often incorporate a variety of land use categories as inputs and, thereby, can account for different sub classifications of urban and non urban land use such as commercial, industrial, and agricultural, and even more detailed sub classifications such as density of residential use and type of commercial/industrial development. Some models offer an environmental approach and research, for example, the impact of transportation and land-use choices on air and water quality. Many of the more user-friendly models are integrated with GISs and IDRISI Andes modeler to become spatially explicit decision-support systems with relational database technology.

The land use change models can also be characterized as dealing with either transformation or allocation. Transformation models start from the current land use and simulate the possible conversion into another land use type, e.g. based on a transformation probability or the status

of surrounding locations. The common denominator of the models summarized in this guide is that each research projected land use changes in the study area for 2020 and for 2050. Understanding these models comprehensively, however, requires a basic understanding of the components of transportation and population growth due to unplanned development. Transportation planners are to consider the likely effect of transportation policy decisions on land use and development, and the consistency of transportation plans and programs with provisions of all applicable short and long term land use development plans (Deakin, 1995).

From **Table 6.1,** it is clear that over the years built-up area has increased distinctly. It is also noteworthy that there is an evidential decrease in vegetation, water-bodies, cultivated land and wet/lowland. The transport and communication has increased rapidly and loss in bare soil/land filled is also found. It is now possible to predict the land use/cover change map of Dhaka city using Markov Cellular Automata (CA_Markov) modeling.

Table 6.1 Summary of land use classification statistics between 1991 and 2008

Land use Category	1991		2008		Change of Area (ha) 1991-2008
	Area(ha)	(%)	Area(ha)	(%)	
Built-up	11,866	28.61	18,451	44.49	+55.49
Bare soil/landfill	2,420	5.84	2,090	5.04	-13.64
Cultivated land	10,395	25.07	8,050	19.41	-22.56
Vegetation	5,418	13.06	2,589	6.24	-52.21
Water-bodies	3,196	7.71	2,068	4.99	-35.29
Wet/lowlands	5,829	14.06	4,732	11.41	-18.82
Transports and communications	2,185	5.27	2,692	6.49	+23.20
Others	159	0.38	796	1.92	+400.63
Total	**41,468**	**100.00**	**41,468**	**100.00**	**0**

CA_Markov modeling

In Markovian processes the future state of a system in time t2 can be modeled based on the immediate preceding state; time t1. A Markov chain is a random process where the following step depends on the current state. Markov produces a transition matrix (**Table 6.2**), a transition areas matrix and a set of conditional probability images by analyzing two qualitative land use images (**Figure 6.15**) from two different dates (1991 and 2008). In **Table 6.2**, the rows represent the older land use/cover classes and the columns represent the newer

land use/cover categories. Here class_1 to class_8 chronologically represent built-up area, bare soil/landfill, cultivated land, vegetation, water-body, wet/lowlands, transport and communication and others land respectively. Markov analysis was performed for the multi-temporal land cover images of 1991-2008 including predicting year of 2020 as shown in **Table 6.2.**

Table 6.2 Markov prediction to 2020 based on land use maps of 1991 and 2008

Given: Probability of changing to

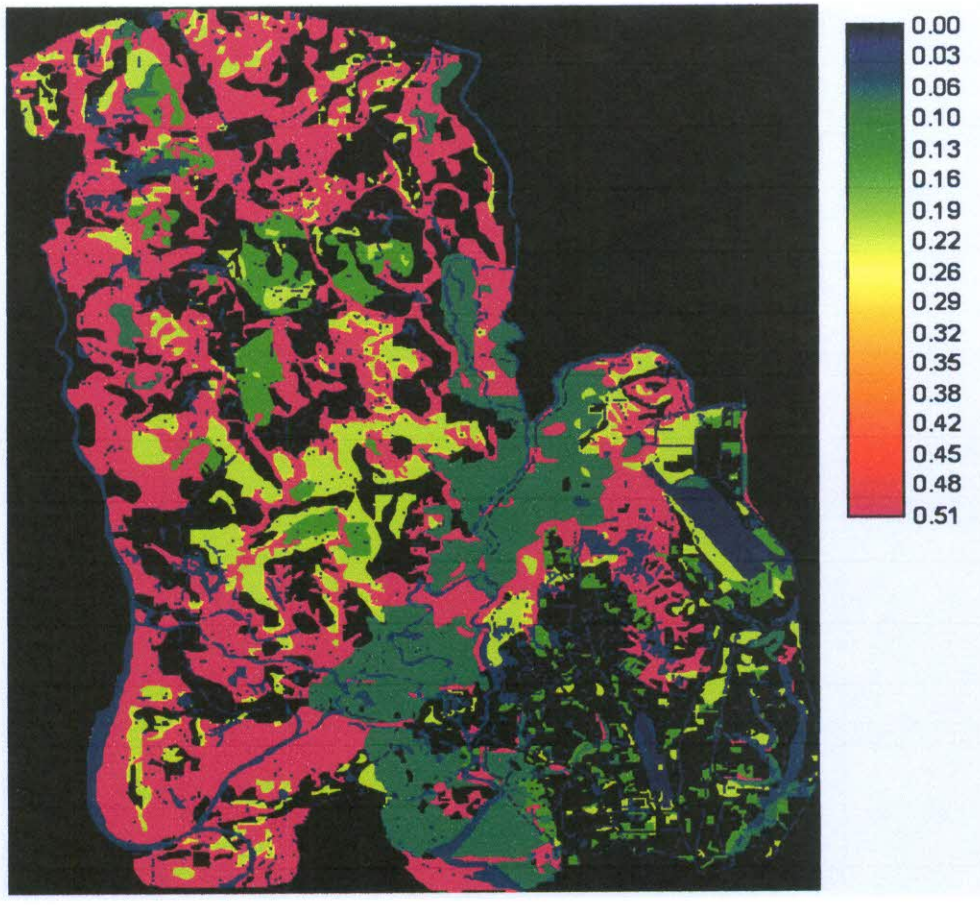
	BU	BL	AL	VG	WB	WL	TC	OT
BU:	0.6140	0.0265	0.1937	0.0880	0.0011	0.0385	0.0282	0.0098
BL:	**0.5156**	0.1774	0.2031	0.0507	0.0005	0.0176	0.0351	0.0000
AL:	0.2624	0.0638	0.5033	0.0510	0.0001	0.1085	0.0010	0.0098
VG:	**0.3469**	0.0532	**0.3784**	**0.1688**	0.0000	0.0358	0.0165	0.0002
WB:	0.0776	0.0169	0.0850	0.0125	0.7397	0.0382	0.0068	0.0155
WL:	**0.0671**	0.0776	**0.2685**	0.0002	0.0003	**0.4878**	0.0044	0.0940
TC:	0.0350	0.0002	0.0084	0.0161	0.0005	0.0044	0.9347	0.0001
OT:	0.0619	0.0000	0.0000	0.0000	0.0000	0.6676	0.0110	0.2595

Note: BU = Built-up, BL = Bare soil/landfill, AL = Agricultural land, VG = Vegetation
WB = Water-bodies, WL = Wet/lowlands, TC = Transport and communication, and OT = Others

According to this transition matrix shown in the **Table 6.2**, the probability of vegetation is only 17% for the period of 17 years. The probability of conversion from vegetation to agriculture and built-up areas are 38% and 35% respectively. Similarly the probability of wet /lowlands classes change into 27% agricultural land and 7 % built-up area; agricultural land to change to built-up areas are 26% and wet/lowlands are 11%; bare soil/landfill area change to built-up area 51% and agricultural land 20%. However, the areas that are likely to be invaded by classes of built-up area in 2020 are shown in **Figure 6.15.**

It can be seen from the figure given below that according to Markov transition probability the lands under vegetation are highly vulnerable to infestation by study area in the next 17 years. The probabilities of the invasive to encroach into the wet/lowlands are as high as 49% (**Table 6.2**). However it can be noticed that those areas which were originally classified under transport and communication, and others area is not represented in the map and the value is shown as near about 0.

Figure 6.15 Projected Markov conditional probability matrixes for built-up area 2020



The above map indicates that the probability of wet/lowlands to convert into agricultural land and built-up area is as high as 27% and 7% (**Table 6.2**) in the next 17 years. However, it should be noticed that according to the table the probability of wet/lowlands to remain as wet/lowlands is 100% but this is not represented by the image. As in the previous image, the areas originally represented by classes' wet/lowlands and others area is shown in black and has a probability of 0.

6.3.2 Transition Probability Matrix

The transition probability matrix records the probability of each land use category to change into the other category. This matrix is produced by the multiplication of each column in the transition probability matrix be the number of cells of corresponding land use in the later image.

In the 8 X 8 matrix (**Table 6.3**) shown below, the rows represent the older land use categories and the column represents the newer categories. Although this matrix was used as a direct input for specification of the prior probabilities in maximum likelihood classification of the remotely sensed imagery, it was however used to predict land use of 2020.

Table 6.3 Transitional probability matrix derived from the land use map of 1991 and 2008

Classes	BU	BL	AL	VG	WB	WL	TC	OT
BU	**0.6140**	0.0265	0.1937	0.0880	0.0011	0.0385	0.0282	0.0098
BL	**0.5156**	**0.1774**	0.2031	0.0507	0.0005	0.0176	0.0351	0.0000
AL	**0.2624**	0.0638	**0.5033**	0.0510	0.0001	0.1085	0.0010	0.0098
VG	**0.3469**	0.0532	**0.3784**	**0.1688**	0.0000	0.0358	0.0165	0.0002
WB	0.0776	0.0169	**0.0850**	0.0125	**0.7397**	0.0382	0.0068	0.0155
WL	0.0671	**0.0776**	**0.2685**	0.0002	0.0003	**0.4878**	0.0044	0.0940
TC	0.0350	0.0002	0.0084	0.0161	0.0005	0.0044	**0.9347**	0.0001
OT	0.0619	0.0000	0.0000	0.0000	0.0000	**0.6676**	0.0110	**0.2595**

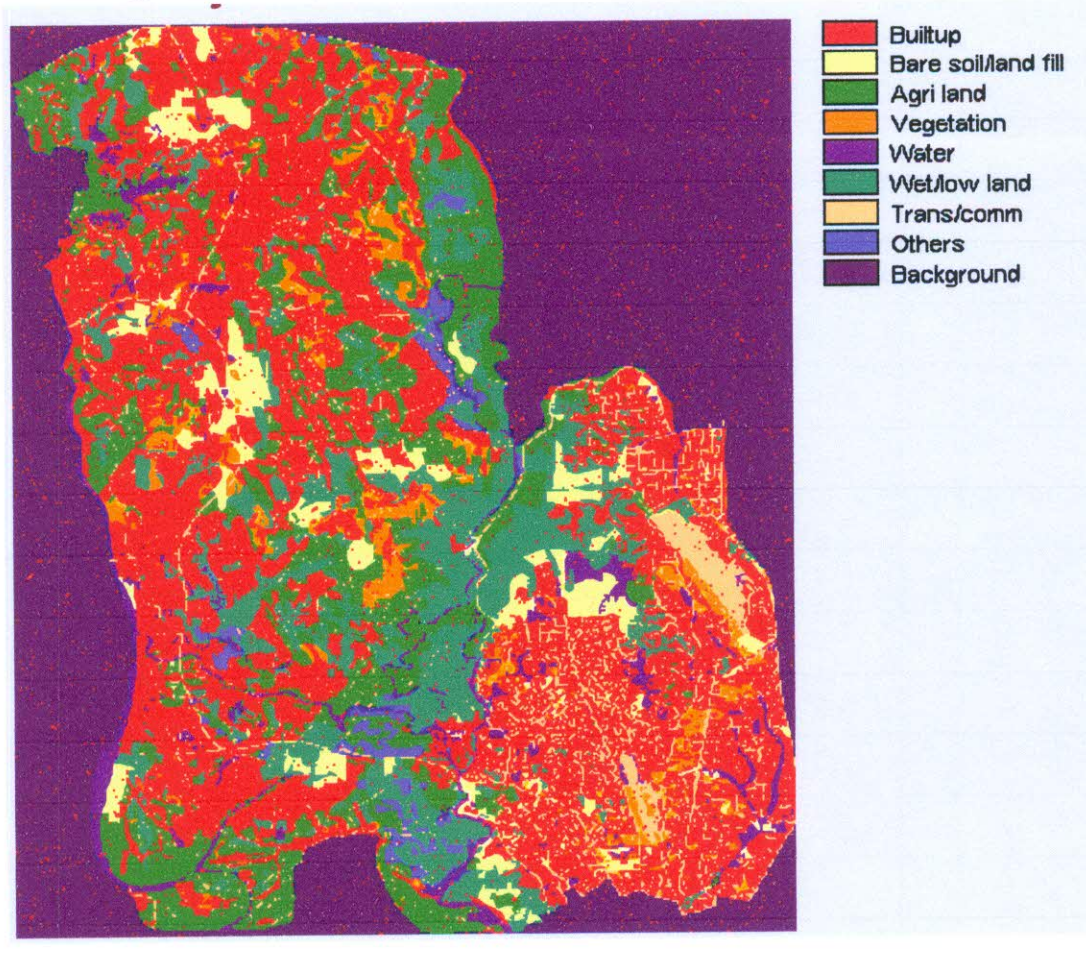
Row categories represent land use classes in 2008 whilst column categories represent classes of 2020. As seen from the **Table 6.3,** built-up area also has a probability as high as 0.6140 to remain as built-up area in 2020 which signifies stability. Bare soil/landfill during this period bears the highest probability of 0.5156 to be remaining built-up area in 2020 which shows instability. Agricultural land also has a probability as high as 0.5033 to remain as agricultural land in 2020 which signifies stability. This, therefore, shows an undesirable change with a probability of change which is much higher than stability. On the other hand, the 0.3784 and 0.3469 probability of change from vegetation to agriculture and built-up area shows that there might be a high level of instability in vegetation during this period. Water-bodies which are the highest class have a 0.7397 probability of remaining as water-bodies and a 0.0850 probability of changing to agricultural land during this period. Wet/lowlands are the highest class with a 0.2685 probability of changing to agricultural land in 2020. The land estimated for transport and communications also has a probability as high as 0.0350 which experiences a minimal change in 2020. And others land which is the last class has a 0.2595 probability of remaining as others land and a 0.6676 probability of conversion to wet/lowlands; which may not however be a true projection of this class except there is an occurrence of drought in the region.

Table 6.4 Projected land use/cover for the study area 2020

Classes	BU	BL	AL	VG	WB	WL	TC	OT
Area (ha)	19201.67	2059.07	7463.36	1665.39	2038.93	5829.83	2638.91	785.94
%	46	5	18	4	5	14	6	2

The **Table 6.4** stated above shows the statistic of land use projection for 2020. Comparing the percentage representations of this table, there exist similarities in the observed distribution particularly in 2008. This may trend to suggest no change in the classes between 2008 and 2020, but a careful look at the area in hectares between these two tables shows a change, although it is small. Thus in **Table 6.5**, built-up area still maintains the highest position in the class whilst others land retains its least position. Agricultural land takes up the next position, followed by built-up land and finally, wet/lowlands. As seen in **Figure 6.16**, there is likely to be compactness in Dhaka city by 2020 which signifies a huge crowd.

Figure 6.16 Projected land use/cover map for the study area, 2020



Again in another transition probability matrix, 8 X 8 matrix table presented below, the rows represent the older land use categories and the columns represent the newer categories. Although this matrix can be used as a direct input for specification of the prior probabilities in maximum likelihood classification of the remotely sensed imagery, it was however used to predict land use of 2050.

Table 6.5 Transitional probability matrix derived from the land use map of 1991 and 2008

Classes	BU	BL	AL	VG	WB	WL	TC	OT
BU	**0.4056**	0.0475	**0.2862**	0.0695	0.0019	0.1037	0.0663	0.0191
BL	**0.4144**	0.0484	**0.2833**	0.0703	0.0016	0.0911	0.0748	0.0159
AL	**0.3757**	0.0549	**0.3142**	0.0632	0.0010	0.1335	0.0326	0.0245
VG	**0.3940**	0.0518	**0.3071**	0.0681	0.0011	0.1087	0.0501	0.0189
WB	**0.2158**	0.0352	0.1916	0.0355	**0.3518**	0.0986	0.0282	0.0238
WL	**0.2869**	0.0597	**0.2975**	0.0438	0.0009	**0.2337**	0.0279	0.0495
TC	**0.0956**	0.0074	0.0521	0.0261	0.0014	0.0185	**0.7947**	0.0028
OT	0.2078	0.0596	**0.2716**	0.0274	**0.0006**	0.3291	0.0293	0.0745

Note: BU = Built-up, BL = Bare soil/landfill, AL = Agricultural land, VG = Vegetation
WB = Water-bodies, WL = Wet/lowlands, TC = Transport & communication, and OT = Others

Row categories represent land use classes in 2008 whilst column categories represent 2050 classes. As seen from the **Table 6.5**, built-up land also has a probability as high as 0.4056 probability of remaining as built-up land and a 0.2862 probability of changing agricultural land in 2020 which signifies instability. Bare soil/landfill during this period was the highest class with a 0.4144 probability of remaining built-up area in 2020 which is instability. Agricultural land also has a probability as high as 0.3142 probability of remaining as built-up land and a 0.3757 probability of changing built-up land in 2020, which signifies instability. On the other hand, the 0.3940 and 0.3071 probability of change from vegetation to built-up and agricultural land shows that there is likely to be a high level of instability in vegetation during this period. Water body has the highest probability (0.3518) of remaining as water body and a 0.2158 probability of changing in to built-up land during this period. Wet/lowlands areas are the highest class has a 0.2975 and 0.2869 probability of changing to agricultural land and built-up area respectively in this time. Transport and communications which is the highest class has a 0.7947 probability of remaining as Transport and communications during this period. And others land which is the last class has a 0.0745 probability of remaining as others land and a 0.2716 probability of changing to agriculture

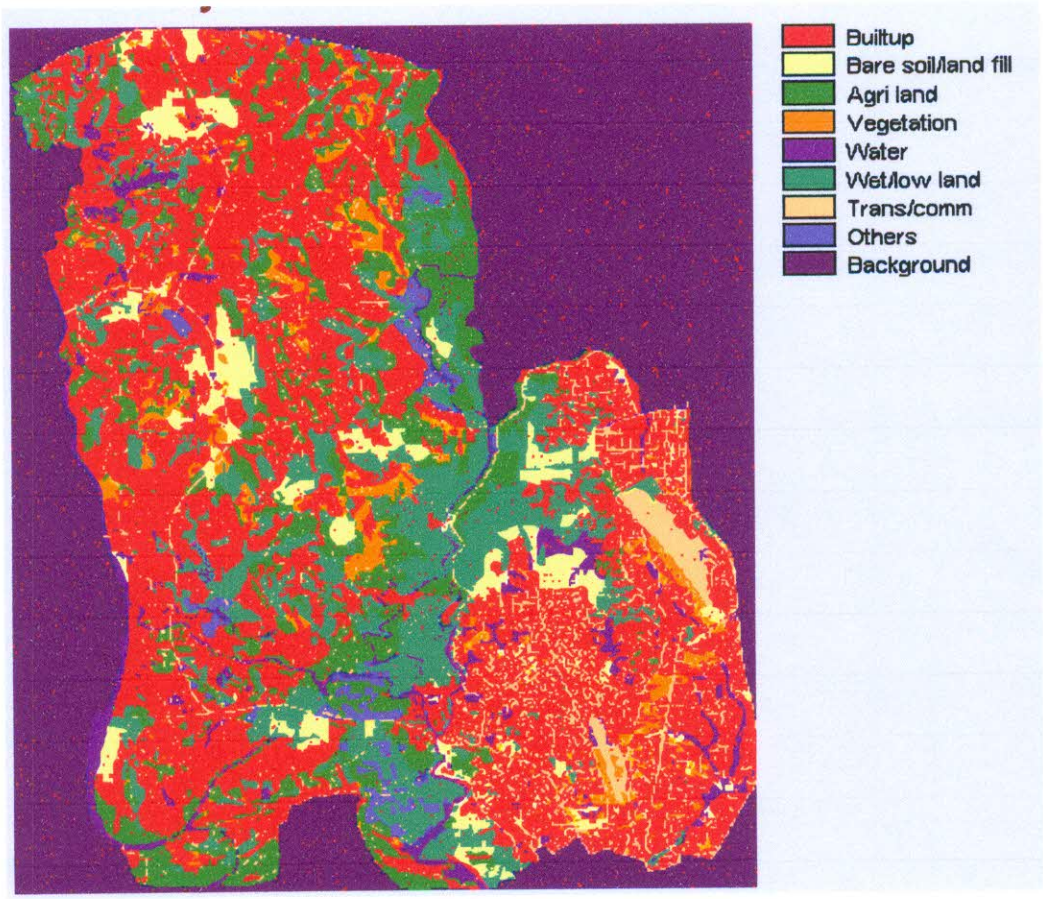
land; which may not however be a true projection of this class except there is an occurrence of drought in the region.

Table 6.6 Projected land use/cover for the study area, 2050

Classes	BU	BL	AL	VG	WB	WL	TC	OT
Area (ha)	20519.18	2066.04	5841.15	1548.77	2045.37	6153.76	2647.50	787.52
%	49	5	14	4	5	15	6	2

This may tend to suggest no change in the classes between 2020 and 2050, but a careful look at the area (in hectares) between these two tables shows some change. Thus in **Table 6.6**, built-up land still maintains the highest position in the class whilst other land retains its lowest position. Wet/lowlands take up the next position, followed by transport and communication, bare soil and finally, agricultural land. As seen in **Figure 6.17**, there is likely to be compactness in Dhaka city by 2050 which signifies crowdedness.

Figure 6.17 Projected land use/cover map for the study area, 2050



6.4 Overall Matrix Land use Classification between 1960-1991 and 1991-2008

In IDRISI Andes software the entire change detection analyses was performed considering the time spans between 1960-1991 and 1991-2008 using the images.

CROSSTAB 1960-91

The CROSSTAB module was performed for the images of 1960 and 1991 which gave two outputs: an image of cross correlation and a table of cross tabulation (**Table 6.8**). The table shows the number of cells under each cover class in 1960 that has remained the same or has undergone change in 1991.

The **Table 6.8** shows that most of the changes have taken place near to the diagonals which indicate the classes of interest as bare soil, agriculture land and vegetation bares user accuracy of 48%, 63% and 65% that was obtained respectively. As seen in the above **Table (6.7)** the lowest accuracy was obtained for bare soil/landfill only 48%.

Table 6.7 Cross tabulation of land use/cover 1960 (columns) against land use 1991 (rows)

		1960										
	Classes	**BU**	**BL**	**AL**	**VG**	**WB**	**WL**	**TC**	**OT**	**Total**	**Error of Omission**	**Users accuracy**
1991	**BU**	221376	0	0	0	0	0	0	0	221376	0	100
	BL	16622	15616	0	0	0	0	0	0	32238	52	48
	AL	48721	0	116809	0	0	20146	0	0	185676	37	63
	VG	13839	0	0	26045	0	0	0	0	39884	35	65
	WB	0	0	0	0	31877	0	0	0	31877	0	100
	WL	0	0	0	0	0	70786	0	0	70786	0	100
	TC	0	0	0	0	0	0	41285	0	41285	0	100
	OT	0	0	0	0	0	0	0	12286	12286	0	100
	Total	300558	15616	116809	26045	31877	90932	41285	12286	635408		
Error of Omission		26	0	0	0	0	22	0	0			
Producers accuracy		74	100	100	100	100	78	100	100			
Overall accuracy		**58.67%**										

Note: BU = Built-up, BL = Bare soil/landfill, AL = Agricultural land, VG = Vegetation
WB = Water-bodies, WL = Wet/lowlands, TC = Transport & communication, and OT = Others

CROSSTAB 1991-2008

Similarly a CROSSTAB module was used for land cover images of 1991-2008.The cross tabulation result is shown in **Table 6.8**. For the classes of interest bare soil/landfill, agricultural land and vegetation are user accuracy of 59%, 49% and 61% was obtained respectively. As seen in the above **Table (6.8)** the lowest accuracy was recorded for agriculture land is 49%.

Table 6.8 Cross tabulation of land use/cover 1991 (columns) against land use 2008 (rows)

		1991										
	Classes	**BU**	**BL**	**AL**	**VG**	**WB**	**WL**	**TC**	**OT**	**Total**	**Error of Omission**	**Users accuracy**
2008	**BU**	221420	0	0	0	0	0	0	0	221420	0	100
	BL	13359	18878	0	0	0	0	0	0	32237	41	59
	AL	69758	0	91112	0	0	24787	0	0	185657	51	49
	VG	15717	0	0	24175	0	0	0	0	39892	39	61
	WB	0	0	0	0	31880	0	0	0	31880	0	100
	WL	0	0	0	0	0	70793	0	0	70793	0	100
	TC	0	0	0	0	0	0	41298	0	41298	0	100
	OT	0	0	0	0	0	0	0	12285	12285	0	100
	Total	320254	18878	91112	24175	31880	95580	41298	12285	635462		
Error of Omission		31	0	0	0	0	26	0	0			
Producers accuracy		69	100	100	100	100	74	100	100			
Overall accuracy		**57.30%**										

6.5 Accuracy Assessment

There are always ambiguities in acceptability of the result, particularly when the result predicts future based on unsettled variables. But however again, there are some scopes of checking the result in GIS techniques. The location accuracy of land use change model of Landsat TM image of 1991 and Google Earth image 2008 was done using the clear and visible roads which were collected during the field work. In the case of classifying bare soil/landfill, cultivated/agricultural land and vegetation, and the user accuracy were 59%, 49% and 61% respectively. The prediction of land use change was done on Neural Network built-in module in the Andes version of IDRISI. Iterations considered were 5000- sufficient

Chapter 7

Land Transformation and Environmental Degradation

Chapter 7
Land Transformation and Environmental Degradation

This chapter analyses the impacts of land transformation on the environment of the study areas and try to see how the land use change will ultimately affect the environmental condition of Dhaka city. The objectives of this chapter are to assess the impacts of activities causing land use change on the environmental conditions of the study area. In order to achieve the objectives all negative impacts are identified, quantified and then suggestions will be given for mitigation measures of Dhaka city.

Present Dhaka city is inundated results in a number of physical and socio-environmental problems. Such as flooding, drainage congestion and water logging, safe drinking water, sanitation, traffic congestion, garbage disposal, transport, energy, urban pollution, health, housing conditions, slums and squatters; open space etc.(Islam and Ahsan, 1996). However, the present chapter is an endeavor to identify the causes of environmental degradation created from land use change, problems perceived by the population in the study area, laws and responsibility of concerned government agencies and to find ways to reduce those problems. The dimension of problems those were identified looking at the prepared maps will be cross-checked with those of ideas come from the stakeholder, who actually are the targets of the problem mitigation managers.

7.1 Problems of Urban Environment

The quality of the environment depends to a great deal on the quality of the essential infrastructural and utility services like sanitation, sewerage system, drainage, supply of safe drinking water, garbage disposal system, electricity and gas or fuel for cooking etc. Urban environmental problems relate to the deterioration of the ambient environment and the inability of the public infrastructure and services to meet the demands imposed by rapidly growing population. Respondents were asked to identify the problem of environmental degradation, the result from the respondents appear to identify flash flood and drainage congestion (62%), water pollution (68%), air pollution (79%), water and sanitation (63%), garbage disposal system (73%), traffic congestion (79%), decreasing ground water level (61%), health (64%) and open space (36%). **Table 7.1** shows the summarized opinions about the problems originated from land use change and environmental degradation.

Table 7.1 Types of problems originated from environmental degradation

Problems	No. of Respondents	Percentage
Flash flood and drainage congestion	267	67.25
Traffic congestion	312	78.59
Water pollution	268	67.51
Air pollution	314	79.09
Water and sanitation	251	63.21
Decreasing ground water level	242	60.95
Garbage disposal system	289	72.80
Health	256	64.48
Open space	142	35.77

Source: Field survey, 2010

Problems created due to environmental degradation in the study areas might be described here as follows:

7.1.1 Flash flood and Drainage Congestion

Due to rapid urbanization and unplanned and unregulated urban growth, many areas within large cities are affected by lack of drainage system and stagnation of rain water. The situation is particularly bad in Dhaka where all areas, both old and new city parts experience storm and water logging. The severity of floods in Dhaka has intensified partly due to unplanned urban development.

Unwise closure of natural and old artificial drainage and navigational canals has aggravated the situation. Main streets now go under a meter of water after every heavy monsoon shower. Flooding and drainage problem will continue to pose a serious problem for the city in future. The condition is apprehended to worsen further due to the unplanned and often illegal earth filling of wet/lowlands in and around the city by unscrupulous real estate companies (Islam, 2005).

Dhaka city has experienced significant urban growth during the last 50 years. Different types of land have undergone a radical transformation since 1971 when Dhaka becomes the capital of new sovereign state Bangladesh. Change in land use alters the physical characteristics of an area, which in turns brings changes in hydrological regime. A study conducted by JICA (1987) observed that many portion of the major canals used as natural drainage were subjected to encroachment due to earth filling, deposition of city garbage and construction of building and roads. During field survey the respondent were asked about whether facing water logging in the area where he lives. Out of the 390 respondents

388 (99.49%) respondents reply that they face water logging problem. It is observed during field visit due to water logging problem heavy traffic congestion occurred on the streets of Dhaka city. Normal traffic movement hampered during rainfall over 25 mm and people lose their valuable time (Islam *et al.,* 2010). As a result, water logging has become a common phenomenon during monsoon in Dhaka city.

Even real estate developing activities damaged natural landscaping and changed the environmental characteristics of the areas. Urban upstream cannot discharge rain as well as waste water appropriately in the natural reservoir. During field survey the respondents were asked about whether they face water logging in the area where they live. Out of 397 respondents 267(67%) respondents replied that they face flooding and water logging in rainy season **(Photograph 7.1).**

Flooding in Dhaka city is aggravating and is attributed to the rigorous changes of land covers, particularly remarkable increase of urban areas **(Table 7.2).** In 1988 the total flooded area was 48.7%, in 1998 the area was 54.6% and during the flood of 2004 it was 45.4% (Dewan *et al.*, 2008).

Table 7.2 Inundation area percentage in 1988, 1998 and 2004 floods

15 October, 1988	**Dry Season**		
	Water	**Non-water**	**Total**
Water	3.9	44.8	48.7
Non-water	1.0	50.3	51.3
Total	4.9	95.1	100
25 August, 1998	**Dry Season**		
	Water	Non-water	Total
Water	4.0	50.6	54.6
Non-water	0.9	44.5	45.4
Total	4.9	95.1	100
24 July, 2004	**Dry Season**		
	Water	Non-water	Total
Water	3.7	41.7	45.4
Non-water	1.1	53.5	54.6
Total	4.8	95.2	100

Source: Dewan *et al.*, 2008

Khan (2001) observed the relationship between geomorphologic setting and present water logging problems. Medium and lower Madhupur terrace units are more vulnerable to the present water logging situation (**Table 7.3**). This is an indication of adverse effect of human interference over the landscape.

Table 7.3 Distribution of water logging affected areas per geomorphic unit

Geomorphic unit	Number of water-log affected areas
High Madhupur Terrace	15
High and Medium Madhupur Terrace	8
Medium Madhupur Terrace	60
Medium and Low Madhupur Terrace	3
Lower Madhupur Terrace	22
Abandoned Channel	10
Old Natural Levee	0
Depression	12
Sandbar	0
Point Bar	2
Khal/ River	0
Active Natural Levee	3
Natural Levee (lower part)	15
Total	150

Source: Khan, 2001

The water logging problem has been getting worse since the eighties. During this period, Dhaka has experienced high rate of urban expansion both in horizontal and vertical direction in an unplanned and unregulated manner. On the other hand, uncontrolled land development in the low lying areas without following the appropriate planning standards and land use controls result in water logging problem in the higher terrace due to the obstruction and closure of the natural flow and disruption of the hydrological link between major and minor channels. Filling up the eighty percent low lying areas and water bodies in the capital were made by encroachers in the city. These were actually the major channels for draining out rain rater. The rivers around the city were also encroached upon over the years worsening the situation (The Daily Star, July 03, 2010).

The city is experiencing severe problem of rainfall flooding for the last few years. Moderate rainfall creates serious water logging problems in some areas of city, namely Malibag, Mauchak, Modubag, Shantinagar, Rajarbag, Fakirapul, Rampura, Motijheel, Badda, Mohammadpur etc. Drainage congestion results in local floods with ankle to knee-deep water on the streets. This water logging problem is creating environmental and health hazard in the city (Nishat *et al.*, 2000).

Photograph 7.1 Water logging situations at Mohammedpur johori mohalla in Dhaka city

Source: Prothom-alo, June 1, 2010

7.1.2 Traffic Congestion

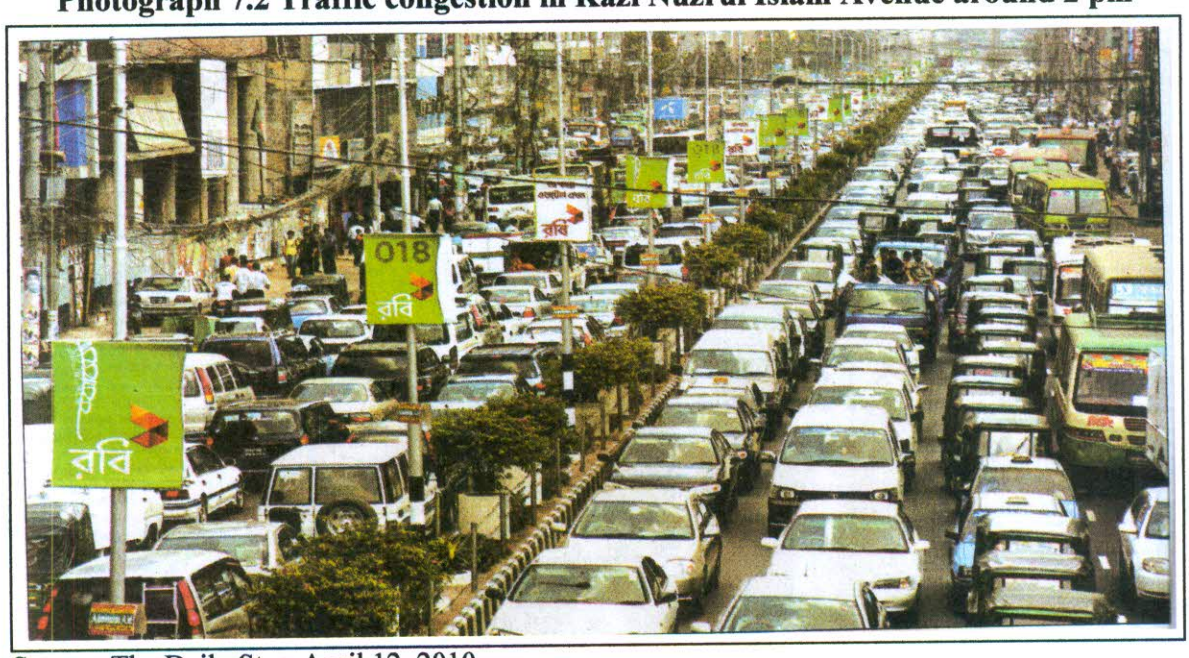
Urban development depends heavily on the transportation system. Unfortunately this essential infrastructure is very poorly developed in the urban areas of Bangladesh. While the small towns can manage fairly well with manual transports like the cycle rickshaw for passenger's movement or the cycle van for goods movement, the large cities have to rely on motorized vehicles (Islam and Ahsan, 1996). The public mass transport system in the form of buses and minibuses is available in the largest cities, but the services are highly inadequate. The number of vehicular transport has increased manifold, but still remains far short of the needs. The cheapest form of public urban mass transport in Bangladesh is the bus. The number of buses is inadequate against the demand. As a result one always finds long queues at bus stands and dangerously overloaded buses on the streets. In response to the growing needs, the numbers of other vehicles are also increased.

The large number of cycle rickshaws and small personalized motorized vehicles and the inadequately planned road system, the poor traffic and road transport management system, corruption of the personnel in the traffic control and implementing authorities, the citizens' disregard for traffic rules and discipline and host of other factors have been responsible for frequent and unbearable traffic jams in various nodes and on important roads in Dhaka city. The frequency and fatality of accidents on roads within city limits are disturbing facts. The other serious problem caused by the transport system, particularly by the motorized transports, is that of air pollution.

Among the study population 88% said that traffic movement disrupts due to drainage congestion and water logging in the city (**Table 7.1**). Normal traffic movement is hampered during rainfall over 25 mm in the city area that causes loss of valuable time of people. Rain water including waste water puddles when water cannot drain out in time bound. This is not only just inconvenience for pedestrians but also dangerous for road users. Following pictures shows the scenario of traffic congestion **(Photograph 7.2).**

The capital's never-ending traffic congestion which is also a sign of rapid but unplanned urban growth is another problem facing by the city dwellers. Modern urban planning requires minimum 25 percent area of total areas as the road communication while only 7.5 percent of Dhaka's total area is dedicated to road communication that creates severe traffic congestion. On the other hand, around one third of these road areas are occupied by hawkers and floating shops, resulting further gear up of the traffic gridlock (The Daily Star, 30 July 2010).

Photograph 7.2 Traffic congestion in Kazi Nuzrul Islam Avenue around 2 pm



Source: The Daily Star, April 12, 2010

7.1.3 Urban Pollution

Pollution in urban areas is primarily manifesting the quality of water and air. But noise beyond a particular level also creates a serious health and social hazard and therefore is considered another type of pollution. The Department of Environment of the government and various scientific aid or environmental NGOs are generally conscious of air and water pollution, but such concern is not equally met by scientific investigation or research. There is, therefore, an acute shortage of relevant data on urban physical pollution in Bangladesh.

7.1.3.1 Water Pollution

In the last few decades, Dhaka has been greatly changed with rapid urbanization and industrialization, especially through garments manufacturing, establishment of small and large-scale business enterprises, and increase of multi national business and trade firms, increasing participation of international organization in the local and national development process etc. Unfortunately, this rapid urbanization process has not taken place in a formal and planned manner. This unplanned approach of development has made this city 'a land of unhealthy life'. The rivers, Buriganga, Turag and Balu, together receive huge volume of untreated industrial effluent as well as municipal waste water regularly through the three major canal systems and direct disposal (**Appendix D8**). Water quality parameters of surrounding rivers and lakes have already been exceeded the standard limits such as DO; BOD, COD, pH and heavy metal concentration in river water in Dhaka City existed above the optimal level (Shamsuzzoha, 2002).

The following **Tables 7.4 and 7.5**, and **Photograph 7.3** indicate deterioration of water quality of rivers and lakes. According to field survey, 68% respondents said that surrounding waterbodies of Dhaka City become polluted due to receiving of large volume of industrial solid and liquid waste, clinical waste, other contaminants, domestic waste water and so on, which contaminate ground water as well.

Table 7.4 Average concentration of water quality indicators, DO, BOD, COD and pH, of different location of Turag River from 2006 to 2009, and Lakes from Nov, 2008

Sample Location	Date	DO	BOD	COD	pH
Turag River, near Ijtema field,Tongi	05.07.06	6	2.8	2	7.1
	02.07.07	5.1	2.7	11	7.1
	06.07.08	5	2.5	8	7.2
	05.05.09	0	32	21	7.4
Near Gabtoli bridge	09.07.09	6.1	3	2.5	7.2
Mirpur Diabari BIWTC landing	09.07.09	6	2.6	3.5	7.22
Asulia BIWTC landing station	09.07.06	6	2.6	3	7.21
	Jun-Aug, '07	6.5	3.9	-	7.3
	Jun-Aug, '08	5.8	2.6	-	7.2
	Jun-Aug, '09	6.7	3.7	-	7.2
Dhanmondi lake near Russell square	Nov.2008	6.1	1.9	-	6.9
Gulshan-Baridhara like, Road No.11	Nov.2008	1.5	3.5	-	7.1
Crescent Lake East side	Nov.2008	8.3	2.1	-	5.9

Source: DoE Office record, 2009

Notes: DO= Dissolved Oxygen, BOD=Biological Oxygen Demand, COD=Chemical Oxygen Demand; Environmental Quality Standards (EQS) for Bangladesh: pH: 6.5-8.5, BOD: 3 or less and DO: 5 or less.

Table 7.5 Heavy metal concentration in river water of Dhaka city

Sample ID	Concentration in mg/l						
	Al	Cd	Cr	Ph	Hg	Sc	Zn
Turag River (Amin Bazar)	11.88	0.018	0.11	0.394	0.0058	0.0002	1.002
Buriganga River(Frend.Bridge)	3.27	0.014	0.036	ND	0.0021	0.001	0.56
Balu River(Zirani *Khal*)	2.116	0.006	0.022	ND	0.001	ND	1.122
Recommended value (For Drinking water*)	0.2	0.005	0.05	0.05	0.001	0.01	5.0

Source: Shamsuzzoha, 2002

ND: Not detectable * Environmental Quality Standards (E.Q.S) for Bangladesh. Department of Environment; July 1991

Photograph 7.3 Toxic effluent from dyeing factory at Ashulia goes into a canal linked with the river Turag

Source: The Daily Star, June 25, 2010

7.1.3.2 Air Pollution

At present air pollution is one of the major environmental concerns of Dhaka city. The air we breathe has not only life supporting properties but also life damaging properties. Under ideal conditions the air we inhale has a qualitative and quantitative balance that maintains the well-being of man. But when the balance of the components is disturbed or other words, if it is polluted, it affects human health. An average man breathes 22,000 times a day and takes in 16 kg of air each day. It far exceeds the consumption of food and water. It has been estimated that a man can live for five weeks without food and five days without water, but only for five minutes without air.[1]

[1] M. N Rao and H V N Rao, *Air Pollution*, (New Delhi: Tata McGraw-Hill Publihing Company Limited, 1990), p.43

Various groups of study respondent perceived that over crowded traffics is the main culprit of air pollution in Dhaka city. A study on air pollution of Dhaka city shows that about 63% of surveyed households, 73% of employees in government and private sectors, 75% of owners of vehicles and 78% of divers identified motor vehicles as a main source of air pollution in Dhaka city (Table 7.6). According to their view industry stands second and solid waste holds third position in respect of source of air pollution. 78%, 12% and about 10% of total respondents identified vehicles, industry and solid waste respectively as the sources of air pollution in Dhaka city (Uddin, 2004).

Table 7.6 Principal source of air pollution in Dhaka city, 2003 (in percentage)

Category	Industry	Transport	Solid waste	Total
Households	25.83	62.5	11.67	100.0
Employees	13.33	73.33	13.33	100.0
Owners of vehicles	13.33	75	11.67	100.0
Drivers	11.67	78.33	10.0	100.0

Source: Uddin, 2004

Contribution of Vehicles to Air pollution

It is empirically observed and conceded that vehicle is the main source of air pollution in Dhaka. The absolute number of motorized 3 and 4 wheel vehicles running on the city street is not large, being only about two hundred thousand. However, the emission from the vehicles is substantial due to back dated technology of the vehicle fleet, weak maintenance culture, overloading and over-fuelling of heavy duty vehicles among other causes. Most of the private operator fleets consist of highly polluting old vehicles. These transport companies have limited resources for operation and maintenance. Poor maintenance coupled with poor fuel quality, congestion and poor transport infrastructure exacerbate the vehicular air pollution in the city. Detailed of vehicle statistics and their emission and emission factors are given in **Table 7.7.**

Table 7.7 Vehicular emission in 2004 in Dhaka city

Vehicle Type	Emission (%)				
	CO	NOX	SO2	HC	PM-10
Cars	66.5	10.8	12.6	38.6	7.9
Taxis-CNG	2.8	2.3	0.0	4.1	0.5
3W Taxis-CNG	3.8	3.1	0.0	5.5	0.7
LD Diesel	3.9	17.9	18.5	5.7	18.6
Buses	8.2	37.5	38.8	11.9	38.9
Trucks	5.9	27.0	27.9	8.5	28.1
Motorcycles	8.9	1.4	2.1	25.7	5.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Diesel Vehicles	18.0	82.4	85.3	26.1	85.6
Non-diesel Vehicles	82.0	17.6	14.7	73.9	14.4

Source: Khaliquzzaman, 2005

Uncontrolled emissions from motor vehicles and other economic activities accelerated the increasing of air pollutants and other forms of pollutants. High levels of emission of air pollutants in a small area exceed the processes of dilution and dispersal, leading to severe episodes of ambient air pollution. Fairly comprehensive air quality data are being collected for Dhaka nowadays (AQMP, 2004). The summary of air quality data for Dhaka obtained at the Continuous Air Monitoring Station (CAMS) of the Department of Environment is shown in **Table 7.8.**

Table 7.8 Average values for criteria pollutants measured at CAMS, Dhaka with standard deviations during 2003 along with Bangladesh standards

Pollutants	Averaging Time	Who Guidelines	Bangladesh Standards	Annual average Concentration during, 2003
CO	1 hour	30 mg/m3	40 mg/m3 (35ppm)	---
	8 hour	10 mg/m3	10 mg/m3 (9ppm)	1.0 ±0.8ppm
SO2	24 hour	125 μg/m3	3655 μg/m3(140ppb)	---
	Annual	50 μg/m3	80 μg/m3(30ppb)	7 ± 8ppm
NO2	24 hour	---	---	---
	Annual	40 μg/m3	100 μg/m3(53ppb)	59 ±58ppm
Ozone	1 hour	---	235 μg/m3(53ppb)	---
	8 hour	120 μg/m3	157 μg/m3(80ppb)	28 ±20ppm
PM10	24 hour	---	150 μg/m3	---
	Annual	---	50 μg/m3	133 ±78mg/m3
PM2.5	24 hour	---	65 μg/m3	---
	Annual	---	15 μg/m3	76 ±57mg/m3

Source: AQMP, 2004 and DoE *et al.*, 2006

It is seen from **Table 7.8** that the main air pollutant in Dhaka is particulate matter. Both PM10 and PM2.5 levels are extremely high, being much above of the optimal standard. The NO_2 levels are also now close to the limit and may have become a concern in the future. The levels of other pollutants are still low and thus are not important regarding health point of view. Lead (Pb) concentration is not shown in the table. The Pb level is now sufficiently low (i.e. around 100 mg/m^3) and therefore airborne lead is no longer considered a health issue (DoE *et al.*, 2006). However, blood lead levels in children are still high indicating that other sources of lead may exist.

Contribution of Brick Fields to Air pollution

From the field survey, it has been found that the existing number of brickfields has occupied many of the arable lands. According to brick-burning act, one cannot change the agricultural lands into non-agricultural uses. If anybody wants to establish a brickfield, he

requires proposing to the Deputy Commissioner. After visiting the proposed location of the brickfield, the deputy Commissioner will permit a barren fallow land having no potentiality for agriculture. On the contrary, one cannot use more than 1.5 acres of land for this purpose. According to the Brickfield Amendment Act of 1992, after removing the soil from one place, it will have to be made into a pond for fish cultivation (MoL, Brickfield Amendment Act, 1992). Unfortunately these rules and regulations relating to brick burning have hardly seen to implement in the field level.

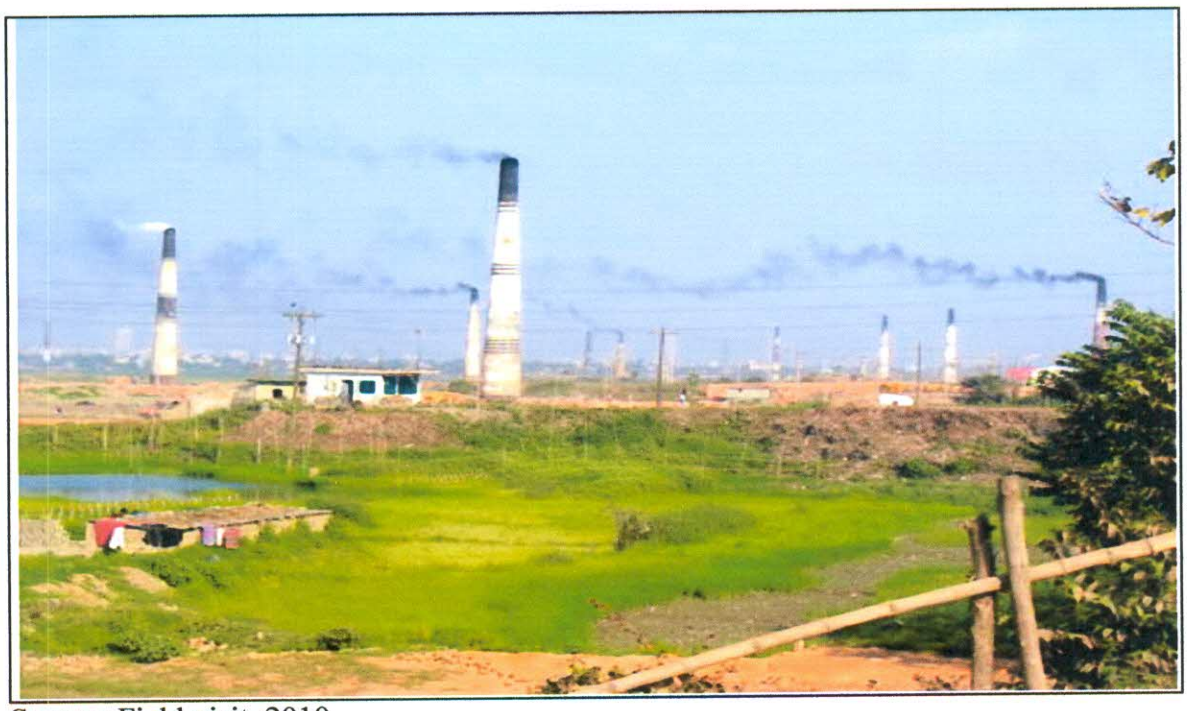
Table 7.9 Previous types of land uses of the brickfields

Types of Damage	Number	Percentage
Were used for agriculture	84	43.8
Were fallow lands	102	51.1
Previously used in brick burning	6	3.1
Total	192	100.00

Source: Kabir, 2003

Table 7.9 shows that most of the agricultural lands are presently used as brickfields. About 44% of the total lands were once used for cultivation. Besides more than 50 percent of the land was fallow but had the potentiality of cultivation. There are a few brickfields in the City surrounding areas, which had been established more than thirty years ago. This is why the previous uses of these lands remain still unknown (**Photograph 7.4**).

Photograph 7.4 Brick kilns to air pollution (Near Amin bazar)



Source: Field visit, 2010

7.1.4 Water and Sanitation

Existing situation in urban water supply and sanitation is not at all satisfactory. Households in different categories of urban centers in Bangladesh obtain drinking water from different sources, with less than one-fourth of the households in all urban areas having house connections (**Table 7.10**). The quality of water in most of the urban areas including the metropolitan cities is generally very bad.

According to one report published in a UNICEF magazine, nearly 50-100% of the water in such cities and towns as Dhaka, Chittagong, Khulna, Rajshahi, Bogra, Pakhi, Rangpur, and Chandpur was found to be polluted (Ahmed, 1989).

Table 7.10 Status of urban water supply in Bangladesh, 1985

(Population served in percent)

Urban Centre	House Connection	Public Stand post	Hand Tube-well	Others*
Dhaka	49	10	-	41
Chittagong	29	8	10	53
District Towns	14	9	29	48
Upazila Centres	4	-	25	71
Average	24	7	17	51

Source: Third Five Year Plan, Planning Commission, GoB, 1985 and CUS, 1990

*Others include own source of water, private hand tube-well and unspecified source.

One of the most important problems during a flash flood or water logging situation is the lack of safe drinking water. Most of the reserve tanks of the buildings or houses in affected area are submerged, which results in water crisis. In some cases, where the reserve tanks are protected by building walls around the water supply pipe causes the water to become contaminated by the floodwater or water logging due to leakages in the pipes. Though the water supply pipes of Dhaka WASA are sealed against any kind of contamination to enter, still through leaks and some underground storage tank water becomes contaminated in many places.

During field survey the respondent were asked about whether they face problem in getting safe drinking water. 63% respondent replies that they face safe drinking water and sanitation problem during flash flood or water logging (**Table 7.11**). They were again asked about the types of problem they face, in reply of this question 58% respondent assert that 'supplied water is dirty', while 23% report 'water is not available when needed' and 19% identify that 'water becomes less'.

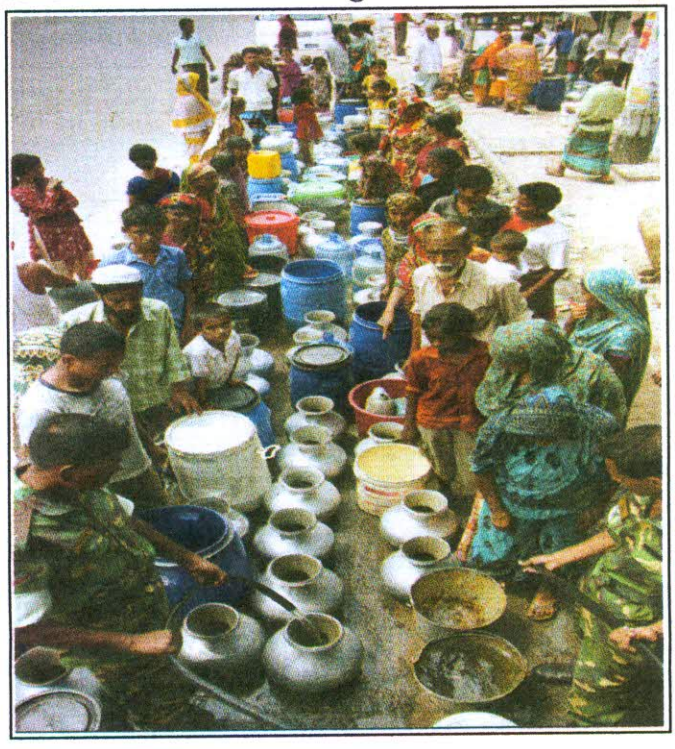
Table 7.11 Perception on getting drinking water problem

Categories	Frequency	Percentage
Whether the respondent face problem in getting drinking water		
Yes	251	63.22
No	146	36.78
Total	397	100.0
Types of problem faced collecting drinking water		
Water becomes less	48	19.12
Water is not available when needed	57	22.71
Supplied water (from WASA) is dirty	146	58.17
Total	251	100.0

Source: Field survey, 2010

Only small minority of urban population have access to modern sanitation system. In the field survey the sewerage systems reveal that Dhaka city sewerage systems suffer from extreme improper management and operation. Many areas of Dhaka, particularly the southern part (Old Dhaka), are home to very unhygienic conditions due to broken and damaged sewerage lines. Open and lidless manholes are a common phenomenon in most of the areas of city. These areas regularly experience overflow of sewerage wastes, drains and manholes that makes the surrounding environment unhealthy with bad odor and contamination of air and water (**Appendix D9**). WASA has already found microbial contamination in ground water in old Dhaka (WASA, 2003).

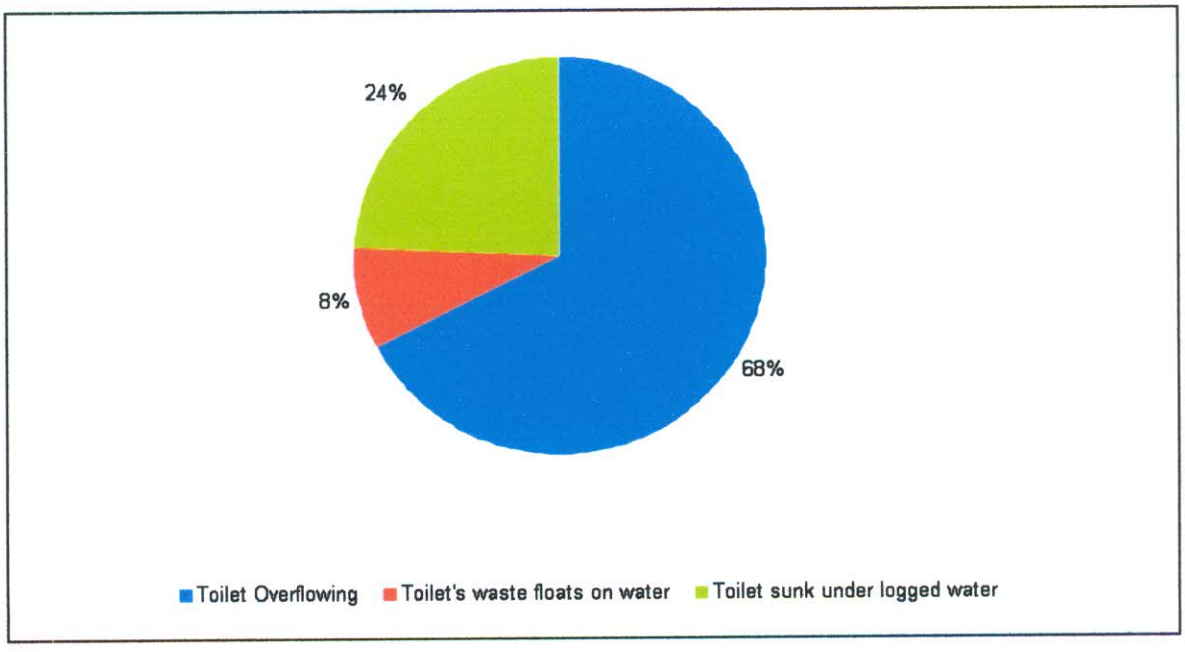
Photograph 7.5 Collected safe drinking water under the supervision of army



Source: The Daily Star, May 12, 2010

Out of 397 respondents, 132 (33.25%) identified that they face sanitation problem (**Appendix B6**). About the types of sanitation problem, 67.42% of the above mentioned respondents opined that 'toilet overflowing' problem, while 8.34% asserted 'toilet's waste floats on water' and 24.24% identify 'toilet sunk under logged water'. Respondents were also asked about the types of unhygienic situations that created during water logging (**Figure 7.1**).

Figure 7.1 Types of sanitation problem caused by flash flood and water logging



Source: Field Survey, 2010

7.1.5 Decreasing Ground Water Level

The ground water exists in semi confined as well as unconfined areas of under ground stays is as free water-table conditions. In general, Dhaka city can be divided into two parts based on static water level (Asaduzzaman *et al.*, 1992).

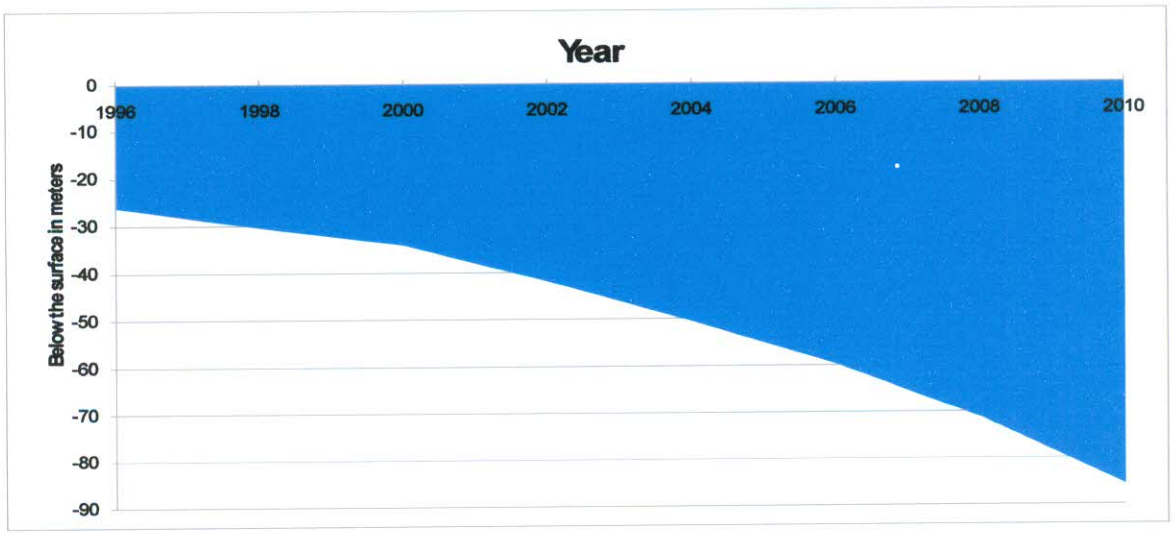
- In the northern part, the ground water table is ranging from 1.0m to 5.0m during August and 2.0m to 7.0m during March, in the wet and dry seasons respectively.
- In the southern part it ranging from 7.0m to 14.0m during August and 8m to 15m during March.

Two major and five minor depressions in the ground water table are locally developed. Major and two of the minor depressions are in the southern part of the city where dense residential and commercial areas are located. The other three depressions are located in the northern part of the city, which are less dense residential areas. The general direction of flow in the northern part of the city is towards the southeast and at the eastern side and the groundwater flow is towards northeast direction. It is observed from the existing data that the fluctuation of the ground water table between dry and wet seasons ranges from 0.5-

2.5m (DWASA, 1991). The aquifer system under Dhaka is discharged by aquifer drainage to the rivers, direct evapo-transpiration and ground abstraction (DWASA, 1992).

Dhaka city's ground water table is depleting at an alarming rate. Ground water depletion is occurring more than 3m/year at most places of Dhaka city (Al-Mamun 2006 and The Daily Star, 7 Jun 2010). Ground water table in the capital has dropped to 85.62 meters, 59 meters in the last 15 years due to lack of recharging which has put the sprawling metropolis at great risk.

Figure 7.2 Ground water depletion in Dhaka city and its surrounding areas



Source: Appendix B7

In 1996 the ground water table was only 26.6 meter but it fell sown 71.23 meter in 2008. Expert says, "If water table continues to fall then a vacuum will be created in the aquifer which could cause a sudden collapse in the surface".

There exist seasonal fluctuations of ground water level characterized by rainfall and surface water reservoir in the one hand and drainage to the rivers and direct evapo-transpiration on the other hand. This rhythm governs the piezometric fluctuation over a large portion of the study area. Urbanization has made a major impact on the water balance of the Dhaka city (Nishat *et al.*, 2000). The effects of urbanization on the water balance of Dhaka city are profound manifold. Urbanization causes dramatic changes to the water balance of many areas. This water balance can be identified as one of the major indication of human interference over the nature. Urbanization changes the hydrographic network of the city, which causes an imbalance in the local water circulation. The land conversion, construction of buildings, paved areas, and drainage and sewer system cause a decrease and even disappearance of natural watercourses and other open basins.

The Plio- Pleistocene aquifer of Dhaka city mainly depends for its recharge on the surface water system, which comprises of,

- Lateral inflow from the streams around the city
- Infiltration due to local rainfall
- Infiltration due to seepage from surface water system
- Regional recharge in Dupi Tila formation from around the city

Due to increasing intensity of building up in the city there has been a decrease in the amount of recharge from the direct percolation due to decrease in the rechargeable area. On the other hand excess extraction of ground water to meet up the urban demand has disrupted the recharge-discharge equilibrium of the city (Choudhury, 2001).

Wetlands function like natural tubs or sponges, storing water and slowly release it. This process slows the water's momentum, erosive potential reduces flood height and allows for ground water recharge, which contributes to base flow to surface water system during dry periods. But most of the wetlands of Dhaka city are diminishing at an alarming rate.

7.1.6 Garbage Disposal System

Another important problem is its perennial waste disposal system. The city produces around 3500 tones of solid waste every day. The under equipped Dhaka City Corporation can only collect half the trash while the rest is left to rot in the open. As the city fans out in rings of crowded slums, the DCC struggles to provide its citizens with such basic amenities as decent sanitation and drinkable water (A Weekly Publication of The Daily Star, 30 July 2010).

According to the CDMP of JICA, and the DCC currently disposes of about 44% of the total generated waste (3340 tons/day) at 3 landfill sites located at Matuail (20ha), Beri Bund (2 ha) and Uttara (1ha). Matuail receives 65% of the total disposal volume; Beri Bund and Uttara receive 30% and 5%, respectively (DoE *et al.*, 2006). All these landfill sites are open, with no gas collection system or leachate treatment technology. The Beri Baandh landfill is very close to the Buriganga River. Matuail, the major landfill site is located with 1 km of residential areas (for example Jatrabari, Jurain). Actually, most of the abandoned landfill sites are also close to residential areas. Many of the households and even individuals do not dispose of their waste properly in the bin or roadside container. On the other hand, none of the municipal waste workers or even community workers takes safety measures during performing their duty **(Photograph 7.6).** The

Municipal authority is also very negligent in this regard, due to its management constraints, particularly financial and technical. Slum housing is very compact and usually remains beyond the collection system. Improper solid waste management causes the following problems:

- Degradation of air quality with emission from open landfill site;
- Creation of extreme discomfort to nearby residents (e.g. bad odor, flies);
- Aggravates surface and ground water pollution.

Photograph 7.6 Solid wastes are disposed in lowland area

Source: Field visit, 2010

7.1.7 Health Related Problems

Environmental degradation exerts significant pressure on human health. Exposure to air, water and soil pollution, to chemicals in the environment, or to noise, can cause cancer, respiratory, cardiovascular and communicable diseases, as well as poisoning and neuropsychiatry disorders.

Outdoor air pollution is a major environmental problem in developing countries. It can have acute health effects resulting from short-term exposure or chronic health impacts resulting from long-term exposure. Health problems linked to air pollution range from minor eye irritation to upper respiratory symptoms, chronic respiratory diseases such as asthma, cardiovascular diseases and lung cancer. Some of these diseases require hospital treatment, and may be fatal.

Table 7.12 shows that out of 397 respondents, 285 (71.79%) identified about suffering from water and air borne disease. It is significant that 58.95% respondents especially suffer from water borne disease and only 41.05% respondents suffer from air borne disease out of total 285 respondents. It appears from their respondents that 36.14%, 14.04%, 11.37%, 27.02%, and 5.26% respondents suffer from diarrhea, skin disease, dysentery, asthma, and hypertension respectively (**Figure7.3 and Appendix B8**). Study respondents identify diarrhea, asthma and skin disease as the acute and most common feature in the study areas.

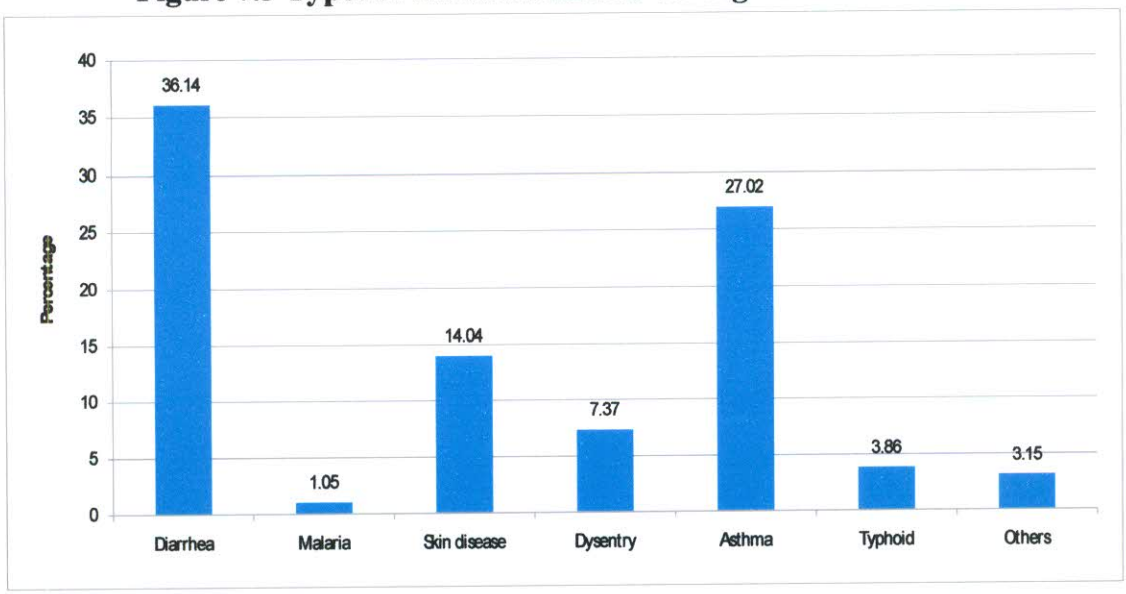
Table 7.12 Perception about suffering from diseases and Spend for treatment

Categories	Frequency	Percentage
Whether suffered from diseases during water and air born		
Yes	285	71.79
No	112	28.21
Total	**397**	**100.0**
Water borne diseases	168	58.95
Air borne diseases	117	41.05
Total	**285**	**100.0**
Amount of money spend for treatment		
Up to 500	109	38.25
501 - 1000	115	40.35
1001 - 1500	19	6.67
1501 - 2000	26	9.12
2000 +	16	5.61
Total	285	100.0

Source: Field survey, 2010

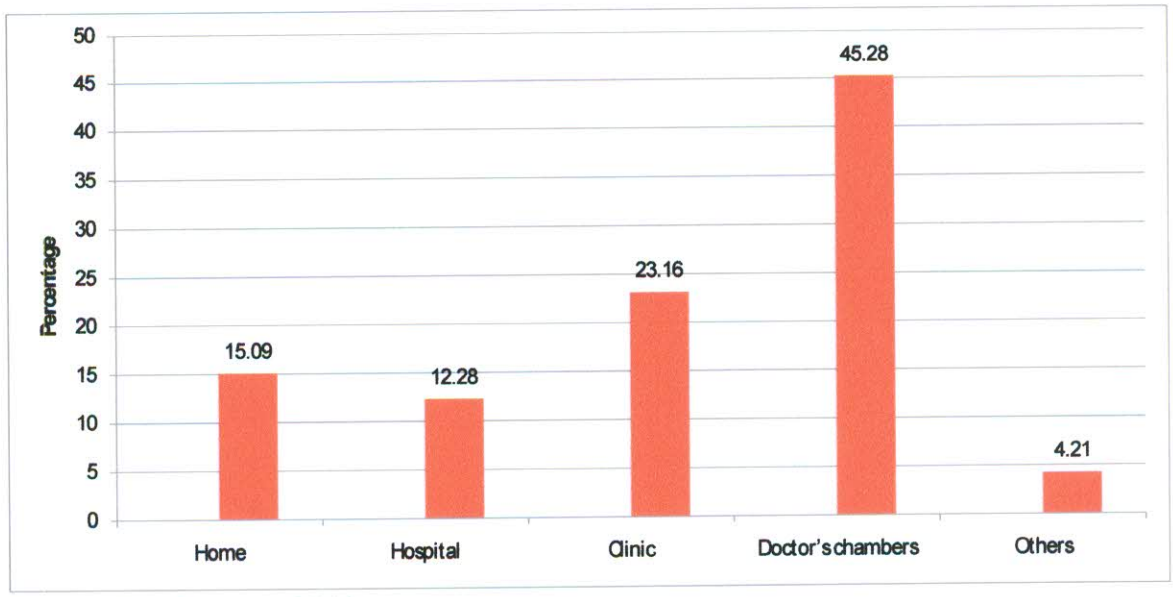
Respondents were also asked about the amount of money they expend for treatment. Survey results revealed that 38.25% respondents spent up to 500 taka in last month at that time for Medicare, while 40.35% expended 501-1000 taka, 6.67% expended 1001-1500 taka, around 9.12% expended 1501-2000 taka and 5.61% expended more than 2000 taka (**Table 7.13**). And respondents were asked from where they received Medicare; 45.26% respondents reported that they received Medicare from doctors doing clinical practices in nearest places, 12.28% from nearest hospital, 23.16% from nearest clinics and 15.09% through self at home (**Figure 7.4 and Appendix B8**).

Figure 7.3 Types of diseases suffered during water and air borne



Source: Field Survey, 2010

Figure 7.4 Place of treatment during suffering from diseases



Source: Field Survey, 2010

7.1.8 Open Space

The urban environment will become physically and socially unbearable if adequate proportion of its land is not planned or kept aside as open space. For a large city this proportion may amount more than 10 percent (Islam and Ahsan, 1996). At an aggregate level, our cities may have close to this proportion of space including the huge amount of vacant land or unused land under government or institutional ownership. But an unfortunate situation emerges due to the unequal spatial distribution of such open spaces. In most cases, (as it also in Metropolitan Dhaka) substantial open space are available in

certain zones or social areas (such as in newer parts and cantonments) while the older city zones and more congested areas enjoy almost no such open space. **Table 7.1** show that out of 397 respondents, 142 (36%) are not satisfied from open space/recreation in the study area.

Outdoor space for socio-cultural and political meetings and assembly has been a strongly felt need in the urban context of Bangladesh. The availability of such space has become continuously limited and restricted in Dhaka (and probably other cities), due to negative attitudes of governments in power in the past. As a result, major avenues and streets are normally turned into arenas for congregation. The economic losses and social inconveniences are immense. City plans must provide such outdoor space adequately.

7.2 People's Perception about Urban Environment in the Study Area

In case of the degree of satisfaction, a wide variation has been identified between perceptions of 'highly satisfied' points of scale. And on the other hand, a little variation has been identified between perception of satisfied and 'dissatisfied' points of scale. About 10 percent respondents were highly satisfied with the quality of cleaning and maintenance system, education facilities and road network. In opposition, about 20 percent respondents were highly dissatisfied with the quality of electricity supply, drainage congestion, parking facilities, recreation facilities and sanitation facilities, cleaning and maintenance of the city, poverty and slum and 32 percent respondents were highly dissatisfied only for the medical facilities. In total 3.96 percent respondents were highly satisfied and 14.37 percent respondents were highly dissatisfied with the quality of neighborhood facilities. About 37.28 percent respondents were dissatisfied with the quality of transportation system in neighborhood environment which is counted as the highest degree of negative satisfaction. About 20-30 percent respondents were satisfied with the quality of water supply, gas supply, housing, road network, *mastan*, and tele-communications and community facilities. High level of dissatisfaction (65-70%) was determined for water supply and traffic management in the study area. On an average 40-50 percent respondents were dissatisfied on the quality of electricity supply, drainage congestion, garbage disposal system, transport and vehicle, parking facilities, employment scope, local security, law and order situation, medical facilities and sanitation facilities. Only for gas supply 31 percent respondents have accepted the qualities with highest degree of acceptance. Except the medical facilities, about 15-20 percent has accepted the quality of most of the neighborhood facilities in the city. It is obvious that from 25 urban environmental variables, people of Dhaka city are dissatisfied with half of the total variables.

Table 7.13 People's perception (level of satisfaction) of urban environmental variables in the study area

Variables	Highly Satisfied		Satisfied		Acceptable		Dissatisfied		Highly Dissatisfied		Not Respondent	
	F	P	F	P	F	P	F	P	F	P	F	P
Water Supply	9	2.27	44	11.08	61	15.37	266	67.0	10	2.52	7	1.76
Garbage disposal	2	0.50	34	8.56	45	11.34	189	47.61	64	16.12	63	15.87
Drainage Condition	5	1.26	41	10.33	49	12.34	203	51.13	81	20.40	18	4.53
Electricity Supply	9	2.27	32	8.06	61	15.37	195	49.12	83	20.91	17	4.28
Gas Supply	21	5.29	116	29.22	123	30.98	53	13.35	33	8.31	51	12.85
Transport and Vehicle	9	2.27	48	12.09	67	16.88	206	51.89	36	9.07	31	7.81
Parking Facilities	5	1.26	72	18.13	44	11.08	191	48.11	76	19.14	9	2.27
Medical Facilities	3	0.76	33	8.31	42	10.58	168	42.32	126	31.74	25	6.30
Traffic Management	1	0.25	37	9.32	49	12.34	261	65.74	38	9.57	11	2.77
Employment scope	7	1.76	52	13.10	65	16.37	192	48.36	57	14.36	24	6.05
Local Security	12	3.02	58	14.61	49	12.34	189	47.61	68	17.13	21	5.29
Cleaning and Maintenance	37	**9.31**	62	15.62	65	16.37	137	34.51	77	19.39	19	4.79
Education Facilities	41	10.3	46	11.59	86	21.66	148	37.28	61	15.37	15	3.78
Anti-social Activities	13	3.27	124	31.23	117	29.47	72	18.14	29	7.30	42	10.58
Housing	17	4.28	98	24.19	76	19.14	65	16.37	21	5.29	120	30.23
Road Network	41	**10.3**	114	28.72	65	16.37	109	27.46	18	4.53	50	12.59
Poverty and slum	3	0.76	53	13.35	79	19.90	104	26.20	85	21.41	73	18.39
Recreation Facilities	11	2.77	72	18.14	92	23.17	125	31.49	84	21.16	13	3.27
Sanitation Facilities	8	2.02	32	8.06	52	13.10	175	44.08	92	23.17	38	9.57
Sewerage System	4	1.00	60	15.11	69	17.38	136	34.26	91	22.92	37	9.32
Law and Order	5	1.26	47	11.84	58	14.61	185	46.60	64	16.12	38	9.57
Tele-communications	49	12.3	113	28.46	74	18.64	57	14.36	14	3.53	90	22.67
Postal and Parcel Service	58	14.6	191	48.11	82	20.65	45	11.34	17	4.28	7	1.76
Community Facilities	10	2.52	105	26.45	73	18.39	82	20.65	49	12.34	78	19.65
Mastan (Musclemen)	8	2.02	112	28.21	101	25.44	116	29.21	33	8.31	27	6.80
Total	388	3.96	1766	18.04	1634	16.69	3669	37.48	1407	14.37	924	9.44

Source: Field Survey, 2010

Note: F= Frequency, P=Percentage (N=397 for the three samples area)

7.2.1 Degradation of Urban Environment

Degradation of urban environment has been measured from value of Satisfaction Index. From the Satisfaction Index, variables have been taken as degradable, which have shown the negative index of satisfaction. Among 25 variables, 17 variables have shown the negative satisfaction index according to rank (**Table 7.15**). Among the degradable variable of urban environment, Traffic Management system (-0.564) has shown the highest negative value of satisfaction index except some VIP roads in the city. Citizens

react strongly upon such mismanagement of the city authority. In this case, the urban poor areas are very poorly served. Dhaka city was huge wet/lowland and vacant lands under government or different institutional ownership, which are yet been developed as wet / lowlands and open space for residential; commercial and industrial purposes. The condition is very worse which is an evident of citizen's perception. Supply of water (-0.559) is second and electricity (-0.410) is placed in third position according to negative index of satisfaction. The poor supply of electricity and load shadings is higher in summer than winter in this city. In this respect there is a huge gap between demand and supply. In Bangladesh, employment facilities are very poor in urban center and Dhaka city is not an exception. Most of the poor are engaged in urban informal activities. In this city, medical facilities have not grown according to public demand (**Table 7.14**).

Table 7.14 Degradation of urban environment in Dhaka city

Neighbourhood /Social Environmental Variables	Number of Satisfied Respondents (fs)	Number of Dissatisfied Respondents (fd)	Satisfaction Index (Is)	Rank
Traffic Management	37	261	-0.564	1
Supply of Water	44	266	-0.559	2
Supply of Electricity	32	195	-0.410	3
Drainage Condition	41	203	-0.408	4
Transport and Vehicle	48	206	-0.397	5
Garbage Disposal System	34	189	-0.390	6
Sanitation Facilities	32	175	-0.360	7
Employment Facilities	52	192	-0.352	8
Law and Order Situation	47	185	-0.347	9
Medical Facilities	33	168	-0.340	10
Cleaning& Maintenance	58	189	-0.329	11
Number of parks	72	191	-0.299	12
Anti-social Activities	46	148	-0.256	13
Sewerage System	60	136	-0.191	14
Recreational Facilities	62	137	-0.188	15
Local Security	72	125	-0.133	16
Poverty and slum	53	104	-0.128	17

Source: Field Survey, 2010

Note: Rank indicates severity of the problem

Recently, some private clinics and hospitals have been set up, which are affordable only by the upper class. Drainage congestion and water logging are interdependent. In the

study area, drainage congestion (-0.408) is one of the most important neighborhood problems. Most of the drainage channels are filled up by waste, used polythene bags and others garbage. For these reasons water logging and drainage congestion are the common measurable conditions during the rainy season. Cleaning and maintenance by cleaners and sweepers from the city authority along the primary roads are rather satisfactory than the internal or access roads of any neighborhood. Local security (-0.133) is also in vulnerable situation. For this reason, the variable has shown the negative index of satisfaction at the local level. According to citizen's perception, local people are always scared about terrorist activities by musclemen or so called *mastan* in metropolitan society. Such kinds of activities are deteriorating day by day in every urban center in Bangladesh. Law and order situation as well as policy activities have compounded the problem.

7.2.2 Variation of Urban Environmental Degradation in Different Area

Degradation of environmental variable has been taken to show the areal variation in three areas/locations in the study area. Most of the citizens are dissatisfied with quality of traffic management system in this city, which is reflected from the areal variation. For traffic management system all three areas have shown the negative index of satisfaction. Among the three areas, area-03 has the highest value of negative index and identified as a highly degraded area. Other two areas (area-01 and area-02) have shown moderately degraded environment (**Table 7.15**). The residential neighborhoods and urban poor areas are worst affected by the mismanagement of traffic management system. In all three areas, facilities of supply of water have shown the negative index of satisfaction. According to least index, area-03 (-0.587) has shown the highest value relating to supply of water. In this respect area-01 and area-02 have been found as the highly degraded areas in the city. In case of electricity supply area-03 (-0.431) has been found as the highly degraded area followed by area-02. Maximum areas in Dhaka city, load shedding is in a deteriorating condition. In these areas load shedding occurs two or three times, but even ten to twelve times a day.

This is evident from the areal variation that all three areas have shown the negative index of satisfaction on drainage condition. Degraded drainage conditions are found only one area, area-03. Piedmont, low laying and congested areas is mainly affected by poor drainage congestion. Areal variations are also found in such feature, area-01 is situated on piedmont and low laying landform and area-02 is located on the congested newer part of the city(Appendix E).

Table 7.15 Areas variation of neighborhood environmental degradation in Dhaka city

Variables	Area-01 (Is)	Area-02 (Is)	Area-03 (Is)
Traffic Management	-0.533	-0.488	-0.590
Rank	2	3	1
Supply of Water	-0.511	-0.488	-0.587
Rank	2	3	1
Supply of Electricity	-0.333	-0.418	-0.431
Rank	3	2	1
Drainage Condition	-0.311	-0.302	-0.458
Rank	2	3	1
Transport & Vehicle	-0.266	-0.116	-0.488
Rank	2	3	1
Garbage Disposal System	-0.422	-0.279	-0.397
Rank	1	3	2
Sanitation Facilities	-0.344	-0.348	-0.367
Rank	3	2	1
Employment Facilities	-0.422	-0.372	-0.325
Rank	1	2	3
Law & Order Situation	-0.311	-0.302	-0.367
Rank	2	3	1
Medical Facilities	-0.333	-0.162	-0.371
Rank	2	3	1
Cleaning & Maintenance	-0.311	-0.139	-0.367
Rank	2	3	1
Number of parks	-0.288	-0.232	-0.314
Rank	2	3	1
Anti-social Activities	-0.388	-0.209	-0.219
Rank	1	3	2
Sewerage System	-0.166	-0.139	-0.208
Rank	2	3	1
Recreational Facilities	-0.166	-0.162	-0.200
Rank	2	3	1
Local Security	-0.177	-0.162	-0.125
Rank	1	2	3
Poverty and slum	-0.055	-0.116	-0.155
Rank	3	2	1
Grand Total	-0.31	-0.26	-0.35
Rank	2	3	1

Source: Field Survey, 2010
Note: Rank indicates severity of the problem

Degradation of law and order situation in major metropolitan areas in Bangladesh is now a hard talk due to insufficient police activities in favour of general public. However, in Dhaka in case of law and order situation only two areas (area-03 and area-01) have shown the negative index of high degradation and another one (area-02) has shown negative value of satisfaction index. All these areas have shown the negative index of satisfaction on employment facilities. Area-01 and area-03 have been found the highly degraded area (**Table 7.15**). In case of medical facilities, all three areas have shown the negative index

and among them area-01 has found the highly degraded area. Highest concentrated medical facilities are at Dhanmondi; Mohammadpur and Mirpur areas and most of them are located on newer part of the city.

Most of the citizens are dissatisfied with quality of garbage disposal management system in this city, which is reflected from the areal variation. For garbage disposal system all these areas have shown the negative index of satisfaction. Area-01 has the highest value (-0.422) of negative index and identified as a highly degraded area. Other two areas (area-02 and area-03) have shown moderately degraded environment. The residential neighborhoods and urban poor areas are worst affected by the mismanagement of garbage disposal system. The anti-social activities of Dhaka city is highly dissatisfied, which is reflected from the areal variation. The area-01 has the highest value (-0.388) of negative index and identified as a highly degraded area. Other two areas (area-03 and area-02) have shown moderately degraded. In case of Sanitation facilities, all these areas have shown the negative index and among them area-03 has found the highly degraded area. Other two areas (area-01 and area-02) have shown moderately degradation of water supply(Appendix E).

In aggregate result, all these areas have shown the negative value of satisfaction index. So it is obvious that in all urban environmental conditions no area is out side the degradation boundary. But the magnitude of degradation may differ from one area to another area. Area-03 has shown the highest value (-0.35) and is identified as the moderately degraded area. Except area-03 other two areas (area-01 and area-02) have been found as lower degraded areas(Appendix E).

7.3 Perception of Respondents on Declining Problems

During field survey, the respondents were asked how they would like to solve the problems. Regarding problems of environmental degradation 67% respondents suggest that concerned authority should control the rapid growth of population, 54% respondents said about batter waste management and improving the local drainage and sewerage system, 23% said to stop unplanned industrialization, 31% opined for providing safe drinking water, 41% suggested to supply sanitary latrines at low cost or free of cost to the poor, 22% suggested to reduce air and water pollution, 16% said for traffic control, 29% said to ensure mass education and poverty alleviation program and 26% said to mitigate water logging problem and raising environmental education and awareness.

The highest number of respondents indicated that rapid population growth, improper management of waste and drainage and sanitation system and pollution need to be controlled to reduce the urban environmental degradation which is shown in the **Table 7.16.**

Table 7.16 Probable solutions to environmental problems by percentage of respondents

Categories of Respondents	Percentage
Controlling rapid growth of population	67.00
Waste management and improving drainage and sewerage system	53.65
Stopping unplanned industrialization	23.43
Ensuring of safe drinking water supply	30.73
Supply sanitary latrines at lost cost, or free of cost to the poor	48.11
Reduced air and water pollution	41.06
Traffic control and withdrawn defective vehicle	22.42
Ensure mass education and Poverty alleviation program	16.12
Removed unplanned dams and water logging problem	28.72
Raising environmental education and awareness and Others	26.45

Source: Field survey, 2010

7.3.1 People's Responsibility

In recent time an emphasis has been placed on the study of environmental perception to focus the whole environmental issues (Hossain, 1992 and Rahman, 1996). The study of environmental perception seeks to focus on specific aspects of the environment which are related to human welfare (Bechtel, 1976). In modern urban planning, urban development decisions are made from local level community participation and in that case citizens' perception in every aspect of urban life is important. Out of 397 respondents, 60% respondents suggest to improve household sanitary system, 53% respondents identify encouraging people to adopt family planning, 55% respondents identify better management of household garbage, 42% respondents identify participation in social forestation and only 14% respondents identify not using polythene. **Table 7.17** summaries the people's responsibility regarding the sustainable environment.

Table 7.17 People's responsibilities for environmental degradation

Categories of Responsibility	Percentage
Improvement of household sanitary system	59.70
Encouraging people to adopt family planning	53.15
Helping to spread mass education	31.73
Better management of household garbage	55.16
Maintenance of local dams and drainage system	38.03
Helping Govt. and other NGOs to alleviate poverty	36.78
Not abusing and polluting water	47.10
Not using polythene	13.60

Source: Field survey, 2010

7.3.2 Perception of Local Communities Regarding Mitigation of the Problems

During field survey respondents were asked about perception of the community to mitigate environmental problems. To mitigate the problems, as **Table 7.18** shows, 36% respondents suggest for participation in promoting family planning; while 53% respondents identify the involvement of mass people in population control, mass education and poverty alleviation; 37% respondents identify collective effort for community based joint-latrines and safe water supply for the poor; 46% respondents identify participation in cleanliness to drive wastage of the local; 41% respondents identify involvement in drive against all kind of pollution, especially air and water pollution; and 25% respondents identify participating in community based tree plantation/social forestry.

Table 7.18 Responsibilities to the local communities for better environment

Categories of Responsibility	Percentage
Participate in promoting family planning	36.27
Involve population control, mass education and poverty alleviation	53.15
Community based joint-latrines and safe water supply for the poor	37.03
Participation in cleanliness drive and waste management of the local	46.10
Against all kinds of pollution, specially air and water pollution	40.55
Helping the concerned authorities and agencies for pollution control	20.91
Participating in community based tree plantation/ social forestry	24.94
Campaign against spread of disease establishing healthcare centre and participate in environmental awareness raising	28.21

Source: Field survey, 2010

In reply of the question whether the respondents take any help during natural hazards, out of 397 respondents, 139 (35%) respondents reply that they take help during this period. These respondents were also asked about the source and categories of help they take during these time. 83% respondents specify that they take help from the neighbor (**Table 7.19**). About kinds of help, 56.83% respondents reveal that they take only food as help, 30.50% mention that they take living facility, 10.07% report that they need only medicine and 3.60% respondent emphasize that they take all of the above mentioned helps.

Table 7.19 Opinion of the respondents regarding mitigation of the problems

Categories	Frequency	Percentage
Whether the respondent take help during these time		
Yes	139	35.01
No	258	64.99
Total	397	10.0
Sources of help		
Govt. Organization	7	5.04
NGO	4	2.88
Relatives	11	7.91
Neighbors	115	82.73
Others	2	1.44
Total	139	100.0
Types of help		
Living	41	30.50
Food	79	56.83
Medicine	14	10.07
Above All	5	3.60
Total	139	100.0

Source: Field Survey, 2010

7.3.3 Government Steps to Overcome the Environmental Degradation

Respondents were asked whether government has taken any step to curb the environmental problems in Dhaka city. Out of 397 respondents only 171(43%) respondents point out that government has taken steps to curb the environmental problems (**Table 7.20**). These respondents (43%) were also asked about the types of steps taken by the Government. In reply, 32 % respondents state that controlling the growth of population, 27% stopping unplanned industrialization and better management of industrial effluents, 20% respondents mention controlling all types of pollutions; 16% respondents indicate supply of sanitary latrine free or low cost among the poor and only 4.68% respondent mention that re-excavated the encroached natural drainage system.

Table 7.20 Government's steps to over come environmental degradation

Categories of Responsibility	No. of Respondents	Percentage
Whether there is any steps taken by the govt.		
Yes	171	43.07
No	226	56.93
Total	397	100.0
Steps taken by the govt.		

Controlling population growth	54	31.58
Stopping unplanned industrial and management of effluents	47	27.48
Controlling all types of pollutions	35	20.47
Supply of sanitary latrine free cost/low cost among the poor	27	15.79
Re-excavated the encroached natural drainage system	8	4.68
Total	**171**	**100.0**
Measures should be taken to overcome the environmental problem		
Better management of waste and local drainage systems	66	29.20
Remove all illegal structure in the city	37	16.37
Encouraging people to plant tree and social forestation	17	7.52
Govt. helped the proper planning and development	24	10.62
Enhancing rules and regulation for protecting natural resources, fisheries and land and control the pollution	16	7.08
Enhancing rules and regulation for protected Traffic jams	23	10.18
Re-excavating river and canals	5	2.21
Preparedness to tackle flood and cyclone	7	3.10
Environmental awareness raising for short films, T.V, Radio advertise and others	31	13.72
Total	**226**	**100.0**

Source: Field survey, 2010

These questions were asked to the respondents to know what types of measures should be taken by the government to overcome the environmental problem. Maximum respondents (29%) suggest better management of waste and local drainage systems; 16% respondents indicate removal of all illegal structures from Dhaka city; 11% respondents suggest to the proper planning and development; 10% respondents suggest to rules and regulation for protected traffic jams and 14% respondents opine environmental awareness raising through short films, T.V, Radio advertise and others.

The situation revealed from the last chapter regarding land use change and certain prediction of environmental condition is also reflected from the people's perception, to some extent. The differences that found is certainly due to awareness of mass population, gap between the understanding between urban governance and stakeholders, capacity and expectation and lastly reality of wide-spread poverty in regional level-the source of all migration that affects city. It is clear from the picture that if built-up areas grow following its current trend all the environmental problems mentioned will deteriorate.

Chapter 8

Findings, Suggestions and Conclusion

Chapter 8
Findings, Suggestions and Conclusion

This chapter attempts to present a synopsis of findings regarding various aspects of land use change found in different chapters in accordance with the objectives of research. Then conclusions are drawn on the basis of these findings. Finally, some potential suggestions are formulated to mitigate the environmental degradation and to conserve and develop environment through an integrated sustainable approach. It is observed that rapid growth of population, unplanned urbanization and industrialization, lack of awareness among stakeholders, appropriate compliance and implementation of regulations are the major causes and factors of environmental degradation which needs an environmentally sound land use model and land management including economic instruments for improvement of environment quality of Dhaka in a sustainable manner.

8.1 Findings of the Research

The findings of the research found in different chapters through analyzing required data and information collected from primary and secondary sources are described here as below:

8.1.1 Unplanned Growth of Dhaka City and Land use Change

Bangladesh has been experiencing a rapid growth in urbanization during last four decades. It is revealed that between1960 - 2000, the level of urbanization increased from about 5.1% to about 24%. By the year 2020 the level of urbanization is expected to reach about 36%.

Dhaka, the primate city and the other metropolitan areas of Chittagong, Khulna and Rajshahi dominate the urban system in Bangladesh. Among the four cities, Dhaka itself contains more than half of the total urban population and the four largest cities together account for less than half of the total.

Dhaka's population has grown at an annual rate of about 15.51 percent during 1961-1974, 14.89 percent during 1974 -1981, 13.02 percent during 1981-1991, and 8.6 percent during 1991-2001(BBS 2001). The area of Dhaka has also increased substantially. In 1974, it was 324 sq. km (125 sq. mile) whereas the Statistical Metropolitan Area of Dhaka in 1991 showed as 1353 sq. km (522 sq. mile). At present the Dhaka City Corporations area is about

751 sq. km (290 sq. mile) and it is now spread over an urban area of about 2000 sq. km and has approximately 11 million of people which is estimated to reach about 20 million by 2015.

Dhaka's rapid growth in population and fast urbanization has led to the demand for better transportation facilities. Existing roads were not planned to accommodate the growth. Being a principal city, it contributes greatly to the nation-building process, but such role often leads to potentials negative social and environmental impacts. Moreover Dhaka is growing in an unplanned way. The capital is growing at two square kilometers and almost half a million people a year which is almost unplanned. The present trend of city development is unscientific. The physical features, topography and demographic features of Dhaka city have always influenced its physical expansion.

Dhaka has grown on its own way in a haphazard manner and the topography of the area dictated the terms and direction of the growth. Since Dhaka has become the capital of an independent country, the pressure on it has been increased enormously. Rural urban migration is recognized as a major component of the aerial extent of the city. Because of the population growth/migration, urbanization is stretching along the land use changes.

The Buriganga, Turag and Balu River are the main streams that surround Dhaka city and these spillways help an efficient drainage in the city. The natural drainage system in the greater Dhaka city comprises of several retention areas and *Khals*, which are linked to surrounding rivers. There were more than 35 canals in Dhaka city area. Some canals were filled up for the construction of road and box culverts were made on some canals i.e. Tongi *Khal*, Dhanmondi *Khal*, Paribagh *Khal* and Rajarbagh *Khal*. These canals could have remarkable contribution in drainage service. The whole system is not functioning properly due to encroachment and improper management and overload of sewerage.

Field observation reveals that the major factors responsible for land use changes in Dhaka city are: rapid population growth and unplanned urbanization, industrialization, some socio-economic sectors; and political and institutional factors. The Land use change processes are degraded the quality of overall environment. The industrial pollutants are to the river and *khals*; and cause water and soil pollution. On the other side, air and sound pollution are seriously degraded in urban environment.

According to the view of 397 respondents, the causes of land use change; it appears from their identified rapid population growth (63%), urbanization (85%), industrialization (61%), encroachment and land filling (54%); and lack of regulations and its implementation (35%).

On the other hand, the opinion of the respondents is that real estate housing companies, GOs, political leaders, influential people and local musclemen are the main involved participant in water bodies and wet/lowlands loss. And unplanned urbanization and industrialization is the major converter of agricultural and forest land.

8.1.2 Trend and Pattern of Land use Change

Analysis of land use/cover map of 1960, 1991 and 2008 shows that, in 1960 cultivated land areas were the largest land use/cover types (32%), the wet/lowland areas were the second largest land use/cover types (22%), vegetation areas were the third largest land use/cover types (18%), transport and communications were the smallest land use/cover types (1%) and the built up areas were only (15%).

In 1991, though the built-up areas were increased as the highest land use/cover area (29%), but both types of wetlands (water bodies and lowlands) were decreased. The transport and communication and land fill areas were increased more than double; and cultivated land and vegetation areas covered the second highest land use/cover types. But in 2008, the situation was completely reversed; the built-up areas became the highest land cover types (45%).

Three sectors namely public, private and individual householders are responsible for rapid land use/cover change in Dhaka. The declining trends of vegetation were the second largest between the periods 1960-1988 which is relatively higher than that of the period 1991-2008. During the study period the vegetation decreased by 66%. The declining trend of wet/lowlands between the years 1960 - 1991 is relatively higher than that of the year between 1991 and 2008. The percentage of changed wet/lowlands during the total study period (1960-2008) is 47%, water-bodies 45% and cultivated land 40%.

The nature of land use/cover changes reveals that the built-up and transport and communication categories have been increased significantly. The built-up areas increased in an average more than 387.35 hectares per year during 1991-2008 and increased to more than 203% in 2008 compared to 1960. The analysis also reveals that transport and communication areas increased 103 ha/year during 1960-1991, indicating 409% growths within 31 years and

from 1991-2008 increased 30 ha/year indicating 23% growths within 17 years and transport and communication areas increased to about 528% in 2008 compared to 1960. Conversely cultivated land decreased 97 ha/year during 1960-1991, 138 ha/year during 1991-2008, vegetation decreased 71 ha/year during 1960-1991, 166 ha/year during 1991-2008, water bodies decreased 17 ha/year during 1960-1991, 66 ha/year during 1991-2008 and wet/lowlands decreased 102 ha/year during 1960-1991, 65 ha/year during 1991-2008. The decline of wet/lowlands was clearly seen due to intensification of urban development in the Dhaka city and the vegetation was converting to built-up and cultivated area.

It has been found from the three selected areas, Ashulia-Uttara-Amin Bazar that developed areas have gradually increased from 1960 to 2008. It is significant that developed area has increased 218.2% in Ashulia during 1960 to 1991; on the other hand in 1991 to 2008 developed area has decreased 14.5% in the same area on an average; the developed area has increased 172% in 1960 to 2008. On the other hand, it has gradually increased 540.4% without any interruption in Uttara during the same period. It means that the rate of urbanization is much more in Uttara than in Ashulia and Amin Bazar.

It has been observed that cultivated land area has been reduced owing to urbanization in Uttara, whereas the opposite features are evident in Ashulia and Amin Bazar. It has also been observed that in Uttara land with vegetation has increased (159.2%) during 1960-2008, but it has declined in Ashulia and Amin Bazar.

This research presents a dynamic change of land use in Dhaka city based on selected physical and social factors. Land Change Modeler (LCM) was used to analyze the land use changes between various land use classes during the period 1960-1991 and 1991-2008. The land use change was assessed through evaluation of gains and losses by those classes.

During 1960-1991, cultivated/agricultural land lost 76.51% and gained 68.45%, with a net loss of 8.06%. And in 1991-2008 it lost 78.31% and gained 63.72%, with a net loss of 14.59%. Vegetation lost 67.53% and gained 25.34 % in 1960-1991 with a net loss of 42.19 %. In 1991-2008 the loss was 36.28% and the gain 19.36% with a net loss of 16.92%. Wet/lowlands lost 57.45% and gained 12.53 % in 1960-1991 with a net loss of 44.92 %. In 1991-2008 the loss was 23.57 % and the gain 24.85% with a net gain of 1.28% and water bodies changed silently.

Built-up area lost 27.61% and gained 93.58%, with a net gain of 65.97 % in 1960-1991. During 1991-2008 periods the loss was 56.42% and gain 71.26% with a net gain of 14.84%. Net gained bare soil/landfill was 10.58 % and in transport and communication it was 18.24% in 1960-1991, and during 1991-2008 similar trends have been noticed for the rest of the classes, with the exception of bare soil/landfill, which seems to be stable, and transport and communication and other categories have gained.

But however, there are again always some scopes of checking the result in GIS techniques. The location accuracy of land use change model of Landsat TM image of 1991 and Google Earth image 2008 was done using the clear and visible roads during the field work. In the case of classifying bare soil/landfill, cultivated/agricultural land and vegetation, and the user accuracy were 59%, 49% and 61% respectively. The prediction of land use change was done on Neural Network built-in module in the Andes version of IDRISI. Iterations considered were 5000-sufficient for running the data. The lowest accuracy obtained was 57.30 for all the conversion types.

The transition probability matrix records the probability of future changes in which each land use category indicates in relation to other category. This matrix is produced by the multiplication of each column in the transition probability matrix where the numbers of cells of corresponding land use show the later scenario. Though this matrix can be used to predict future land use in any period, it was specially designed for the predictions about the years 2020 and 2050.

Markov analysis was performed for the multi-temporal land cover images of 1991-2008 including predicting year of 2020 as shown in the probability of conversion from vegetation to agriculture and built-up areas are 38% and 35% respectively. Similarly the probability of wet/lowlands classes change into 27% agricultural land and 7 % built-up area; agricultural land to change to built-up areas are 26% and wet/lowlands are 11%; bare soil/landfill area change to built-up area 51%.

Thus it is revealed from this analysis that the rate of transformation of wet/lowland is highly related with urban settlement. It is clearly observed from the analysis of change in land use dimension of three selected areas that vegetation and wet/lowlands are mainly converted to built-up areas.

8.1.3 Impact of Land use Change on Environment

Land use change through filling of wetlands and low-lying areas prompted due to needs of rapid urban expansion, establishment of infrastructures including road infrastructure, electricity, gas and water supply etc. Urbanization enhanced to develop facilities through establishment of residential, commercial, and industrial area, educational and administrative infrastructure, in addition to that motorized road network contributing to economic development and enhancing the quality of life.

The demand for land within Dhaka has increased tremendously as the mobility of urban, sub-urban and regional commuters has increased. This has initiated the ongoing development of housing through land filling in the fringe areas of Dhaka.

Environmental conditions include topography, soil condition, land use and pattern of land use change, existing vegetation and plantation, building materials, traffic densities and consequential air pollution, sanitation and habitat-environment, disposal of solid and liquid waste, privation wetlands and fringe areas etc.

Earth-filling and infrastructure development, however, have caused widespread environmental degradation. Poorly planned development, malpractices in construction activities and ill maintenance had far-reaching and negative effects on the environment. The resulting damages in many cases are permanent. The negative effects continuing for a long time and have prolonged consequences. The extended coverage of such damage is very extensive to the non-living as well as living and natural and human environment.

As discussed in the previous chapters, land use change areas by earth filling have caused, in most cases, minor to serious damages to land, water, air, vegetation and biodiversity. Land users have disfigured topography and landscape, damaged soils, disrupted drainage systems, contaminated water bodies and deteriorated air quality. It is assumed that land use change areas through earth-filling is a major cause of damage to the natural living environment including ecological destabilization, habitat destruction, and damage to flora and fauna.

At present Dhaka city is beset with a number of physical and socio-environmental problems. Among these water logging; traffic congestion; solid waste disposal; and black smoke from

vehicular and industrial emissions; air and noise pollution; pollution of water bodies by industrial discharged affluent causing health hazards.

Environmental hazards are not new phenomena in Dhaka city but the frequency of environment problems is increasing day by day. The respondents appear to identify water pollution (83%), air pollution (79%), drainage congestion and water logging (72%), traffic congestion and water logging (79%), waste disposal system (73%), decreasing ground water level (36%), sanitation and unhygienic problems (68%), increase air and water born diseases (64), scarcity of safe drinking water (60%) and only 23% respondents identify threats to bio-diversity.

Dhaka city has experienced significant urban growth during the last 50 years. Different types of land have undergone a radical transformation since 1971 when Dhaka becomes the capital of new sovereign state of Bangladesh. Change in land use alters the physical characteristics of an area, which in turn brings changes in hydrological regime. During field survey the respondents were asked about whether they face water logging in the area where they live. Out of 397 respondents 329 (83%) respondents replied that they face water logging in rainy season.

Urbanization changes the hydrographic network of the city, which causes an imbalance in the local water circulation. The land conversion, construction of buildings, paved areas, and drainage and sewer system cause a decrease and even disappearance of natural watercourses and other open basins. For this dense urbanization in the city there has been a decrease in the amount of recharge from the direct percolation due to decrease in the rechargeable area. On the other hand excess extraction of ground water to meet up the urban demand has disrupted the recharge-discharge equilibrium of the city. Dhaka city's ground water level is depleting at an alarming rate. Ground water depletion is occurring more than 3m/year at most places of Dhaka city. Ground water table in the capital has dropped down to 85.62 meters below the surface, 59 meters in the last 15 years, due to lack of recharging which has put the sprawling metropolis at great risk. Expert opined that if water table continues to fall then a vacuum will be created in the aquifer which could cause a sudden collapse in the surface.

The present trends of residential land development in and around the city have posed environmental threat to the areas. The developing activity damaged natural landscape and is

changing the character of the areas. Survey result reveals that 83% respondent opined about facing water logging. 35% respondents opined water logging damaged the roads and houses, about the types of damage, among the above respondents 56% said water logging mainly damage the carpeting of roads. About the risk to run motor vehicle, in the situation is dangerous to run motor vehicles in water logging and risk of dropping into open manhole.

One of the most important problems during a flash flood or water logging situation is the lack of safe drinking water. Most of the reserve tanks of the buildings or houses in affected area are submerged, which results in water crisis. During field survey 63% respondents reply that they face safe drinking water problem during flash flood or water logging. They were again asked about the types of problem they face, in reply of this question 58% respondents assert that 'supplied water is dirty', while 23% report 'water is not available when needed' and 19% identify that 'water becomes less'.

During field survey 33.25% respondent identified that they face sanitation problem due to water logging. About the types of sanitation problem, 67.42% of the above mentioned respondents opine that 'toilet overflowing' problem, while 8.34% assert 'toilet's waste floats on water' and 24.24% identify 'toilet sunk under logged water'. About unhygienic situations that created during water logging time 36.52% respondents identify that mosquito increases during this time, while 26.45% report about spreading of odor, 3.53% mention kitchen waste floats on water and 33.5% identified waste of open drainage floats on water.

It is significant that 58.95% respondent's specifically suffer from water borne diseases and about 41.05% respondents suffer from air borne diseases. It appears from their respondents that 36.14%, 14.04%, 11.37%, 27.02%, and 5.26% respondents suffer from diarrhea, skin disease, dysentery, asthma, and hypertension respectively. Among their identification diarrhoea and asthma are in leading position and skin diseases are as the acute and most common feature in the study areas. Survey results revealed that 38.25% respondents expend up to 500 taka in last month for medicare, while 40.35% expend 501-1000 taka and 5.61% expend more than 2000 taka.

Survey results reveal that maximum respondents (43%) were also asked about the types of steps taken by the Government. In reply, 32 % respondents state that controlling the growth of population, 27% stopping unplanned industrialization and better management of industrial

effluents, 20% respondents suggest to control all types of pollutions; 16% respondents indicate to supply of sanitary latrine free or low cost among the poor and only 4.68% respondent mention that re-excavated the encroached natural drainage system to overcome the environmental degradation.

8.1.4 Land use Management and Government Organizations

Land use management in Dhaka city is cross-related with the functions of some ministries and departments. The ministries, which relate to urban land management in different ways, are Ministry of Land, Ministry of Environment and Forest, Local Government Division, Ministry of Water Resources and Ministry of Shipping.

The responsible departments and organizations under the above mentioned ministries are Rajdhani Unnayan Katripakkha (RAJUK), Dhaka Water Supply and Sewerage Authority (DWASA), Dhaka City Corporation (DCC), Bangladesh Inland Water Transport Authority (BIWTA) and Bangladesh Water Development Board (DWDB) and Deputy Commissioner Office, Dhaka. Among them RAJUK, DWASA, DoE and BIWTA are directly related to land management.

The present land management practices of the public agencies are not at all systematic. The existing acts/laws of different agencies remain, as management tools, which are not followed properly in the areas. Overlapping of functions among the agencies creates conflicts in management and controls. Coordination among the public agencies and their management system are ineffective because most agencies implement their programs in their own way.

RAJUK is the regulatory and supervisory body in the planning and development of Dhaka. RAJUK has neither enough planners nor institutional arrangements to promote a planned development of Dhaka. The existing organization setup in the RAJUK is weak in terms of plan preparation, development and development control. This organization has poor technical manpower and logistic support especially the manpower to oversee the in-filed development of the city.

DWASA authority is mainly concerned about to supply water, drainage and sewerage within city areas. This authority is also responsible for the management and preservation of canals to discharge storm water. DWASA often conducts surveys to demarcate land of the canals

and recover them from the grabbers to facilitate its natural flow during the rainy season. But the grabbers again encroaches the canal.

The Department of Environment (DoE) holds the responsibility of environmental management and control of water resources, specifically it concerns to protect land, water and air pollution. The DoE is presently weak by technicalities like shortage technical manpower and equipments. The building capacity of DoE and financial strengthening are not up to the mark.

The existing canals are gradually being filled up as well as obstructed by road constructions and building box culverts; as a result the canal and channel networks are drying up. At the same time, the PLDCs are forcing drastic reduction in wetlands by unregulated land filling and encroachment activities without paying attention to their drainage network.

The public agencies involved in city development has short, medium and long term development programs and they are implementing those programs in phases ignoring the programs of other agencies. Law enforcement activities from the public sector and their performances are weak and ineffective. It is observed that each agency/organization carries their programs within their institutional framework. In the process, implementation of some functions is overlapped among the agencies. Moreover, some conflicts occur due to overlapping of jurisdictions of different agencies. Above mentioned all laws/regulations are not particularly effective in controlling unauthorized and illegal activities regarding land uses, since there are numerous loopholes that allow much malpractices.

Ramsar Convention is the modern global intergovernmental treaty regarding wetlands. The principle actor in the domain of ICTPs in Bangladesh is Ministry of Environment and Forest, with the Department of Environment (DoE) and the Department of Forests (DoF) acting as the technical arm of MoEF for implementation of the ICTPs. *Ramser* Convention is looked into by these institutions. These institutions have limited manpower and financial resources back up in addressing the implementation issues of ICTPs. In the Department of Environment one small section has been created to look after all the ICTPs including Ramsar Convention.

Survey result clearly reveals that 65% respondents who reflect this picture think that land use related laws and regulations are not enforced properly and out of them 43% respondents

identify negligence of the authority as the main cause, while 35% respondents assert corruption of the concerned department, 19% respondents opine lack of co-ordination among the concern agencies is the main cause and 3% respondents claim that complicated system is responsible for non-enforcement.

Out of the total sample households, around 87% respondents opine that government has no initiatives to build awareness about this matter. Data show that around 54% respondents think proper planning in development activities is needed, while 30% respondents believe that strong monitoring regarding encroachment is essential, around 14% respondent emphasize on ensuring enforcement of concern laws and 2 % respondents stress on built up a special body for Sustainable land management and conservation.

8.1.5 Environment Management

The prime objective to explore environmental degradation through land use change in Dhaka is a great concern of this research. The environmental management plan is to protect natural water bodies, ecological habitation, drainage, canal network, wetlands and environmental resources. The major impacts of physical and social environmental degradation are due to land use change. However, in the environmental management plan, the general suggestion and mitigation measures are put forward to improve the environmental conditions, these are:

- Immediate actions are needed from the DWASA for disconnection of domestic sewer lines to the existing storm sewers and facilities construction of properly designed septic tank at residential and surrounding areas.
- The storm sewers discharging into the low-lying areas of waterwheel also carry domestic sewage from the surrounding residential areas. The industrial effluents from Tajgaon Industrial Area are also discharged into the Begunbari *khal* and Ashulia industrial area are also discharged into the Turag River. Management of water quality would be a major challenge in the overall development planning of the study area. Adequate measures should be taken to stop discharge of domestic and industrial wastewater into the area. Such measures may include establishment of combined sewage treatment plant for both domestic and industrial wastewater and gradually connecting domestic wastewater line from the sewer line.

- The liquid and solid waste generated in the proposed urbanized areas at present and future need management plan and implementation of the plan must be ensured.
- A monitoring system for identification of possible pollution sources and to assess water quality of the canals and wetlands. According to the requirement treatment needs to be taken up.

8.2 Suggestions

This study reveals that land use changes of Dhaka have made the total situation vulnerable. All the preceding chapters give an alarming situation of loss of vegetation, cultivated land, water bodies and wet/lowlands in and around Dhaka city. Rapid population growth and its growing demand for housing in Dhaka city are encouraging the real estate business and private developers to grab and encroach the water bodies and wet/lowlands for housing, roads and commercial activities. These unplanned development activities are grossly violating the Dhaka Metropolitan Development Plan (DMDP) and the Wetland Conservation Act, 2000. Due to such activities, the natural drainage pattern and flood retention areas are destructed and if the trend of wet/lowland changes goes on, it will create more environmental degradation. So it is very urgent to take necessary steps to protect the remaining wet/lowlands of Dhaka. The policies/guidelines/suggestions are formulated on the basis of findings of this study are outlined below:

Strong Regulatory Framework to Mitigate Unplanned Development Activities

RAJUK is responsible to monitor the development work within the study area to monitor the whole area with its insufficient manpower and technical expertise. Moreover RAJUK does not have any field office to monitor the development work and enforce the laws properly. To improve the monitor of unplanned development and enforcement of laws RAJUK should set up its field office to monitor the development work.

In the existing set up of RAJUK, only 10 Urban Planners are working for 120 million populations in its jurisdiction area. They are working in plan preparation, implementation and development control. A particular ratio must be maintained in 'planner' and 'the people to serve'. At least 120 town planners should be in the RAJUK so that one planner can serve one lac people. Organogram of RAJUK should be reviewed and duties and responsibilities should

be reexamined. Right people with right qualification should work in the appropriate positions. So the institutional capacity of the planning department of RAJUK should be independently appraised, existing authorized posts should be filled on a priority basis and necessary additional planning positions, where required built into the organizational set up of the planning department.

RAJUK may continue to be the apex planning authority responsible for overall urban planning and regulate land use development, implementation functions should be preferably taken up only by the sector related agencies. In addition, the process of approval of building plans should be preferably divested to urban local bodies and the same should be monitored by RAJUK to assess adherence to proposed land use and land development controls. As a result, multi-agency checks and balances would be built into the system. Capacity of other relevant organizations involved in land management, like DWASA, DoE, DCC and BIWTA need to be enhanced in respect of manpower and equipments.

Reduction of Traffic Congestion

An evaluation of traffic management of Dhaka reveals that there is in general a lack of efficient traffic management and very poor enforcement of traffic regulations. In terms of the roads, a number of problems arise, including conflicts between fast and slow moving vehicles, lack of discipline and knowledge of traffic regulation and enforcement by street vendors. There is a lack of co-ordination among the various agencies involved with the road network infrastructure, including the utility agencies and the road maintenance agencies.

The manpower of traffic rules enforcement agencies is inadequate. There is an absence of adequate monitoring of implementation of traffic and transport schemes. There is no proper traffic control infrastructure or modern traffic room in Dhaka. The penal provision provides in the existing laws are not adequate as a deterrent to breaking of the traffic laws, and there is an absence of Computer networking between BRTA, Police and Courts.

Demarcation of Wet/lowlands

Discrimination of wetlands is now a widely raised issue. Due to discrimination problem it has become easy to legitimate the illegal encroachment. The structure plan of DMDP designated the retention pond in and around Dhaka city by a circle. Retention ponds are not

properly located in Mouza maps. From the DMDP structure plan, it is not clearly understandable that in which mouza the proposed pond is located because the size of the pond covers more than one mouza in the map. To avoid this confusion the ponds should be shown to scale in the map so that specific areas can be preserved for the retention purpose according to the Master Plan. Detailed Area Plan (DAP) is an opportunity to bring Dhaka metropolitan areas under planning guidelines. It will provide more detailed planning proposals for the specific sub areas of Dhaka city. DAP is supposed to address the wetland issue with immense importance. Through DAP demarcation of wetland can be done. If the Detail Area Plan for the study area is prepared properly, there will be no confusion regarding the delineation of the wetlands. So RAJUK should complete the DAP as soon as possible which will ensure the proper enforcement of law and will help to protect the remaining wetlands of Dhaka.

Conservation of Wet/lowlands

The amount of high land within the study area is limited. Due to the over population pressure, the city needs more houses and other infrastructures. As a result the city is expanding and lowlands are being filled up by different private and public organizations. So a comprehensive guideline and action plan needs to be prepared defining the extent of filling as also the areas which should be protected and defining the drainage channels that should be protected. This should be done in close consultation with stakeholders and after working out a rehabilitation package for land owners who stand to loose their lands for urbanization. Guidelines should preferably demarcate all this information on a map and this should be public information. The rehabilitation package should be attractive, such as, the land owner should be given plot to another place for construction of structure or he lives outside the lowlands area, should enjoy the benefit of tax exemption for some of the utilities and municipal taxes.

Conservation of Permanent Water-bodies

Encroachments of the permanent water bodies such as lake, canals and rivers by land developers as well as individuals for so called development, illegal structures have already affected city life in many ways. The natural drainage system of the city is losing their actual width and existence due to such encroachment and reducing the water carrying capacity day

by day with the results of water logging during monsoon period within the city area. So to solve this problem, the original width and alignment of the lakes, canals and rivers has to be re-established in proper shape and ensure easy drainage flow through these natural channels. The government should construct walkways and plant trees along the banks of these permanent water bodies to protect the encroachment.

Proper Waste Management System

Dhaka City Corporation (DCC) is the responsible authority for solid waste management in the city. There is no scientific and technological method for disposal of solid waste applied today. As a result large pieces of lowlands are used for solid waste disposal, which encroaching the natural water bodies and causing pressure as well as having a negative impact on the environment. DCC can solve the problem with cooperation of citizens, central government NGOs and private sectors. Community based waste management can be a better alternative solution. Moreover solid waste can be used to prepare manure which is doing by Waste Concern, a private organization. Government can encourage this type of program by public-private partnership to save the water bodies and lowlands.

Appropriate Implementation and Compliance of Regulations

The present study reveals that Dhaka has only 4.99% water bodies and 11.14% of lowlands. Experts opined that, a densely populated city like Dhaka requires 25% wetlands for ecological balance and sustainability of habitats. The remaining water bodies and lowlands have been filled up or converted in the name of development by both private and government sector. Due to absence of coordination, development program such as, construction of box culvert, road, embankment by the government agency often accelerate the process of water bodies and wetland conversion. So the concerned authorities like RAJUK, DCC, DWASA, BWDB and BIWTA should take the appropriate measures immediately to solve the unplanned development. It would be better to stop all kind of land development project through a government order before completion of DAP.

This study showed that negligence of the authority and corruption of the concerned department are the main causes for non-enforcement of laws. Government should take strong and strict initiatives regarding enforcement of wetland related laws. In this regard Government commitment as well as political will is needed. A few wetlands monitoring team

can be formed under the proposed wetland management cell. This team will act like a mobile court and will report to the wetland management cell.

Formation of Wetland Management Cell

The present programs and responsibilities of concern public agencies regarding wetland protection are not coordinated, rather isolated. The civic organizations are making significant contribution to save wetland with their limited resources. But they are not performing in a coordinated way with government agencies. So, for the strong coordinated effort regarding wetland protection a 'wetland management cell' can be developed under the Ministry of Environment and Forest or Ministry of Land and this management cell will be monitored by Prime Minister's Office. This cell will be formed with the participant of experts and professionals both from GOs and NGOs and have the authority to assign responsibilities to different agencies including law enforcing agencies.

Positive Role of Media

Role of mass media can play a vital role regarding protection of wetland loss. Media can work as a supervisory body. Government should encourage the media for their campaigning and reporting to draw attention to the encroachment on the wetlands. At the same time government can discuss with the media personnel about banning advertisement of illegal real estate project in all media and with understanding can issue an order about banning this advertisement.

Awareness Buildup

There is a serious lacking of public awareness about the necessity of urban environment and wetlands. A large portion of people in the city do not understand the effect of filling of wetlands. The problem of wetland loss can be effectively solved with the mobilization of stockholder in the city. Public awareness will also promote people's participation in the implementation of relevant rules and regulations. The public awareness can be best achieved in association with the civil society, environmental groups, NGOs and the media.

8.3 Conclusion

Dhaka is one of the 10th mega cities in the world. Growing at a very fast rate, the urban area of Dhaka is predicted to increase from 11.3 million today to 21.1 million by 2015 (World Bank, 2007). The city is expanding in an unplanned and uncontrolled manner. Among the six metropolitan cities, Dhaka itself contains more than half and other four metropolitan cities together account for less than half of the total urban population of the cities. A principal reason of such a rapid growth is over concentration of maximum activities and development works in the city and little improvement in other cities, towns and villages in terms of infrastructures development and economic activities. Rapid population growth creates extra pressure on the land of already over crowded Dhaka city. For this reason urbanization is stretching towards the water bodies and wet/lowlands.

Wet/lowlands are the most important component of environment in the city and peripheral areas. There is serious lacking of public awareness about the necessity and importance of urban water bodies. Behavioral pattern and attitude towards urban water bodies of different classes of people are different because the classes of people of Dhaka city in term of social and economic position are heterogeneous. The plight of environmental degradation in Dhaka city is alarming, as it is suffering from adequate legislative, administrative and social management. This study intends to investigate how wetlands are being converted. Through this research it is found that the main causes of land use changes are unplanned urbanization and earth filling for construction of infrastructures. Wet/lowlands are randomly being filled up or encroached by mainly real estate housing companies, Government organization and influential people. The private land management companies legally and illegally occupy the wetlands and try to establish their rights and are developing the areas according to their will, flouting the policies stated in DMDP Structure Plan. It is evident from the satellite image of 2008 that a large portion of the vegetation and wetland has already been lost. From the analysis of land cover map of three different years 1960, 1991 and 2008, it reveals that in 1960 wetlands areas were the second highest land cover types, the transport and communication areas were the lowest land cover types and the built up areas were the second lowest land cover types. But in 2008 the situation was almost changed, the built-up areas became the highest land cover types. The transport and communication areas increased in an average about 528% and built-up areas increased more than 203% in 2008 compared to 1960.

From 1960- 2008 Dhaka has already lost 66% of vegetation, 45% of water bodies and 47% of lowlands. If vegetation and wetland decreased in and around Dhaka city continues at the current rate Dhaka will be threatened as a city of living. The remaining vegetation and wetlands are crucial for Dhaka to keep the ecological balance, especially to reduce the environmental impact and water logging situation.

The present trend of encroachment into vegetation and wetlands in Dhaka city is a clear prohibition of planning norms. No rules/standards of planning will allow the present trend of uncontrolled loss of vegetation and land filling and encroachment into the wetlands.

It is revealed that from the analysis of land use change pattern of the selected changed areas (Ashulia, Uttara and part of DCC and Amin bazaar area) the trend of changing pattern of land use that is primarily vegetation and wet/lowlands are converted to landfill areas then it is used as any kind of informal purpose and finally converted to built up areas. So it is revealed from this analysis that the rate of transformation of vegetation and wet / lowland is highly related with urban settlement.

It is found from the above discussion that urbanization process is rapidly increased in Uttara than Ashulia and Amin Bazar areas. If the present rate of urbanization in Uttara continues there would be hazards that might force to leave the area by letters. On the other hand, there would be environmental hazards if the present rate of urbanization process must be taken before creating any environmental disaster.

This research attempts to apprehend the perception of local people regarding change of land uses through questionnaire survey. It is evident from the views of the respondent's that real estate companies, unplanned urbanization, industrialization and government organizations are involved in the change of land use pattern. They also claim that air and water pollution and water logging are the main impacts of unplanned urbanization.

The air and water pollution and water logging are becoming an acute for the inhabitants of Dhaka city and creating adverse physical and social environmental impacts. Interruption of daily life, traffic congestion, flash flood, risk of run over by motor vehicles, damage of houses, scarcity of drinking water, disrupted sanitation, unhygienic situation and spread air and water borne disease are the outcomes of water logging. The respondent's view that to address all the socio-environmental problems, it is immediately necessary to control rapid

population growth, unplanned urbanization, air and water polluting industries, raise environmental awareness programs, remove all illegal structures from the wetlands.

In order to reduce haphazard urban expansion and also in order to maintain reasonably good quality of the air and water in cities and to provide smooth and adequate supplies of basic services, the need for urban development with planning is paramount. While unplanned urbanization may become a liability, planned and balanced urbanization is expected to play a positive role in national development.

Survey results reveal that (87% respondent's views in this sector) most of the national level plans, policies and laws on land management have not been enforced properly. From the analysis of opinion of the experts and peoples perception, it also appears that the major reasons, which practically delay the implementation of the national laws, plans and policies, are lack of co-ordination among the concerned agencies of the government, negligence of authority, corruption of the concerned development organizations, and abuse of laws by the influential elites. The responsible departments/organizations, which are mainly involved in land management, are RAJUK, DWASA, DCC, BIWTA, BWDB, DoE and Deputy Commissioner Office Dhaka. These organizations have poor technical manpower and logistic support. Overlapping of functions among the agencies creates conflicts in management and controls. Coordination among the public agencies and their management system are ineffective because most agencies implement their programs in their own way. It is evident from the analysis of court cases that the concerned government authorities are not serious to protect the wetland. The higher court directed several times to the concern government organization to protect the wetlands in and around Dhaka city. But the government authorities did not execute these directions. At the same time dishonest practices of real estate housing companies and other involved participants in wetland loss, with connivance of a section of government officials should be stopped immediately for the protection of remaining wetlands of Dhaka city.

As a result combined effort is necessary from the part of involved stakeholders, like local people, NGOs, local government body, central government and civic organization to implement the conservation strategies of forestation (25% in the total area) and wetlands. Political will and government commitment is also needed for this purpose. If government has

the inclination to preserve the forest and wetlands; and if general people are also made conscious regarding the importance of forest and wetlands, the present trend of land conversion, filling and encroachment will be stopped and it would be possible to protect the remaining environmental degradation of Dhaka city.

Despite the limitation, this study will help the decision makers as well as urban planners, researchers and other relevant organizations to formulate better planning and monitoring the measures related to land management and protection of environmental degradation of Dhaka city.

8.3.1 Future Research

The present study focuses on nature of land use change, associated causes and its impact, mainly the air and water pollution, traffic congestion and water logging problem in Dhaka. Changes of land use in this research also have been viewed from prevailing policy planning perspective and institutional set up. All environmental problem of Dhaka city related to land use changes is not taken into consideration in this research. This research indicates that a significant amount of vegetation and wetland is still available in and around Dhaka city. Finding of this study can be used as a baseline work. Keeping this in mind some areas of further studies are suggested in the following heads:

- Study on change of land use and its impact on land degradation of surrounding areas.
- Study on loss of vegetation and its impact on biodiversity of surrounding areas.
- Study on assessing the function of wetlands to make economic valuation of wetlands.

Future research can be designed to evaluate the feasibility of the suggestions/strategies of this study to protect the remaining environmental degradation of Dhaka city.

References

References

Agarwal, C., Green, G. M., Grove, J. M., Evans, T. P. and Schweik, C. M. 2002. *A Review and Assessment of Land-Use Change Models: Dynamics of Space, Time, and Human Choice,* General Technical Report NE-297, Newtown Square, Pennsylvania: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 61 pp. Available at: http://nrs.fs.fed.us/pubs/gtr/gtr_ne297.pdf

Ahmad, N. and Khan, F. K. 1961. *Land use in Rampal Union: A Horticultural Area*, East Pakistan Geographical Society. Department of geography, University of Dhaka, East Pakistan, Monograph No. **1:**1-42.

Ahmad, N. and Khan, F. K. 1963. *Land use in Fayadabad Area,* East Pakistan Geographical Society, Department of geography, University of Dhaka, East Pakistan, Monograph No. **2:**1-54.

Ahmad, N. 1963. The Landscape of Dhaka Urban Area. *The Oriental Geographer*, **VII (1):**3-18.

Ahmed, S. U. 1991. *Dhaka Past Present Future*. Asiatic Society of Bangladesh, Dhaka.

Air Quality Management Project, 2004. Average suspended particulate matter concentration at Continuous Air Monitoring Station (CAMS), Sangsad Bhaban. Department of Environment (DoE), Dhaka. 33pp.

Akash, M. M., Singha, D. 2003. *"Provision of water points in low income communities in Dhaka, Bangladesh"*, paper prepared for the civil society consultation on the Commonwealth Finance Ministers meeting, Bander Seri Begawan, 2003.

Alam, N. 1989. *Population Growth and Land Use Changes in Peri-urban areas: a Case Study of Uttara East.* M. Sc Thesis, University of Jahangirnagar, Dhaka. 165p.

Alam, M. M., and Rashid, M. A. 1996. *Urban geology and environmental aspects of Dhaka City, Bangladesh,* Atlas of urban geology, **9**:1-12.

Ali, A. M. S. 1984. Urban expansion and agricultural change. *The Oriental Geographer,* **28**(1): 1-14.

Al-Mamun, H. 2006. *Water Utility Services in Dhaka City: Present and Future.* Paper presented workshop on Partnership for Improving the Performance of Water Utilities in the Asia and Pacific Region. 25-27 July 2006, Bangkok, Thailand.

Anderson, J. R., Hardy, E. E., Roach, J. T. and Witmer, R. E. 1976. "*A Land Use and Land Cover Classification System for Use with Remote Sensor Data*," U.S. Geological Survey, Professional Paper 964, p 28, Reston, VA.

Available at: http://www.fws.gov/wetlands/_documents/gSandT/OtherInformation/LandUseLandCoverClassificationSystem.pdf

Anwar, Sk. M. 2002. *Land use Change Dynamic: A Dynamic Spatial Simulation*. M. Sc Thesis, Asian Institute of Technology School of Advance Technologies, Thailand. Available at: http://cormas.cirad.fr/pdf/Thesis_Morshed.pdf

Asaduzzaman, A. T. M., Nahid, N. and Olsen, H.W. 1992. *Engineering Geology of Dhaka City Bangladesh*. Geological Survey of Bangladesh and U.S Geological Survey.

Asaduzzaman, M. 1997. *Geomorphological Control over Urbanization: A Case Study of Dhaka City*. M. Sc Thesis, Department of Geography and Environment, University of Dhaka, Bangladesh.

Atiqullah, M. and Khan, F. K. 1965. *Growth of Dacca City: Population Area: 1608 – 1981*. Social Science Research Project, University of Dhaka, Bangladesh.

Balzter, H. 2000. Markov chain models for vegetation dynamics. *Ecological Modeling*, **126:**139-154.

Available at: https://lra.le.ac.uk/bitstream/2381/4683/1/ecomod409revised.pdf

Banglapedia, 2004. Asiatic Society of Bangladesh, Dhaka.

BARC, 1999. *Land degradation situation in Bangladesh*, Bangladesh Agricultural Research Council, Soil Davison, Dhaka.

Bari, F. M., and Hasan, M. 2001. *Effect of Urbanization on Storm Runoff Characteristics of Dhaka City*. Tsinghua University Press. XXIX IAHR Congress. Beijing.

Basher, M. A. 2001. Management of homestead: Plantation and Agro-forestry. Bangladesh Observer. June 24 issue. Dhaka.

BBS, 1989. *Statistical Yearbook of Bangladesh,* Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

BBS, 1997. *National Accounts Statistics of Bangladesh (Revised Estimates, 1989-90 to 1994-95),* Bangladesh Bureau of Statistic, Ministry of Planning, Dhaka, Bangladesh.

BBS, 1999. *Statistical Yearbook of Bangladesh,* Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

BBS, 2001. *Bangladesh Population Census 2001*, Preliminary Report. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

BBS, 2007a. *Statistical Pocketbook Bangladesh*. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

BBS, 2007b. *Bangladesh Population Census 2001*, Community Series, Zila: Dhaka. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

BCAS, 1999. Guide to the Environmental Conservation Act 1995 and Environmental Conservational Rules 1997 of the Government of Bangladesh. Bangladesh Centre for Advanced Studies, Dhaka.

Bechtel, R. B. 1976. "The Perception of Environmental quality: Some New Wineskins for Old Wing", in Kenneth, H. Creaik and Ervin, H. Zube (eds) *Perceiving Environmental Quality: Research and Applications,* New York and London: Plenum Press.

Available at:
http://www.housingeducators.org/Journals/H&S_Vol_20_No_2_Satisfaction_of_Elderly_Residents_in_Subsidized_Housing_The_Effect_of_the_Managers_Leadership_Style.pdf

BELA, 1995. *Paribes: Rajnaitik Daler Bhumika* (Environment: Role of Political parties). Bangladesh Environmental Lawyers Association, Dhaka.

Bell, E. J. 1974. Markov Analysis of Land Use Change-An Application of Stochastic Processes to Remotely Sensed Data. *Socio Economic Planning Sciences,* **8**:311-316. Available at: http://uwf.edu/zhu/evr6930/28.pdf

Best, R. H. 1981. *Land Use and Living Space*. Methuen, London.

Bhuiyan, M. A. H., Huq, N. E. and Hossain, M. M. 2002. Unplanned Waste Disposal and Its Possible Impact on Subsurface Environment of Dhaka City, Bangladesh. In: *Bangladesh Environment 2002.* Bangladesh Poribesh Andolon, Dhaka.

Briassoulis, E. 2000. Analysis of Land Use Change: Theoretical and Modeling Approaches. In *The Web Book of the Regional Science.* S. Loveridge (ed.). West Virginia University, Regional Research Institute, Morgantown, WV.

Available at: http://www.rri.wvu.edu/WebBook/Briassoulis/contents.htm

Brown, L. A. 1970. On the Use of Markov Chains in Movement Research. *Economic Geography,* **46**, 393-403.

Available at: http://nexus.umn.edu/Papers/PavingNewGround.pdf

Chowdhury, M. H and Ahmed, R. 1998. Multi-temporal Analysis of Land-use Change Using Different Satellite Platforms and GIS Integration: A Case Study in Bangladesh. *The Journal of Bangladesh National Geographical Association*, **20**(1&2):19-40.

Choudhury, N. Y. 2001. Impact of Land Use Change and Urbanization on Geomorphologic Environment: A Case Study of Eastern Part of Dhaka Metropolitan Area. *Oriental Geographer*, **45**(2), 29-40.

Chowdhury, Q. S. 2001. *Bangladesh State of Biodiversity*. Forum of Environmental Journalists of Bangladesh (FEJB).

Chowdhury, J. A. 2007. *Essays on Environment*. Botomul, Dhaka.

CUS, 1990. *The Urban Poor in Bangladesh* Centre for Urban Studies, Dhaka.

Dani, A. H. 1962. *Dacca: A Record of Its Changing Fortunes*. Ahmed Hasan Dani, Dhaka.

Das, A. C. 1992. Urban Vacant Land: Public and Private Issues and prospects for Development. In: *Urban Land Management in Bangladesh*. Ministry of Land, Government of the People's Republic of Bangladesh, Dhaka.

DCC, 2002. *Report on Solid Waste Disposal and Treatment Sites*. Dhaka City Corporation, Dhaka.

DCC, 2004a. Available Logistics for Waste Management. Conservancy Department, Dhaka City Corporation, Dhaka.

Available at: www. Dhakacity.org/html/logis_waste.hrml

DCC, 2004b. *Profile of Dhaka City Corporation*. Urban Planning Department, Dhaka City Corporation, Dhaka.

Deakin, E. 1995. Land Use Model Conference Keynote Address. In *Travel Model Improvement Program Land Use Modeling Conference Proceedings*. Travel Model Improvement Program. February 19-21, 1995, DOT-T-96-09. U.S. Department of Transportation, U.S. Environmental Protection Agency, and U.S. Department of Energy. Available at: http://tmip.fhwa.dot.gov/resources/clearinghouse/docs/tmip/newsletter/nov95_issue4/

Dewan, A. M and Yamaguchi, Y. 2008. Effect of land covers changes on flooding: example from Greater Dhaka of Bangladesh. *International Journal of Geo-informatics*, **4(1),** 11–20.

Dewan, A. M and Yamaguchi, Y. 2009. Land use and land cover change in Greater Dhaka, Bangladesh: Using remote sensing to promote sustainable urbanization. *Applied Geography*, **XXX:** 1-12.

Dimyati, M., Mizuno, K., Kobayashi, S., and Kitamura, T. 1995. An Analysis of Land Use/Land Cover Change Using the Combination of MSS Landsat and Land Use Map-A case study of Yogyakarta, Indonesia, *International Journal of Remote Sensing*, **17**(5): 931 – 944.

Available at: http://www.informaworld.com/smpp/content~db=all~content=a777908829

DIT, 1959. *Master Plans for Dhaka City*. Dacca Improvement Trust (now RAJUK), Dhaka.

DMAIUDP, 1981. *Dhaka Metropolitan Area Integrated Urban Development Project.* Government of Bangladesh, Asian Development Bank and United Nations Development Program.

DoE, 2009. *Annual Report on Environment for Sustainable Development, 2006*. Ministry of Environment and Forest, Dhaka, Bangladesh.

DoE, BCAS and UNEP, 2006. *Dhaka City State of Environment 2005*. United Nations Environment Program.

Douglas, I. 1994. Human Settlements. In *Change in Land Use and Cover: A Gobal Perspective*, eds. W. B. Meyer and B. L. Turner II, Cambridge: Cambridge University Press, Pp.149-170.

DWASA, 1991. *Dhaka Region Ground Water and Subsidence Study*, Main Report, Dhaka Water and Sewerage Authority, Dhaka.

DWASA, 1992. *Dhaka City Emergency Water Supply Project*, Feasibility Study, Main Report. BCEOM French Engineering Consultants.

DWASA, 2003. Management Information Report for the Month of October 2003, Dhaka.

DWASA, 2005. *Strategies for Drainage Development: A Perspective of Dhaka City*, Drainage Circle Division, Dhaka Water and Sewerage Authority, Dhaka.

Elahi, K. M. and Hassan, M. M. 1989. Population Change and Suburban Development: A Case Study of Savar, *Oriental Geographer*, **XXXIII,** 53-65.

Elahi, K. M. and Hasan, M. M. 1991. Pattern of Fringe Development of the Dhaka Metropolitan Area (DMA). *The Journal of the Bangladesh National Geographical Association,* **19**(1 & 2): 7-19.

Elahi, K. T. 2005. Understanding the Sustainability of Dhaka City: Some Preliminary Observations. *Journal of the Bangladesh National Geographical Association*, **33**(1&2): 15-24.

FAO, UNDP and UNEP, 1994. *Land Degradation in South Asia: Its severity causes and effects upon the people,* FAO World Soil Resources export No. 78.

FAO, 2001. *FAO Yearbook -Production 1999*, Vol.53, Food and Agriculture Organization of the United Nations, Rome.

Farooque, M. and Hasan, S. R. 1996. *Laws Regulating Environment in Bangladesh.* Bangladesh Environmental Lawyers Association (BELA).

Fernandez, R., Martin, A., Ortega, F. and Ales, E. 1992. Recent changes in landscape structure and function in Mediterranean region of SW Spain (1950-1984). *Landscape Ecology,* **7**(1): 3-18.

Gain, P. 2002. *Bangladesh Environment: Facing the 21st century*. Society for Environment and Human Development (SHED), Dhaka. 341p

Geoghegan, J., Klepeis, S. C. P., Mendoza, P. M., Yelena, O. R., Chowdhury, R., Turner II, B. L. and Vance, C. 2001. Modeling tropical deforestation in the southern Yucatan peninsular region: comparing survey and satellite data. *Agriculture, Ecosystems and Environment,* **85**: 25-46.

Available at: http://earth.clarku.edu/lcluc/pubs/Modeling/II-2_Geoghegan_et_al_2001.pdf

GOB, 1985. *The Third Five Year Plan*, Planning Commission, Government of Bangladesh, 1985.

GOB, 1986. *Census of Agriculture*, Ministry of Agriculture, Government of Bangladesh.

GOB, 1999. *Census of Agriculture*, Ministry of Agriculture, Government of Bangladesh.

Google Earth, 2008. *Google Earth Image*. (www. earth. google.com, accessed on 25. 02. 2008).

Grubbler, A. 1990. Technology. In *the Earth as Transformed by Human Action*, eds B.L. Tuner, II, W.C. Clark, R. W. Kates, J.E. Richards, J.T. Mathews, and W.B. Meyer, Cambridge: Cambridge University Press, Pp. 287-328.

Available at: http://www.ltu.se/cms_fs/1.5035!/deforestation%20-%20final.pdf

Hasan, M. M. 1991. *Population change and Suburban Expansion: A Case Study of Savar*. M. Sc Thesis, Jahangirnagar University, Dhaka.

Hasan, S., and Mulamoottil, G. 1994. *Environmental problems of Dhaka City*. Cities, **11**(3): 195–200.

Heilig, G. K. 1996. *Anthropogenic Driving Forces of Land Use China*. WP-96-011. Laxenburg: International Institute for Applied Systems Analysis.

Hoque, M. A. 2004. *Hydrostragraphy and Aquifer Piezometry of Dhaka City*. Unpublished P.G.Dip. Project Report. Institute of Water and Flood Management, BUET, Dhaka.

Hossain, M. 1992. "Population and Environmental Interrelationship", *Training Manual on Environmental Management in Bangladesh,* 8 (4): 412-429.

Houghton, R. A. 1994. The Worldwide Extent of Land-use Change. *BioScience*. **44**:305–312.

http://leml.asu.edu/jingle/web_pages/wu_pubs/pdf_files/wu_chapter_2003.pdf

Huda, K. M. N. 2002. Municipal Solid Waste Management-Dhaka City Perspective. In: *Bangladesh Environment 2002*. Bangladesh Poribesh Andolon, Pp 732 - 746.

Huq, M. E. 2002. *Paribes Ain Sangkalan*. BEMP, DoE and MoEF, Government of the People's Republic of Bangladesh, Dhaka.

Huq, N. E. 2002. *Optimum Land Use in the Lowlying Areas Around Dhaka City: A Geological Perspective*. In: *Bangladesh Environment 2002*. Bangladesh Poribesh Andolon, Pp. 465-475.

Hussain, M. S. Elahi, S. F., Eswaran, H., Islam, S. and Uddin, M. J., 2002. *Challenges of Sustainable Land Management in Bangladesh*. Land Quality Assessment Project. Department of Soil, Water and Environment. University of Dhaka, Bangladesh.

IDRISI, 2006. Idrisi Andes Guide to GIS and Image Processing. Clark labs, Clark University, USA.

Available at: http://www.cartografia.cl/download/manuales/idrisi_andes.pdf

Inca, C. A. G. 2009. *Assessing the Land Cover and Land Use Change and Its Impact on Watershed Services in a Tropical Andean Watershed of Peru.* Unpublished M.Sc Thesis, Department of Biological and Environmental Science, University of Jyväskylä, Peru. Available at:

https://jyx.jyu.fi/dspace/bitstream/handle/123456789/21792/URN_NBN_fi_jyu-200909223930.pdf?sequence=1

Iqbal, M. 1992. Residential Land Price Inflation in the Dhaka Metropolitan Area: 1976-88. *Oriental Geographer*, **36**(1): 53-66.

Islam, M. A., and Ahsan, R. M. 1986. Land Use Study in Bangladesh, *Oriental Geographer*, **XXIX-XXX,** 173-181.

Islam, N. and Chowdhury, A. I. 1992. *Urban Land Management in Bangladesh*, Ministry of Land, Government of the People's Republic of Bangladesh, 183p.

Islam, N. 1996. *Dhaka From City to Megacity Perspective on People, Places, Planning and Development Issues.* Urban Studies Programme, Department of Geography, University of Dhaka.

Islam, N and Ahsan, R. M. 1996. *Urban Bangladesh*, Geographical Studies, Urban Studies Programme, Department of Geography, University of Dhaka. Pp.21-31.

Islam, N. 1998. *Recent Urban Studies, Bangladesh.* Department of Geography, University of Dhaka.

Islam, M. S. and Hoque, A. 1999. Application of Remote Sensing Technique to Study the Landuse Changes of Maheshkhali Island in Bangldesh, *Journal of Remote Sensing and Environment,* Bangladesh, Space Research and Remote Sensing Organization (SPARRSO), **3**:69-85.

Islam, I. 2000. Urban Land Use Policy in Bangladesh: Toward A Sustainable Future. In: *Bangladesh Environment 2000.* Bangladesh Poribesh Andolon, Pp. 338-351.

Islam, M. S. 2001. Landuse change and Environmental Degradation of the Chakoria Sundarban in Bangladesh, *Journal of the Bangladesh National Geographical Association,* **29**(1& 2):16-29.

Islam, N., 2005. *Dhaka Now Contemporary Urban Development*. Bangladesh Geographical Society (BGS), Dhaka.

Islam, M. S., Ahmed, R., M. R., Shahabuddin, and Sheikh, A. H. 2009. Pattern of Land use Change and its Dynamics of Urban Expansion in Dhaka City, *Journal of Geo-Environment*, University of Rajshahi, **9**:107-120.

Islam, M. S., Rahman, M. R., Shahabuddin, A. K. M and Ahmed, R. 2010. Changes in Wetlands in Dhaka City: Trends and Physio- environmental Consequences, *Journal of Life and Earth Science*, University of Rajshahi, **5**:37-42.

IUCN Bangladesh, 1980. World Conservation Strategy: Living Resource Conservation for Sustainable Development.

IWM, 2006. *Study on Drainage Master Plan for Dhaka City and DND Area*. Institute of Water Modeling (IWM) and Dhaka Water and Sewerage Authority, Dhaka.

JICA, 1987. *Study on Storm Water Drainage System Improvement Project in Dhaka City.* Local Government Division, Dhaka.

JICA, 1991. *Master Plan on Greater Dhaka Flood Protection Project*. Flood Action Plan No. 8A, Supporting Report-I and II, Flood Plan Coordination Organization (presently WARPO), Dhaka.

JICA, 1992. *Feasibility Study on Greater Dhaka Flood Protection Project*, FAP 8A, Interim and Main Reports, Flood Plan Coordination Organization (presently WARPO), Dhaka.

Kabir, M. H. 2003. Environmental Degradation of Dhaka City and its adjacent areas due to the Brick Kilns. *Oriental Geographer*, **47**(10):43-52.

Karim, M. A. 2000. *Shrimp Culture and Changing Land Use Pattern in Rampal Thana, Bagerhat Zila: A Spatial Analysis*, Ph D Thesis, Department of Geography and Environmwnt Studies, Rajshahi University, 294p.

Khaliquzzaman, M. 2005. *Vehicle emission inventory for Dhaka- year 2000*. In DTCB, 2002 Motor vehicles in Bangladesh.

Khan, F. K. and Islam, N. 1964. High Class Residential Areas in Dhaka City. *The Oriental Geographer*, **VIII** (1): 1- 41.

Khan, N. I. 1997. *Urban Storm Runoff Assessment Using A Combined Geomorphological and Hydrological Approach: A Case Study on Greater Dhaka City.* An unpublished M. Sc Thesis, ITC, Enschede, The Netherlands.

Khan, N. I. 2001. Assessment of Water logging Conditions Using Integrated GIS and Remote Sensing Techniques: A Study of Dhaka Mega City. *Oriental Geographer*, **45**(2): 41-54.

Khan, A. K. 2004. *An Introduction to Environmental Law: Principle and Practice*. Isamoti Prokashoni, Dhaka.

Khuda, Z. R. M. M. 2001. *Environmental Degradation Challenges of the 21st Century*. Environmental Survey and Research Unit, Dhaka, Bangladesh.

Kleckner, R. L. 1981. "A National Program for Land Use and Land Cover Mapping and Data Compilation." In *Planning Future Land Uses*, eds. G. Peterson and M. Beatty, 7-14. ASA Special Publication No. 42.

Kruger, 1996. *Urban environmental Management in Thailand: A strategic Planning Process*. National Economic and Social Development Board, Thailand.

Lambin, E. F., Turner, B.L., Geist, H., Agbola, S and Angelsen, A. 2001. The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change,* **11**(4): 261-69.

Lambin, E. F., Geist, H. J. and Lepers, E. 2003. *Dynamics of Land-use and Land-cover Change in Tropical Regions*, Annual Review of Environment Resource, 2003. **28**:205–41. http://www.rainforestcoalition.org/documents/Synthesisofinformationonrapidlandcoverchange19812000.pdf

Leitman, J., Bartone, C. and Bernstein, J. 1992. Environmental Management and Urban Development: Issues and Options for Third World Cities. *Environment and Urbanization,* **4**(2): 131-140.

Lillesand T. M. and Kiefer. R.W (ed.) 2000. *Remote Sensing and Image interpretation* John Willy & Song, New York, 724p.

Logsdon, G.M., Bell, E.J., and Westerlund, F. V. 1996. "Probability Mapping of Land use Change: A GIS Interface for Visualizing Transition Probabilities." *Computers, Environment and Urban Systems,* **20**(6): 389-398.

LUCC, 1990. *Land Use and Land Cover: Implementation Strategy*. IGBP Report 48, IHDP Report 10, Stockholm: IGBP Secretarial.

Mack, S. R and Jacobson, S. D. 1996. Core periphery analysis of the European Union: a location quotient approach, Regional analysis & Police, **26**(1): 3-21.

Mafizuddin, M. and Hossain, M. S. 1990. Spatio-temporal Variation of Ground Water Level in Dhaka City. *Oriental Geographer*, **34**(1& 2): 3-14.

Mannan, M. A. 1990. *An integrated approach towards land evaluation using remote sensing: A case study of the urbanizing area north-west of Dhaka City,* M. Sc. Thesis (Unpublished), Department of Geography and environment, Jahangirnagar University, Savar, Dhaka.

Marsh, W. M. 1978. *Environmental analysis for land use and site planning,* McGraw Hill Book Company, Pp 69-109.

Meyer, W. B., and Turner, B. L. 1994. *Changes in Land Use and Land Cover:* A Global Perspective. Cambridge University Press, Cambridge England; New York, NY, USA.

Meyer, W.B. 1995. *Past and Present Land-use and Land-cover in the U.S.A. Consequences*, Pp. 24-33.

Medley, K., Okey, B., Barrett, G., Lucas, M and Renwick, W. 1995. Landscape change with agricultural intensification in a rural watershed, southwestern Ohio, USA. *Landscape Ecology*, **10**(3): 161-176.

MoL, 1982. *Report on the Study of Land Ownership Pattern in Selected Urban Areas of Bangladesh1981.* Ministry of Land, Government of the People's Republic of Bangladesh, Dhaka.

MoEF, 1992. *Bangladesh Country Report for United Nations Conference on Environment and Development (UNCED).* Ministry of Environment and Forest, Government of the People's Republic of Bangladesh, Dhaka.

Mouat, D. A., Glenda. G. M., and Lancaster, J. 1993. Remote sensing techniques in the analysis of change deletion. *Geocarto International*, **8**(2):39-50.

Muller, M. R. and Middleton, J. 1994. "A Markov Model of Land Use Change Dynamics in the Niagara Region, Ontario, Canada." *Landscape Ecology,* **9**:151-157.

Nakashima, S. and Khan, M. H. 1994. *A Basic Guide to Understanding the Environmental Impacts of Rural Roads on the wetlands of Bangladesh.* Care International in Bangladesh.

Nishat, A., Reazuddin, M., Amin, R. and Khan, A. R. 2000. *The 1998 Flood: Impact on Environment of Dhaka City.* Department of Environment and IUCN Bangladesh, Dhaka, Bangladesh.

Rahman, M. A. 1996. "*Residents Perception of Urban Environmental quality: A Case Study of Narayanganj*", An Unpublished M. Sc. Thesis, Department of Geography, University of Dhaka, Dhaka.

Rashid, M. S. 2003. *A Study of Land Transformation of Savar Upazila, Bangladesh, 1951-2001: An integrated GIS Approach using Remote Sensing,* Census, Map and Field Data. A Ph.D. thesis submitted to the Department of Geography, Durham University, England.

Rahman, A., Ali, M. A. and Chowdhury, F. (eds.) 2001a. *Peoples Report on Bangladesh Environment 2001*. Vol. 1. Main Report. The University Press Limited, Dhaka.

Rahman, M. M., Dewan, A. M. and Islam, M. S. 2001b. Degradation of Urban Environment: A Case Study of Cittizens Perceptions in Chattagong City. *Oriental Geographer*, **45**(1):35-52.

Rahman. A. K. M. and Bashar, K. 2001c. Geo-environmental assessment for Landuse Planning of Savar upazila, Dhaka. *Journal of Science*, Jahangirnagar University, Savar, Dhaka, **24**.

Rahman, M. R. and Saha, S. K. 2009. Spatial Dynamics of Cropland and Cropping Pattern Change Analysis Using Landsat TM and IRS P6 LISS III Satellite Images with GIS. *Geo-spatial Information Science*, **12**(2):123-134.

Rahman, R. 2003. *Dhaka City-An Environmental Report.* [WWW document] URL http://www.banglarights.net/HTML/Environment.htm.

RAJUK, 1997. *Dhaka Metropolitan Development Plan (1995-2015)*, volume-I&II, Dhaka Structure Plan, Rajdhani Unnayan Kartripakha, Dhaka.

Rashid, M. S., Alam, M. S and Sultana, S. 2003. Environmental Changes at Plot Scale of Savar Upazila, 1951-2001. *The Journal of Geo-Environment*, **3**:12-25.

Rashid, H. 1991, *Geography of Bangladesh,* 2nd edition, University Press Ltd., Dhaka, 346p.

Razzaque, J. 2000. Access to environmental Justice: Role of Judiciary in Bangladesh. In *Bangladesh Environment 2000*. Bangladesh Poribesh Andolon, Pp. 693-709.

Reza. G. A. N. M and Alam, M. S. 2002. Transformation of the Western Part of the Dhaka City Wetlands, *Bhugal Patrika,* **21**: 23-40.

Rizvi, N., and Rizvi, A. I. H. 1959. Barami: A Land use Study of Sripur Terrace, *The Oriental Geographer*, **V (1):**33-46.

Roy, S. 2007. *A Study on Private Residential Land Development Activities in Dhaka and Their Compatibility with DMDP Structure Plan 1995-2015*. Unpublished MURP Thesis. Department of Urban and Regional Planning, BUET, Dhaka.

Saleheen, M. 2010. The Plights of Mega City Dhaka. *Presentation on 13th Bangladesh International Geographical Conference*, Department of Geography & Environment. Jahangirnagar University, Savar, Dhaka-1342, Bangladesh.

Sangawongse, S. 1995. Land use/land cover change detection in the Chiang Mai area using Landsat TM. *Proceeding of the 16th Asian Conference on remote Sensing*: 20-24 November 1995, Nakhon Ratchasima, Thailand.

Seraj, T. M. and Sadeque, C. M. Z. 2005. An Evaluation of Urban Governance of Dhaka City and Its Effects on the Growth of Private Real Estate Sector. *Environment and Urbanization,* Pp.42-57.

Shuq, S. and Alam, M. 2003. *Flood Management and Vulnerability of Dhaka City,* Bangladesh Center of Advance Studies (BCAS), Dhaka.

Shahabuddin, A. K. M. 2010. *Changing Pattern of Wetlands and its Impact on Environment of Dhaka City,* Ph. D Thesis, Institute of Environmental Science, University of Rajshshi, Rajshahi. 296p.

Shaik, M. R. S. 2006. *Socio-Economic and Environmental Impacts of Urbanization in Bogra Municipal Area of Bangladesh*. M. Phil Thesis, Institute of Environmental Science, University of Rajshahi, Rajshahi, 143 pp.

Shamsuzzoha, M. 2002. *Dhaka City's Waste and Waste Management Scenario*. In Ahmed, A. F., Tanveer, S. A., Badruzzaman, A. B. M. (edts.) Bangladesh Poribesh Andolon, Dhaka.

Siddiqui, K. 1997. *Land Management in South Asia A Comparative Study*. The University Press Limited, Dhaka.

Siddiqui, K., Ghosh, A., Bhowmik, K.S., Siddique, S.A., Mitra M., Kapuria, S.Ranjan, N., Ahmed, J. 2004. *Mega city governing in South Asia: A comparative study*. The University Press Limited, Dhaka.

Singh, A. 1989. Digital Change Detection technique using remotely sensed data. *International Journal of Remote Sensing*, **10:** 989-1003

Singh, R. and Mangat, N. S. 1996. *Elements of Survey Sampling*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

SGTZ and DOLA, 1990. *Manual for Urban environmental Management*. Urban environmental Management project, Center for Urban Development, Bangkok.

Soepboer, W., Veldkamp, A. and Limpiada, R. 2002. Modeling the Spatial Dynamics of Regional Land Use: The CLUE-S Model, *Environmental Management,* 30 (3): 391–405.

Stamp, L. D. 1948. *The Land of Britain its Use and Misuse*. Longmans, Green & Co., London.

Sultana, S. 1989. Land use and Human Settlements in Bangladesh: Some Planning Issues. *Journal of the Bangladesh National Geographical Association,* **17**(1&2).

Sultana, S. and Huq, N. A. 2001. Water Pollution in the Lakes of Dhaka City. *Oriental Geographer*, **45**(1): 53-61.

Tawhid, K. G. 2004. *Causes and Effects of Water Logging in Dhaka City*, Bangladesh. M. Sc Thesis, Department of Land and Water Resource Engineering, Royal Institute of Technology, Stockholm

The Daily Star, April 12, 2010

The Daily Star, May 12, 2010

The Daily Star, June 7, 2010

The Daily Star, June 22, 2007

The Daily Star, June 25, 2010

The Daily Star, July 03, 2010

The Daily Star, July 30, 2010

The Prothom-alo, June 1, 2010

The Environment Encyclopedia and Directory 2001, (3rd edition). Europa Publications Limited, London, Pp. 146-149.

The Ramsar Convention, 1995. *National Policy for the Conservation and Management of Wetland Resources*. Ministry of Natural Resources, The Republic of Uganda. (http://www.ramsar.org/wurc/wurc_policy_uganda.htm. April, 2009).

Turner, M. G. 1987. Spatial simulation of landscape changes in Georgia: A comparison of 3 transition models *Landscape Ecology,* **1:** 29-36.

Turner, B. L. II and B. L. Meyer. 1994. "Global Land Use and Land Cover Change: An Overview." In *Changes in Land Use and Land Cover: A Global Perspective*, eds. W.B. Meyer and B.L. Turner II, 3-10. Cambridge: Cambridge University Press.

Turner, II B. L, Skole, D and Sanderson, S. 1995. *Land-use and Land-cover Change Science/Research Plan.* [IGBP Report no 35 and HDP report no 7], Stockholm and Geneva: IGBP and HDP, 132 pp.

Uddin, M. N. 2004. *Air Pollution Control in Urban Areas of Bangladesh: Quest for Sustainable Improvement of Air Quality of Dhaka City*. Ph. D Thesis, Institute of Bangladesh Studies, Rajshahi University, Rajshahi.

Ulfarsson, G. F. 2003. Urban sprawl and the cost of public services. *Environment and Planning* B, **30**(4):503–522.

UNEP, 1999. *Global Environment Outlook 2000*. New York: United Nations Environment Programme, Oxford University Press, 398 p.

UNEP, 2001. *Bangladesh State of the Environment, 2001.* United National Environmental Programme. Regional Centre for Asia and the Pacific: Thailand. Urban land management in Bangladesh. Dhaka: Ministry of Land.

U.S. EPA, 2000. *Projecting Land-Use Change: A Summary of Models for Assessing the Effects of Community Growth and Change on Land-Use Patterns.* EPA/600/R-00/098. U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio. 264pp.

http://www.epa.gov/reva/docs/ProjectingLandUseChange.pdf

Verburg, P. H., Veldkamp, A., Fresco, L. O. And Bouma, J. 1997. "*Quantifying the Spatial Structure of Land Use Change: An Integrated Approach*", Conference on Geo-Information for Sustainable Land Management, Wageningen University, The Netherlands.

Verburg, P. H., Chen, Y., Soepboer, W and Veldkamp, A. 2000. GIS-based modeling of human-environment interactions for natural resource management. Applications in Asia. *In Proceedings of the 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4): Problems, Prospects and Research Needs,* Canada 2000, Pp1-13.

http://gissrv.iend.wau.nl/~clue/banf/banf71/banf71.html

Verburga, P. H., Schota, P., Dijsta, M. and Veldkamp. A. 2004. Land use change modelling: current practice and research priorities, *GeoJournal,* **3:**359-383.

e-mail: peter.verburg@wur.nl

WCED, 1987. Our Common Future, Oxford University Press. Oxford. WEB Address, http://www.thedailystar.net

Weng, Q. 2002. Land use change analysis in the Zhujiang Delta of China using satellite remote sensing, GIS and stochastic modelling. *Journal of Environmental Management*, **64:**273-284.

WHO, 2002. *Indoor Air Pollution Status in Bangladesh*. Environmental Health unit, Dhaka.

Williams, M. 1990. "Forest." In *The Earth as Transformaed by Human Action*, eds. B.L. Turner, II. W.C.Clark, R.W. Kates, J.E. Richards, J. T. Mathews, and W. B. Meyer, 179-201. Cambridge; Cambridge University Press.

World Bank, 1994. *Managing Urban Environment Quality in Asia*. World Bank Technical Paper NO. 220. Washinton, D.C.

World Bank, 1999. *World Development Indicators: 1999*, The World Bank, USA.

World Bank, 2007. *Dhaka Metropolitan Development Plan Strategic Environmental Assessment.* Prepared by SENES Consultants Limited in Association with Techno Consult International Ltd. Dhaka, Bangladesh.

Yamane, T. 1970. *Statistics: An Introductory Analysis*. Harper and Row, New York.

Yeh, S. H. and Tan, S. L. 1975. "Satisfaction of Living Condition" in Yen, S. H. (ed), *Publi housing in Singapore, Singapore: Singapore University Press.*

Zubair, A. O. 2006. *Change Detection in Land use and Land cover using Remote Sensing data and GIS: A case study of Ilorion and its environs in Kwara state*. M. Sc Thesis, Department of Geography. University of Ibadan, Ibadan.

Available at: http://www. OpeyemiZubair_ThesisDoc.doc

Appendice

Appendices

Appendix-A

Questionnaire for Field Survey

Research title: Land use Change and Environmental Degradation in Dhaka city

(Only for Research Purpose)

Researcher: Md. Shahidul Islam
Ph.D Fellow
IES, University of Rajshahi.

Date: ----------

A. 1. Personal Information of the Respondent

SL. No.	Questions	Categories	Answers
1.1	Name		
1.2	Age	Complete Years----------	
1.3	Address	Household No---------- Ward/Village---------- Road No---------Upazila/ Thana----	
1.4	Gender	Male ☐ Female ☐	
1.5	Education		
1.6	Occupation		
1.7	How long years are you living in this area?	Complete Years----------	
1.8	Are you migrants here? If yes, causes of migration? Please describe----------		
1.9	Why did your family come to Dhaka?		
1.10	Have you any own land? If Yes, what is the amount of land and how you use this land?	Homestead----------Decimal/Katha Cultivable land---------- Vegetation ---------- Water bodies/lowland--------- Lowlands---------- Others (Specify)----------	

A. 2. Socio-economic Information of the Household Members

1.11 How many members in your family? Total Persons--------Male------Female--------

Sl No	Relationship of H.H*	Age	Gender	Marital status	Education	Occupation			
						Main	Income	Secondary	Income

Note: H.H*=Head of household, 1. Son/Daughter 2. Brother/Sister 3. Cousin 4. Grandfather/ Grand mother 5. Nephew/nice 6. Husband/wife7. Father/Mother 9.Others.
Income level: 1). Below,5000 2).5000-10000 3).10001-20000 4).20001-30000 5).Above,30000

1.12	Monthly Expenditure of your Household :---------- Taka		
1.13	Sources of House hold Monthly income (Taka).	Wages & Salary---------- Agriculture ---------- Personal service---------- Rent---------- Business---------- Mortgage---------- Others----------	Total ☐
1.14	Monthly Savings Amount----------Taka.		

B. Causes of Environmental degradation

SL. No	Questions	Categories	Answers
2.1	What are the main causes of environmental degradation?	Social causes----------1 Economic causes----------2 Institutional cause----------3 All----------4 Others (specify)----------	☐
2.2	What types of Social causes?	Over population----------1 Unplanned urbanization----------2 Encroachment----------3 Slums and squatters---------- 4 Poverty----------5 Others----------	☐
2.3	What types of Economic causes?	Industrialization----------1 Increase Land value----------2 Filling for construction----------3 Develop transport.& commu.----------4 Improper Agriculture Practices----------5 Others----------	☐

2.4	What types of Institutional causes?	Government organizations----------1 Non-govt. organizations----------2 Lack of laws and regulations----------3 Others----------	☐
2.5	Nature of land values since 1960.	Taka per Decimal 1960---------- 1991---------- 2008----------	
C Problems/impact of environmental degradation due to land use change			
3.1	What is the most important environmental problem in your opinion?		

3.2 What are the environmental impacts due to the different activities in the study areas?

Sl. No	Environmental Factors	Relative Impact					
		Unknown	Beneficial	No change	Significance %		
					Low	Medium	High
A	**Physical Environment**						
1	Rapid Urbanization						
2	Unplanned set-up industries						
2	Flash floods						
4	Earthquath						
5	Ground&surface water depletion						
6	Transport & Vehicle						
7	Water logging and drainage						
8	Air pollution						
9	Land degradation/pollution						
10	Water pollution						
B	**Biological Environment**						
1	Wetland and aquatic habitat						
2	Fish and other aquatics						
3	Wildlife and bio- diversity						
4	Unwanted aquatic weed and hyacinth						
C	**Social Environment**						
1	Over population						
2	Safe drinking water						
3	Traffic jam						
4	Accident						
5	Poverty and spreading						
6	Improper waste disposal						
7	Housing						
8	Employment scope						
9	Poor health and sanitation						
10	Culture and heritage						
11	Anti social activities (crime,drug						

SL. No	Questions	Categories	Answers
3.3	Do you suffer from any water born disease? If yes, what are types?	Diarrhoea----------1 Malaria----------2 Skin disease----------3 Dysentery----------4 Typhoid----------5 Others (please mention)----------6	☐
3.4	Do you suffer from any air born disease? If yes, what are the types?	Asthma----------1 Bronchitis----------2 Hypertension----------3 Cough----------4 Cancer----------5 Others----------	☐
3.5	Where do you go for treatment?	Home----------1 Hospital----------2 Clinic----------3 Doctor's chambers----------4 Others ----------	☐
3.6	Approximate cost of treatment?	Taka----------(last time)	

D. Dimension of Environmental degradation and perception of urban life

4.1. Please indicate the quality of environment the following services in this area.

Services	Highly Satisfied 5	Satisfied 4	Acceptable 3	Unsatisfied 2	Highly Unsatisfied 1	Not Respondent 0
Water Supply						
Sanitation Facilities						
Drainage Condition						
Housing						
Poverty and slum						
Employment scope						
Transport & Vehicle						
Traffic Management						
Medical Facilities						
Cleaning and Maintenance						
Sewerage System						
Recreation Facilities						
Garbage Removal						
Community Action Programs						
Local Security						
Law &Order						
Mastan(Musclemen)						

E. Environmental degradation and Adoption of human life

SL. No.	Questions	Categories	Answers
5.1	How can this problem be solved/manage?		
5.2	What is your responsibility regarding the solution of this problem?		
5.3	What should be the group/ communities responsibility regarding the problem?		
5.4	What do you think should be the Government's responsibility regarding this Problem?		
5.5	What are the cause of non-enforcement of laws and regulation?	Lack of coordination among the concern agencies----------1 Negligence of the authority----------2 Corruption of the concerned department----------3 Complicated system ----------4	☐
5.6	In your opinion, what measures should be taken to management of the environment?	Strong monitoring regarding encroact------1 Proper planning in development active----2 Ensure the enforcement of concern law----3 Built up for a low/wetland managt.--------4 Others(specify)----------	☐
5.7	Is there any initiative from government to generate awareness about environment management in your area? Yes ☐ No ☐		
5.8	Do you think the contibution of NGOs are graterthan GOs inrespect of environmental degradation and adoption?		
5.9	Are there any existing environmental management/protection activeties in your locality?		
5.10	Do you think strong public support is needed for the protection of existing environment? Yes ☐ No ☐		
5.11	Do you have any other comments or suggestions for better management of environment? Please comment (if any)		

Thanks for your kind cooperation.

Appendix-B
Tables

Appendix-B1 Contribution to national pollution by selected sectors due to industrialization

Type of industry	Toxic chemical to land	Toxic chemical to air	Toxic metal to water	BOD	SO_2	Total particulate	Number of pollutants with>5% contribution
Textiles	14.02	21.72	8.20	10.72	23.06	7.11	6
Non-ferrous metal	12.01	6.52	6.10	11.41	13.28	1.88	5
Iron and steel	12.09	3.04	53.55	0.07	8.67	3.88	3
Sugar and refineries	2.02	0.61	0.00	41.34	11.13	12.42	3
Chemicals	6.25	2.59	8.09	3.08	0.80	0.22	2
Cement	0.03	0.01	0.00	0.00	10.42	8.49	2
Tanneries	15.64	8.40	1.56	1.90	0.36	0.07	2
Fertilizers/Pesticides	10.03	10.66	2.09	0.36	0.79	0.37	2
Vegetable oil	4.65	1.15	0.06	2.19	10.47	18.06	2
Chem. products	1.76	5.58	6.31	0.06	2.28	1.34	2
Tobacco	0.53	7.71	0.0	0.08	5.65	0.18	2
Drug/Medicines	8.99	8.65	0.58	0.64	1.71	0.54	2
% contribution to nationwide load	88.02	76.64	86.55	71.84	89.15	54.56	--

Source: Modified version based on Hettige *et al.,* 1997

Appendix-B2 Land use change pattern in the study area since 1960-2008

Land use Category	1960		1991		2008	
	Area(ha)	(%)	Area(ha)	(%)	Area(ha)	(%)
Built-up	6,083	14.67	11,866	28.61	18,451	44.49
Bare soil/landfill	1,083	2.61	2,420	5.84	2,090	5.04
Cultivated land	13,404	32.33	10,395	25.07	8,050	19.41
Vegetation	7,615	18.36	5,418	13.06	2,589	6.24
Water-bodies	3,725	8.98	3,196	7.71	2,068	4.99
Wet/lowlands	8,982	21.66	5,829	14.06	4,732	11.41
Transports and communications	429	1.04	2,185	5.27	2,692	6.49
Others	147	0.35	159	0.38	796	1.92
Total	**41,468**	**100.00**	**41,468**	**100.00**	**41,468**	**100.00**

Source: Field survey, 2009 and Land use map, 1960, 1991and 2008

Appendix-B3 Trends of land use change in the study area of Ashulia, 1960-2008

Land use categories	1960 Land area (ha)	1991 Land area (ha)	2008 Land area (ha)	1960-1991 area changed (ha)	% of changed area	1991-2008 area changed (ha)	% of changed area	1960-2008 area changed (ha)	% of changed area
Built-up	531.30	1465.65	1342.55	934.35	175.86	-123.1	-8.40	811.55	152.75
Bare soil/landfill	49.68	321.42	159.05	271.74	546.98	-162.37	-50.52	109.37	220.15
Cultivated land	1249.68	1319.76	1801.00	70.08	5.61	481.24	31.69	551.32	44.11
Vegetation	1880.97	566.04	369.07	-1314.93	-69.91	-196.97	-34.80	-151.19	-8.04
Water-bodies	224.18	179.58	69.02	-44.60	-19.89	-110.56	-61.57	-155.16	-69.21
Wet/lowlands	576.57	534.90	420.28	-41.67	-7.23	-114.62	-21.43	-156.29	-27.11
Trans.&Commu.	28.82	153.27	157.33	124.45	431.82	4.06	2.65	128.51	445.90
Others	0	0	217.00	-	-	217.00	-	217.00	-

Source: Prepared by researcher based on figure 5.4 Note: (+) or (-) sign indicates direction of change

Appendix-B4 Trends of land use change in the Uttara area, 1960-2008

Land use categories	1960 Land area (ha)	1991 Land area (ha)	2008 Land area (ha)	1960-1991 area changed (ha)	% of changed area	1991-2008 area changed (ha)	% of changed area	1960-2008 area changed (ha)	% of changed area
Built up	122.91	186.48	618.43	63.57	51.72	431.95	231.63	495.52	403.16
Bare soil/landfill	0	41.82	89.64	41.82	100.00	47.82	114.35	89.64	100.00
Cultivated land	613.23	336.50	200.21	-276.93	-45.13	-136.29	-40.50	-413.02	-67.35
Vegetation	119.74	310.37	26.37	190.63	159.20	-284.0	-91.50	-93.37	-77.98
Water bodies	111.77	113.69	64.06	1.92	1.72	-49.63	-43.65	-47.71	-42.69
Wet/lowlands	409.20	291.75	208.01	-117.45	-28.70	-83.74	-28.70	-201.19	-49.17
Trans.&Commu.	13.01	95.98	162.38	82.97	637.74	66.40	69.18	149.37	1942.52
Others	0	0	39.15	-	-	-	-	39.15	100.00

Source: Prepared by researcher based on figure 5.6 Note: (+) or (-) sign indicates direction of change

Appendix-B5 Trends of land use change of Amin Bazar area, 1960-2008

Land use categories	1960 Land area (ha)	1991 Land area (ha)	2008 Land area (ha)	1960-1991 area changed (ha)	% of changed area	1991-2008 area changed (ha)	% of changed area	1960-2008 area changed (ha)	% of changed area
Built up	440.29	823.02	901.46	382.73	86.92	78.44	9.53	461.17	104.74
Bare soil/landfill	120.91	103.00	293.28	-17.91	-14.81	190.28	184.74	172.37	142.56
Cultivated land	538.65	932.69	1219.98	394.04	73.15	287.29	30.80	681.33	126.49
Vegetation	172.70	107.88	17.86	-64.82	-37.53	-90.02	-83.44	-154.84	-89.66
Water-bodies	443.47	469.19	285.97	25.72	5.80	-183.22	-39.05	-157.50	-35.52
Wet/lowlands	2368.20	1547.45	901.05	-820.75	-34.66	-646.40	-41.77	-1467.15	-61.95
Trans.&Commu.	38.38	143.17	195.33	104.79	273.03	52.16	36.43	156.95	408.94
Others	55.11	54.18	365.47	-0.93	-0.017	311.29	574.54	310.36	563.16

Source: Prepared by researcher based on figure 5.7 Note: (+) or (-) sign indicates direction of change

Appendix-B6 Sanitation and Hygiene Problems Due to Flash flood and water logging

Categories	Frequency	Percentage
Whether the respondent face any sanitation problem		
Yes	132	33.25
No	265	66.75
Total	397	100.0
Types of sanitation problem		
Toilet Overflowing	89	67.42
Toilet's waste floats on water	11	8.34
Toilet sunk under logged water	32	24.24
Total	132	100.0
Unhygienic Situation created by Flash flood and water logging		
Mosquito Increase	145	36.52
Spread odor	105	26.45
Kitchen waste floats on water	14	3.53
Waste of open drainage floats on water	133	33.5
Total	397	100.0

Source: Field survey, 2010

Appendix-B7 Ground water depletion situation in the Dhaka city and its surrounding area

Year	1996	1998	2000	2002	2004	2006	2008	2010
Below the surface(m)	-26.30	-30.45	-34.18	-42.00	-50.6	-59.72	-71.23	-85.62

Source: Analysis from Al-Mamun, 2006 and The Daily Star, 7 Jun 2010

Appendix-B8 Perception about suffering from diseases and Place of treatment

Categories	Frequency	Percentage
Whether the respondent face any diseases problem		
Yes	318	80.10
No	79	19.90
Total	397	100.0
Types of diseases		
Diarrhoea		36.14
Malaria		1.05
Skin disease		14.04
Dysentry		7.37
Asthma		27.02
Typhoid		3.86
Others		3.15
Total	318	100.0
Place of treatment		
Home		15.09
Hospital		12.28
Clinic		23.16
Doctor's chambers		45.28
Others		4.21
Total	397	100.0

Source: Field survey, 2010

Appendix-C
Paper Clipping on Land use Change Issues

The Daily Star

24 May, 2010

Rainwater to recharge underground reservoirs

Wasa finally initiates pilot project to up falling water level in Dhaka

HELEMUL ALAM

After over two decades of groundwater level decline, Dhaka Wasa will at last start recharging the aquifers of the capital this monsoon, to save the city from a looming scarcity of supply water, and subsidence of the ground surface.

Dhaka Water Supply and Sewerage Authority (Wasa) started a pilot project titled "Artificial Recharge from Rainwater" around five months back at two places of the city, said a high official of the government agency.

"Under the taka one crore pilot project, rainwater will be harvested at Wasa office compounds in Lalmatia and Segunbagicha, then the water will be filtered and sent to aquifers through two wells," said Wasa Deputy Managing Director (Operation and Maintenance) Liakat Ali.

The infrastructural work including construction of the wells, and rainwater harvesting reservoirs is expected to be completed next month, said the other official.

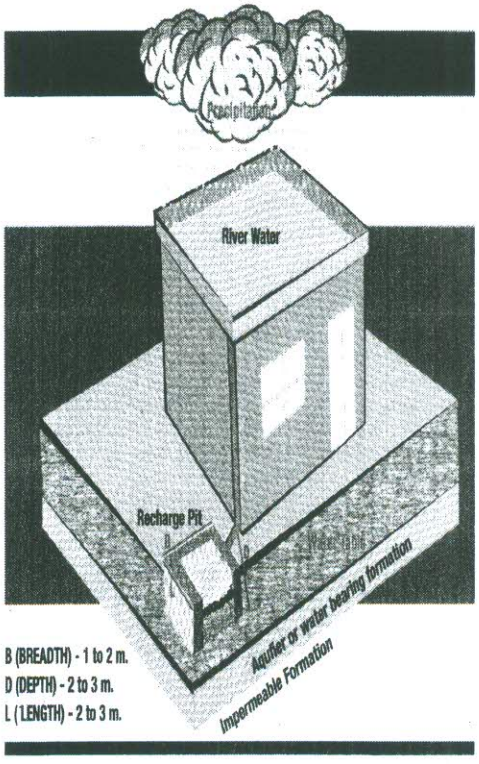
According to a 2006 assessment study by the Institute of Water Modelling (IWM), commissioned by Wasa, the groundwater level at different parts of the capital has been dropping by two to three metres a year, Liakat said.

The reason for the decline is excessive use of the groundwater through deep tube wells; and filling up of low lands, canals, and other water bodies, said experts.

Unplanned dumping of sewage, and household and industrial wastes, in the city rivers and other water bodies, makes it difficult for Wasa to use surface water, resulting in its dependency on groundwater, said Selim Bhuiyan, a Bangladesh Water Development Board engineer.

Prof Mujibur Rahman of Bangladesh University of Engineering and

SEE PAGE 15 COL 4



Rainwater

FROM PAGE 1

Technology (Buet) said the city will face a huge water crisis in the near future if Wasa continues lifting groundwater through the huge number of its deep tube wells.

The practice, if goes on unabated, might lead to disasters like subsidence of the ground surface, said Selim Bhuiyan.

Around 80 percent water of unconfined aquifers, which are the closest to the ground surface, is used up, said Md Eftekharul Alam, an engineer of Bangladesh Agricultural Development Corporation.

Dhaka Wasa has already been forced to lift water from the deeper confined aquifer at 90 points of the city including Mirpur, Nakhalpara, Ibrahimpur and Manipur, said a former chief engineer of the agency, Md Nurul Haque.

According to a Wasa statistics, currently the source of 87 percent of supply water in the capital is groundwater through 551 deep tube wells. The remaining 13 percent comes from surface water through 4 water treatment plants at Sayedbad and Chandnighat in Dhaka City; and at Godnail and Sonakanda in Naraynaganj.

Md Nurul Haque said there are also around 1,200 authorised private deep tube wells in the city, which are extracting groundwater as well, on top of which there are almost 2,000 illegal ones.

To save Dhaka from an impending disaster, the experts suggested stopping pollution of the rivers in and around the city, and reclaiming other water bodies as well, along with recharging the aquifers.

Use of effluent treatment plants in industries, and setting up waste treatment plants to treat human excreta, are a must for preserving surface water sources, said Prof Mujib of Buet.

The contract for the aquifer recharging project was awarded to IWM in December 8, 2009 by Wasa. The institute is supposed to submit its report in March next year, said the Wasa high official.

"It is not a new technique, it has been in use all over the world. If we get a positive result from the pilot project, we will start implementing it on a much larger scale in the city next year," said Wasa DMD Liakat, adding, private compounds of high rises can also be brought under the programme then.

Wasa already made a plan to reduce its dependency on groundwater, he said. When Sayedabad Water Treatment Plant Phase-II will be completed, surface water's share at the city's taps will rise to 23 percent, he added saying, the plant is scheduled to be ready for operation in two and a half years.

Wasa also took an initiative to set up two more water treatment plants in Khilkhet and Keraniganj of the city with capacities of treating 50 crore litres and 45 crore litres respectively per day, he said, "We are hoping that the two treatment plants will be operational within the next five years, curbing our dependency on groundwater to fifty percent."

Dhaka Wasa has the capacity of supplying around 200 crore litres per day while the demand is for 220 crore litres.

According to a statistics of Bangladesh Water Development Board, groundwater level in Mirpur dropped 53.75 metres between 1991 and 2008, while the decline was 18.59 metres in Mohammadpur, 37.4 metres in Sabujbagh, 8.22 metres in Sutrapur, and 14.14 metres in Dhaka Cantonment during the same period.

The Daily Star

7 June, 2010

Filled-up, full of risk

Geologists warn against building high-rises on reclaimed marshy lands, say Dhaka's declining groundwater threatens land subsidence

PINAKI ROY

Pink city or green city, lake view or river view--no matter how colourful their names are, high-rises on marshy land in Dhaka are at risk of falling over, as the groundwater level is dropping faster than ever.

It may not need an earthquake for these multi-storey buildings to come tumbling down. The first downpour of the season may prove enough to make them topple over, said geologists.

Citing Begunbari collapse and several other buildings tilting or developing cracks in last few days, they said it all happened because the groundwater level has gone down sharply and the monsoons led to an 'upward water pressure'.

Explaining how that pressure works, the experts said if the water level falls, the soil under buildings adjusts itself to being without water.

But when it rains heavily after a long break, the rainwater recharges the ground and the existing water pushes the earth from beneath.

ATM Asaduzzaman, an urban geology expert, said many multi-storey buildings on weak foundations and filled-up wetlands might collapse if heavy rains continue for a few days at a stretch.

The groundwater level in the city has been going down by three metres a year, says a survey conducted by Bangladesh Agricultural Research Council(Barc) and Water and Sewerage Authority.

Experts blame the fall on excessive extractions of water. They also say the water table does not get enough space to lift itself mainly for lack of greens in the city.

Geologist Khurshid Alam said Dhaka city stands on three categories of soil.

The oldest of them is Pliocene, also known as Dupi Tila . It is formed 35 lakh years ago and safe for multi-storey buildings.

Pleistocene or Madhupur clay, which was formed six to seven lakh years ago, is less stable. But most unstable of these three is Holocene, which was formed only 10,000 years back.

Low-lying areas like Begunbari, Bashabo and Meradia are on Holocene formation.

Citing a recent survey over 60 square kilometres of filled-up land on the bank of Balu river in Satarkul, ATM Asaduzzaman said some areas are so

SEE PAGE 15 COL 7

LAND FORMATION MAP OF DHAKA

Based on a map by Geological Survey of Bangladesh

The Daily Star

7 June, 2010

Filled-up, full of risk

FROM PAGE 1

vulnerable that buildings on them could fall over even after 70 to 80 metres of piling.

In most cases, building owners try to save money by skipping the soil test.

"Of two adjoining buildings, one could tilt while the other could still stand. It's because soil quality and strength of foundation could be different," said Asaduzzaman, director of Geological Survey of Bangladesh.

Most areas in Motijheel, Sayedabad, Kamalapur, Segunbagicha, Kakrail, Banani, Gulshan, Dhanmondi, Lalmatia, Khilkhet, Baridhara, Agargaon and Mirpur 1-3, 6, 10-12 and parts of Uttarkhan and Uttara are safe for high rises, as they are made of Madhupur clay.

But, he adds, high-rise buildings in areas like Satarkul, Jatrabari, eastern part of Pragati Sarani, Meradia, some portions of Badda, Mirpur Kalapani and Mirpur 14 are vulnerable as most of these areas were wetlands in the near past.

"In some cases, even if we wait for 10,000 years, the land won't be stable enough for high-rise buildings," observed Asaduzzaman.

The vast stretch of low-lying land between Purbachal and Begunbari area, where over 100 developers are filling up wetlands and selling plots to people, is a matter of great concern, geologists say.

Khurshid Alam said it is unfortunate that even reputed developers are building large structures on unsafe land formation like Holocene.

"People should not build any high-rise in those areas. They can at best go for bamboo and wood-made duplexes," he continued.

Asked for an idea about when multi-storey buildings in areas on Holocene might topple, he said it maybe tomorrow or after 10 years. But there's no doubt that those buildings are prone to collapse.

Queried what then the solution is, he said there's no alternative to decentralisation. The capital must have only as many people as it can hold.

Professor Nazrul Islam, a noted urban expert said, every year Dhaka city is expanding by four percent and its population is increasing at the same rate.

Decentralisaiton will not be enough; the government should discourage local migration as well, he added.

The Daily Star

12 June, 2010

Diabolic Dhaka

The ever-worsening traffic tangle, air pollution and severe scarcity of electricity, gas and drinking water have turned the capital into a diabolic city. The young generation, which is growing up in a claustrophobic environment, is becoming vulnerable to so many social ailments.

A.N.M. NURUL HAQUE

IT is not at all surprising that Dhaka has been ranked as the 2nd worst city in the world in a recent global survey of livability, as living conditions are deteriorating fast.

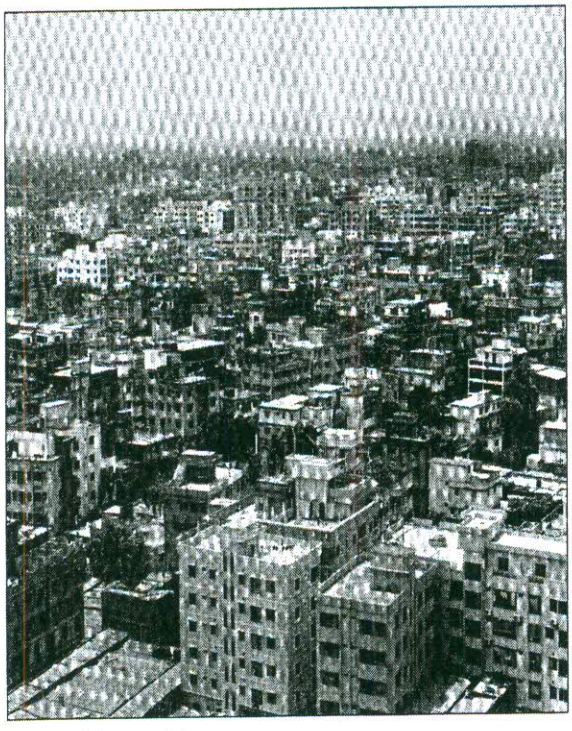
The survey conducted by the London-based Economist Intelligence Unit, based on 30 factors, including political and economic stability, healthcare, education, environment and infrastructural facilities, puts Dhaka just ahead of Harare, the capital of Zimbabwe.

Another global survey revealed that Singapore edged out Tokyo and Hong Kong as the best city in Asia for expatriates to live in, while Dhaka is the worst, just ahead of Karachi.

Dhaka was also bracketed with the 10 most polluted cities in 2007 and 2008, with automobiles emitting 50,700 tons of carbon dioxide and 8,550 tons of nitrogen oxide annually, posing serious health threats. The study also found some 6.10 lakh children showing symptoms of asthma in Dhaka.

The measures taken so far to resolve the traffic tangle, which include introducing automatic traffic signalling and three-lane system, re-fixing office and school timings and dividing the city into seven zones, have seen no success. This clearly suggests that the problem is deep-rooted and comprehensive measures are needed to solve it.

At least 5.25 lakh motorised vehicles now ply the Dhaka streets everyday against 3.03 lakh in 2003. According to BRTA, more than 3,750 motorised vehicles hit the streets of Dhaka every month, with 180 new vehicles being registered on average everyday. The number of non-motorised vehicles in the capital is over five lakh.



Suffocating in its own pollution.

Dhaka now has to accommodate over 10 lakh vehicles while it has the capacity for around 1.5 lakh vehicles with 250-300 kilometre roads. A city needs roads on 25% of its total area but Dhaka has roads on only 8% of its landmass. The number of vehicles in the city is nearly seven times the capacity of the roads, which is a major cause of terrible traffic tangle.

The capital city has already turned too ugly to behold. The ever-worsening traffic tangle, air pollution and severe scarcity of electricity, gas and drinking water have turned the capital into a diabolic city. The young generation, who are growing up in a claustrophobic environment, is becoming vulnerable to so many social ailments.

The underground water level in the capital has reached such an alarming proportion that the prime minister warned the nation about Dhaka facing an earthquake threat as its fallout. Experts have also been issuing similar warnings since long as the city is losing its geo-hydrological balance because of indiscriminate withdrawal of underground water.

The local government (LGRD) minister also expressed his grave concern about the city, apprehending that an unimaginable environmental disaster was awaiting the city dwellers.

In fact, these are old stories told afresh only to highlight the gravity of the situation.

The total population of Dhaka city grew from 0.1 million in 1906 to 12 million in 2008. Though nobody knows for sure, the guesstimate is that the present population of Dhaka is over 15 million, and more than two thousand people are being added to this number every day.

According to Social Science Research Council of the Planning Ministry, more than 71% of the city's nearly one million rickshaw-pullers were farmers prior to their migration to the capital. Lack of earning opportunities in the rural areas forced them to migrate to the capital though they used to enjoy a better livelihood in their villages. Stopping of such city bound exodus has become an imperative to protect Dhaka from becoming a vast city of slums.

Although two master plans for the city were formulated back in 1959 and 1997, they were never implementated. The Dhaka Metropolitan Development Plan was prepared in the third stage. What is now imperative to make the capital livable is to curb further unplanned sprawl of the city and to expand the road network in accordance with the master plan.

Land grabbing and river pollution are, no doubt, other major causes of environmental degradation in the city. The land grabbers have now extended their greedy hands to grab the canals and rivers around the capital city. The government now has the list of land grabbers. Public expectation is that the government will deliver on the pledge to make Dhaka's rivers and canals free.

With the humiliating distinction of being the second worst city in the world, Dhaka is really a diabolic city plunged in manifold problems.

The government has finalised a Dhaka Mass Transit Authority Act to form an authority to operate metro-rail (mass rapid transit), dedicated bus service (bus rapid transit), subways and waterways in and around the city, aiming at facilitating speedy commuter movement.

Tk.107 crore has gone down the drain, as the mega project of circular waterways around the Dhaka city was shelved. The project was taken up in 2004, ostensibly to reduce traffic holdups in the capital.

Starting the construction in 1999, the Delhi Metro Rail Corporation has so far built three lines, 60 kilometres in length, in six years. About five years have already passed since the 20-year Strategic Transport Plan was prepared, and it may take decades to implement the metro-rail mega project.

The dwellers of Dhaka city have become quite accustomed to hearing about such mega projects turning Dhaka into a city fit for the 21st century, but have hardly seen any initiative that would suggest that there is hope for the future.

Dhaka remains as a problem-ridden city with terrible traffic congestion, scarcity of electricity, gas and drinking water, and lack of security, despite the promises by all the successive governments.

Therefore, the government needs to take some serious steps urgently to protect the city from imminent disaster. First of all, Dhaka bound exodus must be stopped and the huge number of unfit vehicles must be withdrawn from the streets. Dhaka is extremely overburdened with more than 15 million people scrambling for its limited facilities and one million vehicles crawling on the streets.

A. N. M. Nurul Haque is a columnist of The Daily Star.
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The Daily Star
15 June, 2010

PM pulls for water bodies

Asks housing minister to go ahead, not to bow down to pressure by developers

SHAKHAWAT LITON *and* RASHIDUL HASAN

Prime Minister Sheikh Hasina yesterday asked the state minister for housing to go ahead with the plans to protect water bodies in the capital without yielding to pressure from any quarters.

She gave the instructions when the state minister, Abdul Mannan Khan, met her on parliament floor.

During the conversation, the two were seen surrounded by senior ministers and lawmakers.

SEE PAGE 15 COL 4

Water bodies

FROM PAGE 1

The prime minister lambasted "land grabbers for their audacious behaviour" with the state minister on Sunday, ruling Awami League lawmaker Enamul Haque told The Daily Star.

"We will implement the detailed area plan (DAP) to save Dhaka city. We will not care if it's inconveniencing anyone," Enamul quoted Hasina as saying.

She then asked the state minister not to be dissuaded by anyone's "browbeating", he added.

Wishing not to be named, another lawmaker said he had heard the prime minister telling the minister: "You don't need to pay heed to anybody. We cannot cater to a few greedy persons."

She asked Mannan to continue his efforts to save the capital.

Hasina observed land grabbers have made thousands of crores of taka thanks to patronage of the past governments. They gave plots to politicians to have them on their side.

Earlier, participating in the budget discussion, Mannan Khan said "some land grabbers are showing audacity to threaten the government in broad daylight", as it is trying to save rivers, canals and other water bodies.

Soon after the sitting was adjourned, Mannan met the premier and briefed her about Sunday's meeting.

At a meeting at the housing and public works ministry, land developer leaders on Sunday blasted Mannan over draft DAP, which reserves 21 percent of the capital's area as water bodies that cannot be filled in.

Contacted by The Daily Star over the phone, the state minister declined to elaborate on his conversation with the premier. He said she knows everything about his encounter with the realtors.

Speaking at the House, Mannan said some land developers first buy a half-katha land at one end and another half-katha at the other, and soon grab the entire land in between.

They place eye-catching ads hiding the real condition of their housing projects to con people who entrust them with their hard-earned money.

The Daily Star
17 June, 2010

Developers should not go unchallenged

BEN hopes that the government will stand firm against the myopic demands of the developers and take strong action against those developers who violated the norms of behaviour at the meeting.

NAZRUL ISLAM

BANGLADESH Environment Network (BEN), the global network of non-resident Bangladeshis and their international friends, takes strong exception to and deplores strongly the way some real estate developers attacked the State Minister for Works, Mr. Abdul Mannan and Prof. Jamilur Chowdhury, the expert who was given the responsibility to review the Detail Area Plan (DAP) necessary for implementation of the Dhaka city Master Plan.

They made this attack publicly, in presence of journalists, in a recent meeting held in the secretariat. The developers are apparently upset by the proposed DAP aiming to retain 21% of the land as floodwater retention zones.

It is well known that many unscrupulous developers are capitalising on the housing demand by capturing wetlands in and around Dhaka city indiscriminately and promising housing construction on lands that are still under water. Yet, filling up of wetlands will leave no room for rain and floodwater, aggravating the water-logging problem that has already become serious in the city.

It is quite natural for these developers to oppose DAP, which preserves wetlands and restricts the space for their projects. However, the audacity they displayed in attacking the minister publicly, using unceremonious language, is unheard of. These people, some of whom have outstanding criminal cases against them, also had the audacity to question the integrity of Prof. Jamilur Reza Chowdhury, who is well known for his independence and honesty.

BEN hopes that the government will stand firm against the myopic demands of the developers and take strong action against those developers who violated the norms of behaviour at the meeting. BEN also calls upon all the conscious citizens of the city and the country to thwart the machinations of the greedy developers.

Of course, the growing housing demand has to be met. However, this can be done by promoting decentralisation and vertical growth. Decentralisation will relieve the pressure on Dhaka city, and vertical growth will allow construction of dwellings while retaining space for passage of rain and flood water. The government also needs to switch from the Cordon Approach to the Open Approach to rivers, so that risk of flooding can be minimised and the problem of water-logging can be avoided.

While deploring the behaviour of many real estate developers, BEN agrees with one of their demands, which is that Rajuk should quit the business of development and instead focus only on planning and regulation. The current practice whereby Rajuk is both the regulator and developer involves conflict of interest. It is open to question whether Rajuk housing projects of Purbachal, Jhilmil, and Uttara Phase III are also not encroaching on wetlands.

Moreover, Rajuk projects are mostly a way of benefitting select members of the elite at the expense of taxpayers, whose money is spent on these projects, and at the cost of the poor people whose land is acquired for these projects. Enough of such grossly socially unfair projects!

SYED ZAKIR HOSSAIN

Filling up water bodies in blatant disregard of the rules.

The recent tragic fire in old Dhaka shows how enormous a task of planning and regulation Rajuk has on its hands, and how poorly it is performing that task.

The government should therefore take an immediate decision debarring Rajuk from further development activities and ordering it to focus fully on planning and regulation. Once this is done, Rajuk will occupy a higher moral ground to oppose the shameless developers who are willing to jeopardise the future of the entire city in order to enrich themselves.

While reformulating Rajuk's objectives, BEN hopes that the government will take immediate action against the developers who threatened the minister. The stake is very high. The government has to protect its credibility and honour.

Taking this opportunity, BEN applauds State Minister Abdul Mannan, Prof. Jamilur Reza Chowdhury, Bapa, Bela, and all other organisations and individuals who are trying to have pro-environment DAP in order to save Dhaka city from impending calamity.

Dr. Nazrul Islam, a former professor of economics of Dhaka University, is the Global Coordinator of Bangladesh Environment Network (BEN) and Vice-President of Bangladesh Poribesh Andolon (BAPA).

The Daily Star
29 June, 2010

40pc wetlands go in 20 years

Drainage fails as indiscriminate filling up of lowland, flood flow zones goes unabated

STAFF CORRESPONDENT

Around 40 percent of the wetlands of Dhaka city has disappeared in 20 years due to indiscriminate filling up of lowland and flood flow zones that also has reduced its drainage capacity.

Quoting a study of the department of Urban and Regional Planning of Buet, Prof Sarwar Jahan, president of Bangladesh Institute of Planners, said this at a roundtable at the National Press Club yesterday.

SEE PAGE 15 COL 4

40pc wetlands

FROM PAGE 16

The study says the temporary wetlands in Dhaka metropolitan development plan area (1,528 square km), which was 40,765 hectare in 1989, came down to 35,740 hectare in 1999 and 24,208 hectare in 2005.

Save Environment Movement (SEM), Jano Udyog Jatiya Committee and Institute for Environment and Development jointly organised the roundtable.

M Mujibur Rahman of Buet in his keynote paper said the eastern Dhaka relies on gravity drainage system based on "khals" and wetlands.

If the existing wetlands and water bodies are not protected, the drainage system of eastern Dhaka will collapse and it will inundate the area frequently, he said.

Mujibur said to protect eastern Dhaka from floods, at least 40 percent of the drainage catchment area must be delineated and protected as wetlands and water bodies under the Wetland Conservation Act, 2000.

Of the 40 percent drainage area, a minimum of 12 percent area (about 20 square km) can be made available as reserved ponds or lakes and another 28 percent (about 46 square km) protected as natural wetlands for retention of storm water, he said.

He suggested declaring this 40 percent area (66 square km) as wetlands including reserved ponds/lakes by the environment ministry without much delay considering this as an "ecologically critical area."

Syeda Rizwana Hasan, chief executive of Bangladesh Environmental Lawyers Association (Bela), said the government should protect 21 percent of water bodies and flood flow zones of Dhaka city to save it from water logging.

She said the government should not accept the demand of land grabbers to approve the projects, which have already filled up water bodies and wetlands rather it should take initiative to restore those water bodies.

Abu Naser Khan, chairman of SEM, said water bodies and wetlands will be the main source of water in future.

The capacity of replenishing ground water will be reduced more if it is not possible to protect water bodies of the city, he said.

Dr Niaj Rahman and executive engineer of BIWTA Tofayel Ahmed, among others, spoke at the roundtable.

The Daily Star
27 July, 2008

Free Turag from encroachment

Demands Bapa

STAFF CORRESPONDENT

Bangladesh Paribesh Andolon (Bapa) yesterday called on the government to take immediate steps to make the river Turag and Tongi canal free from encroachers and pollution.

A team of Bapa placed the demand during a demonstration on Kamarpara bridge at Ashulia.

Earlier, the team found out that the process of encroachment is going on in many points along the Turag river.

They also witnessed many incidents of river pollution while carrying out monitoring activities through a boat rally on the river.

The boat rally, which started from BIWTA landing station at Ashulia at around 10:30am, travelled from Kamarpara bridge to Trimohoni and the Tongi canal. Bapa Vice President Prof Kazi Madina led the team.

During the journey, the Bapa team noticed that the Turag river was filled up in four points in the adjacent areas of Taltala Ghat.

They also found out that many areas of the river from Kamarpara Bridge and Trimohoni are being encroached and that there are activities leading to pollution of the river.

They witnessed the process of encroachment on both sides of the river near Biswa Ijtema ground, at East Abdullahpur and the adjacent areas of Tongi road and rail bridges.

The team also noticed that wastes from industrial units, houses, kitchen markets and hanging toilets along the banks of the river are continuously polluting the water.

Later, the team staged a demonstration on Kamarpara bridge to protest the encroachment.

Speaking on the occasion, the team members criticised the authorities for their indifferent attitude to encroachment and pollution activities.

Prof Kazi Madina, Dr Md Abdul Matin and Iqbal Habib spoke at the demonstration.

The Daily Star
29 October, 2009

Integrated water management a must to address waterlogging

Speakers tell discussion

STAFF CORRESPONDENT

Speakers at a discussion yesterday stressed the need for setting up an integrated water management project to avert water-related hazards, including waterlogging problem.

Disintegrated water management projects have brought economic benefits to one section of the society, while those have caused economic hardships to another section, especially poor people due to lack of environmental and equity considerations, they added.

Titled 'Equity consideration in water management: A crying need for social justice in Bangladesh,' the discussion was organised by Bangladesh Paribesh Andolon (Bapa) at BIP conference hall in the city.

The speakers placed a six-point demand, including giving importance to environmental preservation and the livelihood opportunities of vulnerable groups in water management project, appropriate regulations and guidelines to ensure social justice and ensuring public participation in decision-making.

Other demands include cancellation of leasing system of water bodies, ensuring proper waste management, eviction of grabbers from the river bank and compelling industry owners for setting up effluent treatment plant.

Prof Jahir Uddin Chowdhury of Institute of Water and Flood Management at Buet called on the government to increase dependency on local experts instead of foreign consultants to formulate a water management planning.

He also called for introducing social science or social expectation course in all engineers' institutions to make the planners understand of our socio-economic reality.

Water control structures are to be made multi-functional to smooth agriculture, open water fisheries, navigation and ecosystem, he added.

Former director general of Warpo engineer Enamul Hoque criticised the government not to make the water act draft public, putting a question to the government that why it is going to hold the meeting at Gazipur instead of Warpo building at Dhaka? There must be another motive behind meeting.

He demanded steps to introduce licence system among the public to use the water bodies instead of leasing.

Presided over by Bapa Vice-President ASM Shahjahan, also former adviser to a caretaker government, the discussion was also addressed by Brotee CEO Sharmin Morshed, Kabodak Rakkha Andolon President Rashidur Rahman Rashid and hydro geologist of Netherlands Remi Kempers.

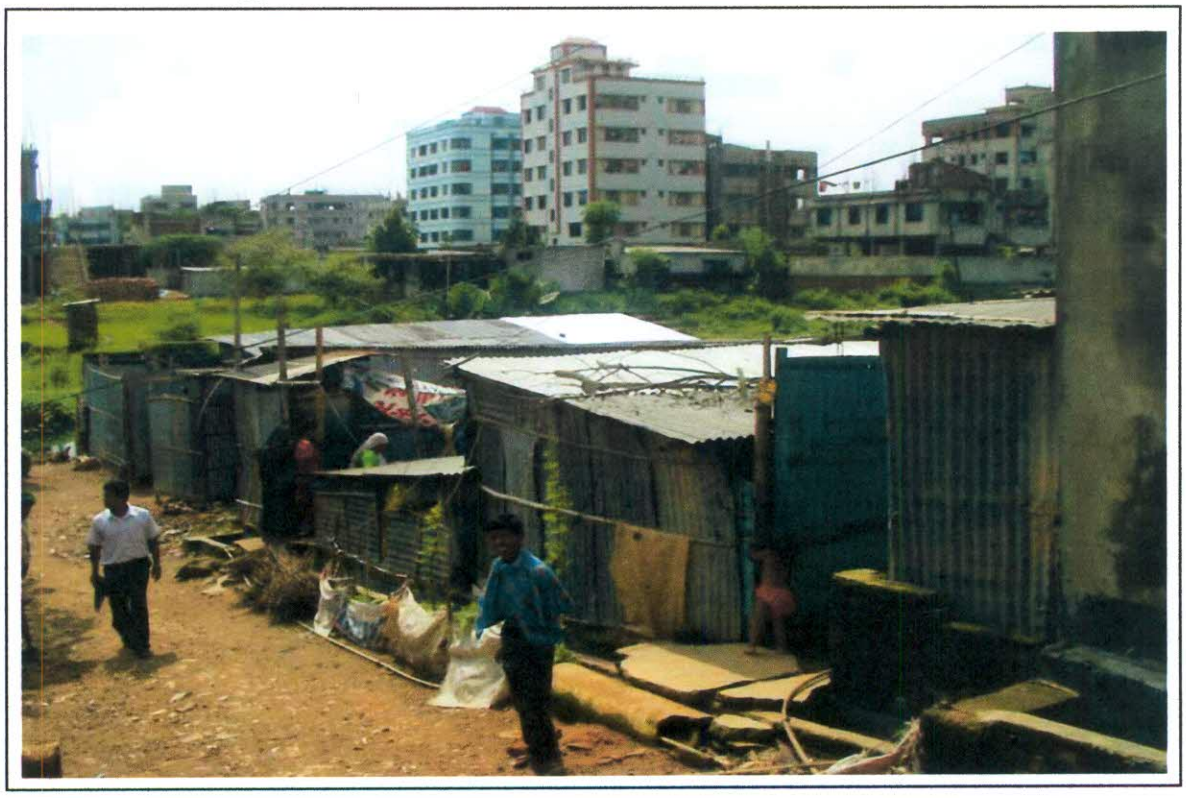
Appendix-D

Photographs from Study Area Regarding Land use Change and Degradation of Environment

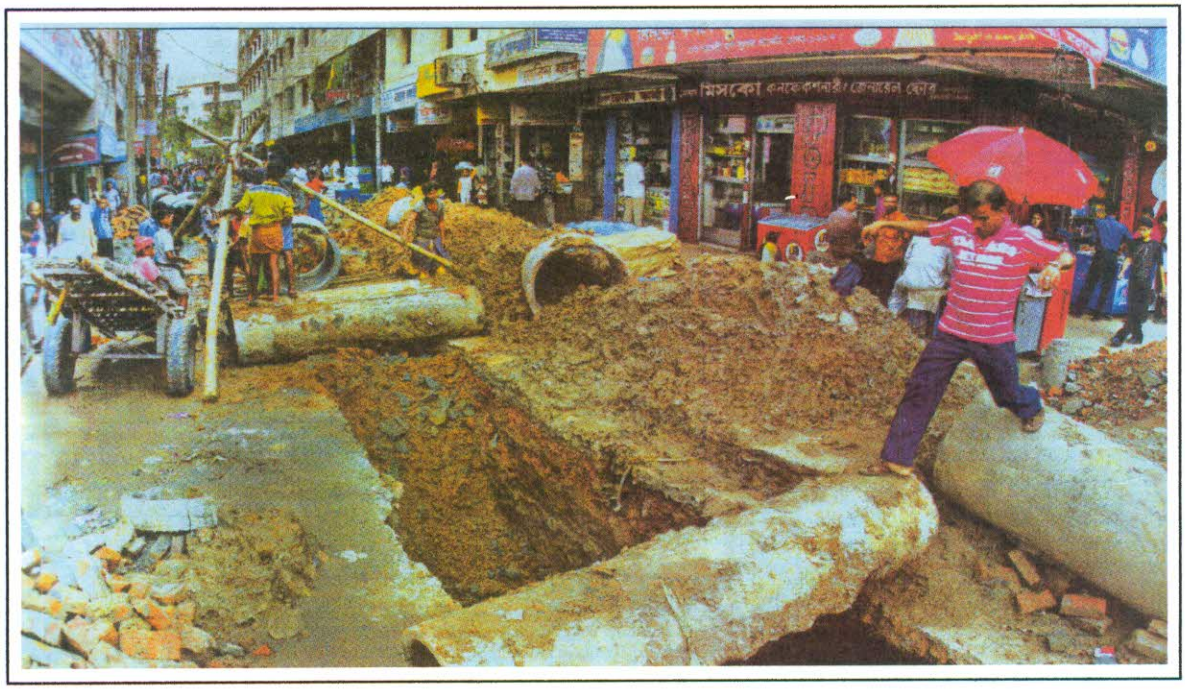
Appendix-D1 Illegal encroachment and polluting the lack

Appendix-D2 Unplanned urbanization in the study area

Appendix-D3 Encroachment *Khas* land by slum people



Appendix-D4 Slow pace of drainage improvement work causes suffering to road users in the study area



Appendix-D5 The condition of this road in the capital has been in this sorry state for quite a long time, causing accidents frequently

Appendix-D6 Rubbish dumped on Beribadh in the Capital

Appendix-D7 Protesting filling of the Lake

(South Nikunja residential area Welfare Samity and Save the Environment Movement (SEM) from a human chain).

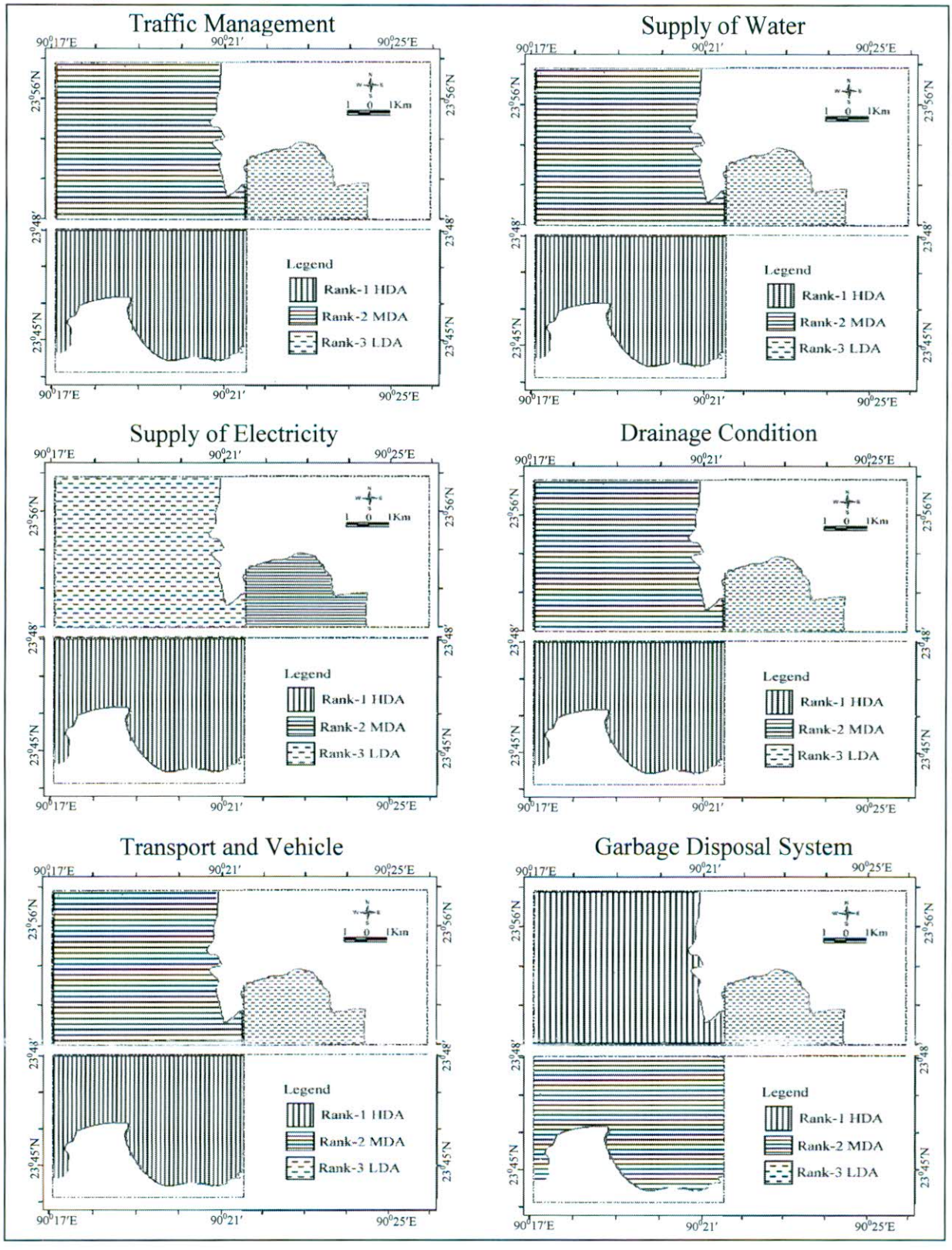
Appendix-D8 Fresh water coming in from the Bangshi, left, shows how murky the water of the Turag has become (Amin Bazar Bridge near Gabtali)

Appendix-D9 Sewage water flows onto a road in the study area

Appendix-D10 Due to poor drainage system, water remains stagnant on roadside, serving as a breeding ground for mosquitoes in the study area Uttara

Appendix E

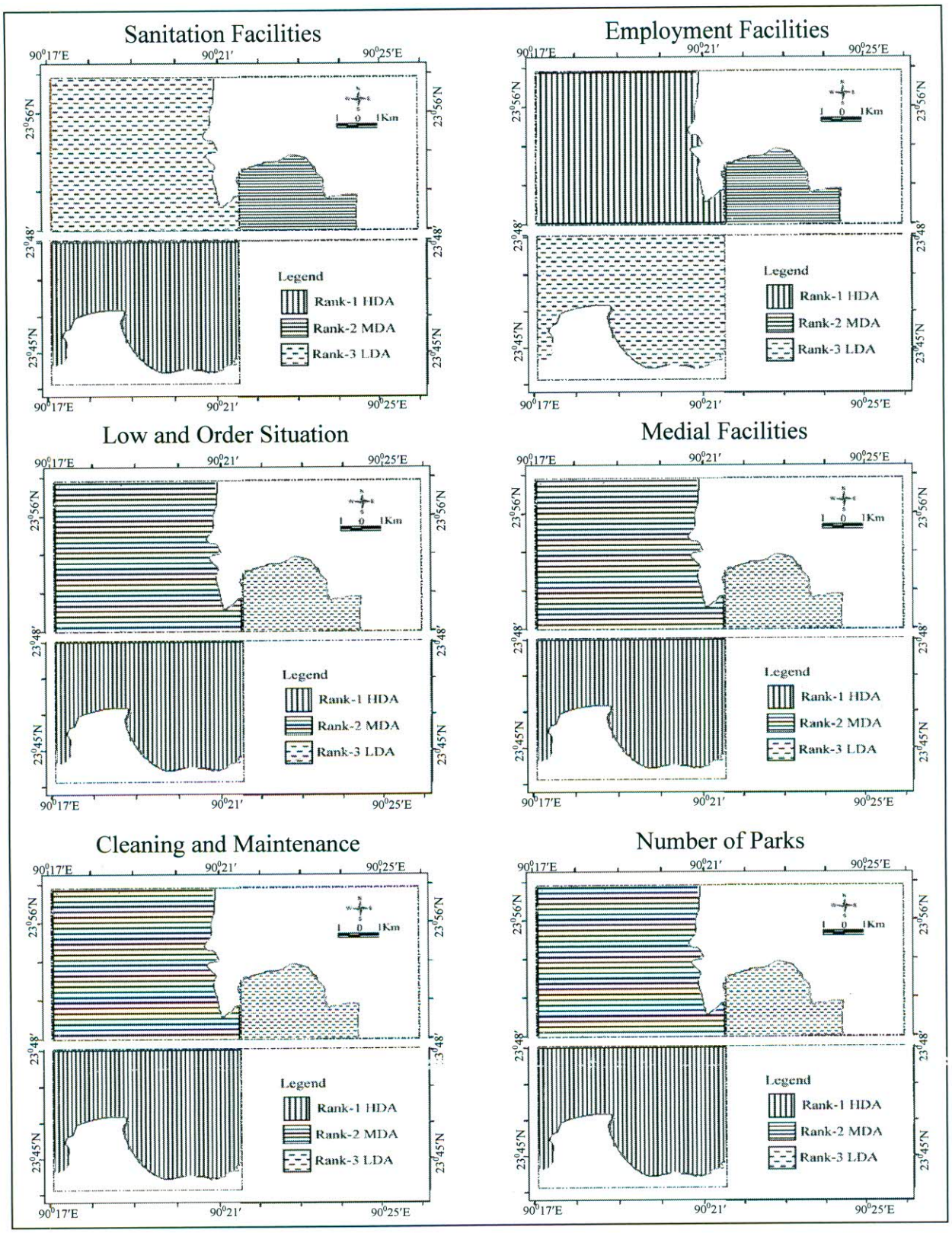
Appendix E1 Spatial Variation of Degraded Urban Environment



Source: Field Survey, 2010

Note: HDA-Highly Degraded Area, MDA-Moderately Degraded Area, LDA- Lower Degraded Area.

Appendix E2 Spatial Variation of Degraded Urban Environment



Source: Field Survey, 2010

Note: HDA-Highly Degraded Area, MDA-Moderately Degraded Area, LDA- Lower Degraded Area.

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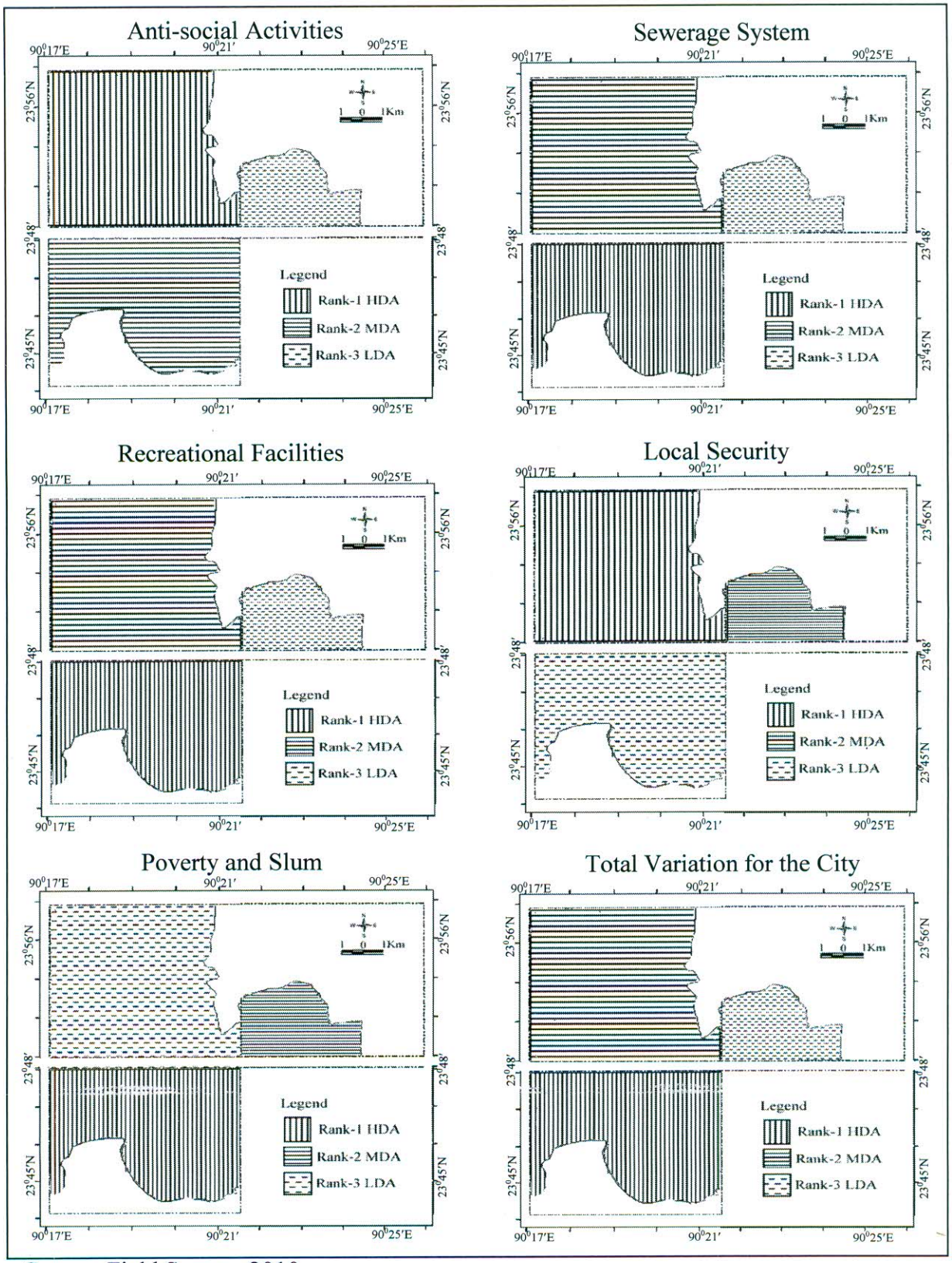
Appendix E3 Spatial Variation of Degraded Urban Environment



Source: Field Survey, 2010

Note: HDA-Highly Degraded Area, MDA-Moderately Degraded Area, LDA- Lower Degraded Area.