Land Suitability Analysis for Urban Green Areas

Using New Methods and Techniques

A thesis submitted in partial fulfillment of the requirements of
The PHD. of Science Degree in Urban Design and Planning

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God gives success
Dedication:

I would like to dedicate this thesis to my husband, my elder son “youssof” and his brother “samir”
بسم الله الرحمن الرحيم

"وَقُل رَّبِّ زِدْنِي عِلْمًا"

سورة طه، اية 114
# List of Contents

- Literature Review .......................................................... XII
- Introduction: ................................................................. XVIII
- Research Problem: .......................................................... XIX
- Research Goal: ............................................................... XIX
- Research Methodology .................................................... XX
- Research Hypotheses: ..................................................... XX
- Research Contribution ....................................................... XXI
- Research Case Study: ....................................................... XXI
- Research Scope and Limitation: ...................................... XXI
- Problems Facing the Researcher: ................................... XXII
- Definitions: ................................................................. XXII
- Research Contents: ....................................................... XXIV
- Research Structure: ....................................................... XXVIII

## Chapter One

1.1. Introduction: ............................................................ 1

1.2. Definition of a City: .................................................. 2

1.3. Type of cities: ........................................................... 3
   - 1.3.1. The First Aspect: .............................................. 3
   - 1.3.2. The Second Aspect: ......................................... 4

1.4. Entireties of City System: ....................................... 4

1.5. Inhabitants: ............................................................ 6
   - 1.5.1. The Common Characteristics of Inhabitant Structure: .......... 6
   - 1.5.2. The Employment of Inhabitants: ............................. 7
   - 1.5.3. Health of Inhabitants: ....................................... 7
   - 1.5.4. Economic Development: .................................... 8
   - 1.5.5. Security of Urban Inhabitants: ............................ 10

1.6. Mobility: ............................................................. 11
   - 1.6.1. Localization: ............................................... 11
   - 1.6.2. Communicational: ........................................... 13
1.7. Environmental Pollution..........................................................13
1.8. Traffic safety: ........................................................................15
1.9. Conclusion:..............................................................................19

Chapter Two

2.1. Introduction: ..........................................................................23
2.2. Definition of Traditional, Digital Urban Planning, Territory Planning, and Spatial Planning: .........................................................23
   2.2.1. Traditional Urban Planning: ............................................24
   2.2.2. Digital Urban Planning: ...................................................25
   2.2.3. Territory Planning: ...........................................................27
   2.2.4. Spatial Planning: ..............................................................29
   2.2.5. The Functions of the Master Plan / Development: .............30
2.3. Urban Planning Objectives and Objects: ..................................30
2.4. Urban Planning Goals: ............................................................32
2.5. Types of Urban Planning: .......................................................34
   2.5.1. Strategic planning: .........................................................34
   2.5.2. Physical planning: ..........................................................36
   2.5.3. General planning: ...........................................................37
2.6. Urban Planning Participants: ...................................................38
   2.6.1. The first group of planning participants: .........................38
   2.6.2. The second group of Planning Participants: .....................39
2.7. Evaluation of General and Detailed Plan: .................................41
   2.7.1. Feasibility of a Plan: ........................................................41
   2.7.2. Governmental Supervision of Planning: ............................41
   2.7.3. Societal & Financial Evaluation: ......................................41
   2.7.4. Organizational & Political Evaluation: .............................41
2.8. Conclusion:..............................................................................43

Chapter Three

3.1. Introduction: ..........................................................................47
3.2. City Structure and Planning: ..................................................49
   3.2.1. Component of City Structure.............................................49
# Land Suitability Analysis for Urban Green Areas

## Using New Methods and Techniques

**Contents**

### 3.2.2. Relation between City Structure and Planning:
- Page 49

### 3.3. City Development:
- Page 50
  - 3.3.1. City Development Concepts:
  - Page 50
  - 3.3.2. City Development Structure:
  - Page 51

### 3.4. Living Territories and Land Uses Carbon emissions:
- Page 54

### 3.5. Transport System Carbon Emission:
- Page 58
  - 3.5.1. Methodologies of Calculating CO₂ Emissions:
  - Page 58
  - 3.5.2. Transportation Green House Gases (GHG) Analysis Tools:
  - Page 65

### 3.6. Industrial Zone Carbon Emission:
- Page 71

### 3.7. Global CO₂ Emission by Sector:
- Page 78

### 3.8. Improving the Natural and Built Ecological Systems in an Urban Environment by Green Network:
- Page 80
  - 3.8.1. Ecological View in Designing New York Green Space System:
  - Page 81
  - 3.8.2. Ecological View in Designing Beijing, China Green Space System:
  - Page 82
  - 3.8.3. Ecological View in Designing London Green Space System:
  - Page 83
  - 3.8.4. Role of Ecological Patches and Corridors in the Sustainability of Urban Environments:
  - Page 84

### 3.9. Conclusion:
- Page 86

---

## Chapter Four

### 4.1. Introduction:
- Page 93

### 4.2. Urban Green Areas:
- Page 94
  - 4.2.1. Urban Green Areas System and Definition:
  - Page 94
  - 4.2.2. Increasing Hedonic (Property) Value:
  - Page 95
  - 4.2.3. Importance of Green Areas:
  - Page 95

### 4.3. City’s Benefit from City Green Areas:
- Page 97
  - 4.3.1. Income from Out-of-Town City Green Network Visitor Spending (Tourists):
  - Page 97
  - 4.3.2. Direct Use Value:
  - Page 98
  - 4.3.3. Health Value:
  - Page 98
  - 4.3.4. Community Cohesion:
  - Page 99
  - 4.3.5. Removal of Air Pollution by Vegetation:
  - Page 100
Chapter Five

5.1. Introduction: .................................................................139
5.2. Practical Model Detected from the Theoretical Part: ...........139
5.3. Development of a Conceptual Framework: .......................141
5.4. Land Suitability Analysis Based on GIS: .........................141
   5.4.1. The prioritize values of each map: .........................142
   5.4.2. Percentage Weight (Influence) Assigned to Each Raster: ....145
5.5. Ways of Calculation of Co2 Emitted from Different Land Uses along New City: ..................................................145
   5.5.1. Ground Based Transportation Sector: .......................146
   5.5.2. Different Building uses along the city: .......................148
   5.5.3. Industrial Zones along the city: ...............................149
   5.5.4. Land Uses along the city: ......................................151
   5.5.5. Green Area Required: ........................................152
5.6. Landscape Ecology Principle: ......................................152
Chapter Six

6.1. Introduction: ................................................................. 157
6.2. Case Study of New City (10 of Ramadan): ......................... 157
6.3. Methodology taken in the case study: ................................ 161
6.4. Data Gathering and Preparation: ..................................... 161
   6.4.1. Types of maps needed: ............................................. 162
   6.4.2. Types of data needed: ............................................. 171
6.5. Data Base Design and System Structure: .......................... 180
   6.5.2. Design of Proper Location for Urban Green Spaces: ........ 183
   6.5.3. The ecological factor threshold method: ....................... 187
   6.5.4. The Landscape Ecology Principles: ............................. 197
6.6. Discussion: .................................................................. 201

Chapter Seven

7.1. Conclusion: ................................................................. 211
7.2. Recommendation: ...................................................... 214
   7.2.1. Actions in homes and offices: .................................... 214
   7.2.2. Actions for transport: .............................................. 215
   7.2.3. Actions for industry: .............................................. 216
   7.2.4. Recommendations for Technologies Contributing to Short- to
          Medium-Term Greenhouse Gas Emissions Reduction: ........ 217
7.3. Findings: .................................................................. 219

References

References. ................................................................. 221
List of Figures

Figure 0-1 A world map at A.D.150 .................................................................XIII
Figure 0-2 A classic “T-O” map with Jerusalem at center and east toward the top .........................XIII
Figure 0-3 Al-Idrisi’s map of the world ..............................................................XIV
Figure 0-4 Northern regions map ......................................................................XIV
Figure 0-5 Ptolemaic projection map ................................................................. XV
Figure 0-6 World map of Rosselli ......................................................................XV
Figure 0-7 fully expanded Ptolemaic projection of the world ............................... XVI
Figure 0-8 World map in Mercator projection .................................................... XVI
Figure 0-9 Shows research contribution method ................................................ XXI
Figure 0-10 Whole Structure of the thesis ........................................................ XXVIII
Figure 1-1 Population density in Egypt ................................................................ 1
Figure 1-2 Government’s boundaries of Egypt ...................................................... 5
Figure 1-3 GNP density .......................................................................................8
Figure 1-4 Migration directions in Egypt ............................................................ 12
Figure 1-5 Carbon dioxide emission along the world ......................................... 14
Figure 1-6 Two separate junctions one for pedestrians and the other for means of transportation .......... 16
Figure 1-7 a street with houses on both sides ..................................................... 17
Figure 1-8 Building located away from street .................................................... 17
Figure 2-1 Gulf Urban layouts ........................................................................... 24
Figure 2-2 Process of Strategic Planning Model ................................................ 24
Figure 2-3 Gwanggyo city centre ....................................................................... 25
Figure 2-4 Contents of digital urban planning ..................................................... 26
Figure 2-5 Application of customer service model ............................................ 27
Figure 2-6 Riga Spatial Planning ....................................................................... 29
Figure 2-7 Planning object Digram .................................................................... 31
Figure 2-8 A picture shows that strategic planning is a collective product of creative thinking .......... 35
Figure 2-9 A picture shows the citizen participation in strategic planning ............. 35
Figure 2-10 Brown University Campus ............................................................. 36
Figure 2-11 Oregon state plan ........................................................................... 37
Figure 2-12 Stages of urban planning ............................................................... 37
Figure 2-13 A picture for inhabitants .................................................................. 39
Figure 2-14 Second group of planning participant ................................................................. 40
Figure 3-1 Moscow functional zoning plan ........................................................................... 50
Figure 3-2 Schematic representation of trips patterns within a metropolitan area ................. 52
Figure 3-3 Rhein-Ruhr Polycentric structure ....................................................................... 52
Figure 3-4 Berlin-Brandenburg monocentric structure ......................................................... 52
Figure 3-5 Urban structure models: a – centralized, b – decentralize, c – decentralize concentration ... 53
Figure 3-6 The “finger plan” for the Copenhagen region ......................................................... 54
Figure 3-7 Global CO2e emissions by sector, (2004) ............................................................ 78
Figure 3-8 CO2 Emissions from Fossil Fuel Consumption by Sector ...................................... 79
Figure 3-9 Total 2002 U.S. CO2 Emissions from Industrial Sources, by Sector (MMTCO2E) .... 79
Figure 3-10 CO2 Emission by Sector in Malaysia ................................................................ 80
Figure 3-11 Contribution to total CO2 – Equivalent Emission by Sector ............................... 80
Figure 3-12 Ecological principle in New York ...................................................................... 81
Figure 3-13 Ecological principle in Beijing .......................................................................... 83
Figure 3-14 Ecological principle in Beijing .......................................................................... 84
Figure 3-15 Considerations for structural and functional improvement of patches, corridors and matrix .... 85
Figure 4-1 Meridian Hill Park in Washington ...................................................................... 95
Figure 4-2 National Historic park in Philadelphia ................................................................. 97
Figure 4-3 Central Park in New York ................................................................................... 97
Figure 4-4 The Frog Pond in the Boston ............................................................................ 98
Figure 4-5 McKinley Park, Sacramento .............................................................................. 99
Figure 4-6 “Friends of parks”, Philadelphia park ............................................................... 99
Figure 4-7 The steps involved in the development of green spaces .................................. 101
Figure 4-8 Flowchart indicating the land suitability analysis for urban green space development 102
Figure 4-9 The land suitability in Hanoi ............................................................................. 103
Figure 4-10 The composite green map for Hanoi ............................................................... 106
Figure 4-11 2020 Hanoi Master Plan ................................................................................. 106
Figure 4-12 the proposed green wedges for Hanoi ............................................................ 109
Figure 4-13 The proposed greenbelt for Hanoi ................................................................. 110
Figure 4-14 The proposed greenways for Hanoi ............................................................... 112
Figure 4-15 The proposed comprehensive green structure for Hanoi ................................. 113
Figure 4-16 Serio-Oglio study area in the Province of Bergamo, northern Italy .................... 115
Figure 4-17 Decision paths in spatial decision problems .................................................... 117
Figure 4-18 The criteria tree constructed for assessing the suitability of each area .............. 119
Figure 4-19 Histogram synthesizing the result of comparing 32 established PLIS green spaces .......... 120
Figure 4-20 The criteria tree used in the analysis of the Serio-Oglio study area ........................................ 121
Figure 4-21 The composite suitability index map of the Serio-Oglio study area ........................................ 124
Figure 4-22 The boundaries of the four alternative options of the local park ................................................. 125
Figure 4-23 The first alternative .................................................................................................................... 125
Figure 4-24 The second alternative ................................................................................................................ 126
Figure 4-25 The third alternative .................................................................................................................... 126
Figure 4-26 The forth alternative .................................................................................................................... 127
Figure 4-27 The criteria tree structure used for the evaluation and choice phase of alternative options ..... 128
Figure 4-28 A figure shows Standardization functions of two distance maps .............................................. 129
Figure 4-29 The comparison of the four alternative choices of the Serio-Oglio study area .......................... 133
Figure 5-1 Practical Model ........................................................................................................................... 139
Figure 5-2 Ground based transportation sectors .......................................................................................... 146
Figure 5-3 The process for improving the natural and built ecological systems .......................................... 154
Figure 6-1 shows 10RC location .................................................................................................................... 158
Figure 6-2 City Cordon and Border .............................................................................................................. 158
Figure 6-3 Master Current Plan of 10th of Ramadan ....................................................................................... 159
Figure 6-4 Current land use and main landmarks within the city ................................................................. 162
Figure 6-5 Satellite image for 10th of Ramadan ............................................................................................ 165
Figure 6-6 Height of the building in 10th of Ramadan .................................................................................... 165
Figure 6-7 Residential Pattern in 10th of Ramadan ....................................................................................... 166
Figure 6-8 Industrial Zones in 10th of Ramadan ............................................................................................ 166
Figure 6-9 Existing green areas ...................................................................................................................... 167
Figure 6-10 Water network system ............................................................................................................... 167
Figure 6-11 Air pollution map source ........................................................................................................... 168
Figure 6-12 A current traffic map .................................................................................................................. 168
Figure 6-13 Paths of mass transportation map ............................................................................................... 169
Figure 6-14 Type of soil ................................................................................................................................. 169
Figure 6-15 Ground water extraction of the soil ............................................................................................ 170
Figure 6-16 Climate properties ...................................................................................................................... 170
Figure 6-17 The steps involved in the development of green spaces in 10th of Ramadan ............................. 181
Figure 6-18 Steps of protection of valuable area ............................................................................................ 181
Figure 6-19 Steps of restoration of degraded situation .................................................................................. 182
Figure 6-20 A figure shows the criteria tree constructed for assessing the suitability of each area ............ 183
Using New Methods and Techniques

Land Suitability Analysis for Urban Green Areas

Figure 6-21 Raster Land Use map ................................................................. 184
Figure 6-22 Raster Lithology Map .............................................................. 184
Figure 6-23 Raster Pollution Map .............................................................. 184
Figure 6-24 Raster Water Network Map ................................................... 184
Figure 6-25 Raster Ground Water Extraction Map.................................... 184
Figure 6-26 Raster Climate Map ................................................................. 184
Figure 6-27 Weighted Sum Tool in GIS .................................................... 185
Figure 6-28 Land Suitability map .............................................................. 185
Figure 6-29 GIS Transportation Model .................................................... 187
Figure 6-30 The GIS Building use Model .................................................. 189
Figure 6-31 CO2 Industrial Zones Emission Model ................................... 192
Figure 6-32 GIS Land Parcel Model .......................................................... 195
Figure 6-33 Pollution Emission map ......................................................... 196
Figure 6-34 Existing green areas along the city ....................................... 198
Figure 6-35 Green structure at region scale ............................................. 198
Figure 6-36 Green structure at city scale .................................................. 199
Figure 6-37 Green structure at the neighbourhood scale ....................... 200

List of Tables

Table 0-1 Terms that has been used along the thesis .................................. XXII
Table 3-1 Forecast for Carbon Dioxide Emissions from Fossil Fuel Use .......... 55
Table 3-2 Aggregate emissions of a conventional building ....................... 56
Table 3-3 Energy consumption and CO2 emissions associated with the use of different types of buildings .... 57
Table 3-4 CO2 Emitted According to Land Uses ........................................ 57
Table 3-5 Fuel Types Commonly Used by Different Transportation Modes ................................................................................................................................. 59
Table 3-6 Average energy use and CO2 emissions by mode ....................... 61
Table 3-7 Fuel Properties Used in the Analysis ............................................ 62
Table 3-8 Forecast for Carbon Dioxide Emissions from Fossil Fuel Use .......... 63
Table 3-9 Applicability of Tools for Transportation GHG Analysis ................. 70
Table 3-10 CO2 emission for different industries ....................................... 72
Table 3-11 Energy used and CO2 emitted for different industries and activities in Netherland .......... 73
Table 3-12 Forecast for Carbon Dioxide Emissions from Fossil Fuel Use .......... 74
Table 3-13 CO2 Emissions for Key Industrial Sectors (MMTCO2E) .................. 75
Table 3-14 CO2 emitted according to industry quantity & type .................... 76
Table 3-15 Carbon Dioxide Emissions from Manufacturing by Industry and Industry Group ............................................. 77
Table 3-16 The natural and built ecological systems in 3 metropolitan areas ................................................................. 84
Table 4-1 The weighting score for each factor to develop the composite map ................................................................. 105
Table 4-2 A table shows the sequence of activities performed in this study .................................................................. 116
Table 4-3 Maps and Standardization methods used to represent the constraints ................................................................. 121
Table 4-4 weights assigned to each factor and group in the design phase ...................................................................... 123
Table 4-5 A table shows Pair-wise comparison matrix, expressing the capability of each alternative ......................... 129
Table 4-6 Weights assigned to each factor and group of factors in the evaluation phase ............................................. 131
Table 4-7 A table shows the results of the evaluation phase .............................................................................................. 133
Table 5-1 Land use suitability ............................................................................................................................................... 143
Table 5-2 lithology suitability .............................................................................................................................................. 143
Table 5-3 Existing green areas suitability ........................................................................................................................ 143
Table 5-4 water network suitability ..................................................................................................................................... 144
Table 5-5 Source of Pollution Suitability ........................................................................................................................ 144
Table 5-6 Climate properties ................................................................................................................................................ 144
Table 5-7 Ground water extraction suitability ..................................................................................................................... 144
Table 5-8 Suitability and influence of each map .................................................................................................................. 145
Table 5-9 Petrol and Diesel Car Emission ........................................................................................................................ 146
Table 5-10 Taxi and Cairo Cap Emission .......................................................................................................................... 147
Table 5-11 Vans Emission .................................................................................................................................................... 147
Table 5-12 Buses Emission .................................................................................................................................................... 147
Table 5-13 Motorcycle Emission ......................................................................................................................................... 148
Table 5-14 Railway Emission ................................................................................................................................................ 148
Table 5-15 CO2 emissions associated with the use of different types of buildings ........................................................ 149
Table 5-16 CO2 emission per factory ................................................................................................................................. 150
Table 5-17 CO2 emission for different land uses ................................................................................................................ 152
Table 5-18 Considerations for structural and functional improvement of patches, corridors and matrix in the urban landscape .......................................................................................................................... 153
Table 6-1 Estimated area and quantity of the data available ............................................................................................... 160
Table 6-2 Sequence of Activities performed in the case study ............................................................................................ 161
Table 6-3 Main land uses within the city ............................................................................................................................. 163
Table 6-4 A Main land uses within the city North Cairo Ismalia Road and East El Robiky Road ................................... 171
Table 6-5 Main land uses within the city North Cairo Ismalia Road and West El Robiky Road .................................... 172
Table 6-6 Main land uses within the city South Cairo Ismalia Road and East El Robiky Road ................................... 173
Table 6-7 Main land uses within the city South Cairo Ismailia Road and West El Robiky Road .......... 173
Table 6-8 Population carrying capacity along years ................................................................. 174
Table 6-9 Building height within the city .................................................................................. 174
Table 6-10 Building pattern within the city .............................................................................. 175
Table 6-11 Industrial zones within the city ............................................................................... 175
Table 6-12 Industries within the city.......................................................................................... 176
Table 6-13 Water sources within the city .................................................................................. 177
Table 6-14 Average traffic volume within the city ................................................................. 178
Table 6-15 Different type of average traffic volume within the city ........................................ 179
Table 6-16 Number of local buses within the city ................................................................. 179
Table 6-17 Suitability Score ...................................................................................................... 183
Table 6-18 Land Suitability Maps for green areas ................................................................. 184
Table 6-19 CO2 Transportation Emission ............................................................................... 188
Table 6-20 CO2 Building Use Emission .................................................................................. 191
Table 6-21 Industrial CO2 emission ......................................................................................... 194
Table 6-22 Land Parcels uses ................................................................................................. 196
Table 0-1 Recommendations Technology .............................................................................. 217
Literature Review

People have used maps for centuries to represent their environment. Maps are used to show locations, distances, directions and the size of areas. Maps also display geographic relationships, differences, clusters and patterns. Maps are used for navigation, exploration, illustration and communication in the public and private sectors. Nearly every area of scientific enquiry uses maps in some form or another. Maps, in short, are an indispensable tool for many aspects of professional and academic work¹.

Cartography is the art and science of making maps. The oldest known maps are preserved on Babylonian clay tablets from about 2300 B.C. Cartography were considerably advanced in ancient Greece. The concept of a spherical Earth was well known among Greek philosophers by the time of Aristotle (ca. 350 B.C.) and has been accepted by all geographers since. Greek and Roman cartography reached a culmination with Claudius Ptolemaeus (Ptolemy, about A.D. 85-165). His "world map" depicted the Old World from about 60°N to 30°S latitudes. He wrote a monumental work, Guide to Geography (Geographike hyphygesis), which remained an authorities reference on world geography until the Renaissance².

At around the time of 500 years B.C, the Greeks understood that the earth was round and this was an essential development for cartography since people earlier had been describing the earth as a flat surface³.

At around 200 B.C, the Greeks started to create more accurate maps of North Africa and in Europe, around the Mediterranean. They even tried to estimate the length of the equator, which they managed to do quite well. This is amazing considering the tools they had at this time⁴.

During the middle Ages, the field of cartography in Europe suffered from a setback caused by the conservative church, which did not allow the field and studies of cartography to develop. It was not until the renaissance began⁵.

At A.D. 150, Ptolemy's map of the world, republished in 1482. Notice the use of latitude and longitude lines and the distinctive projection of this map¹.

⁴ IBID.
During the Medieval period in the beginning of the 12th century, European maps were dominated by religious views. The T-O map was common. In this map format, Jerusalem was depicted at the center and east was oriented toward the map top. Viking explorations in the North Atlantic gradually were incorporated into the world view beginning in the 12th century. Meanwhile, cartography developed along more practical and realistic lines in Arabic lands, including the Mediterranean region. All maps were, of course, drawn and illuminated by hand, which made the distribution of maps extremely limited².

2 IBID
In the 12th century, al-Idrisi's map of the world, 1456. Al-Idrisi was a muslin scholar in the court of King Roger II of Sicily. He completed a map of the known world. Drawn with south at the top.

![Figure 0-3 Al-Idrisi's map of the world](source: Katharine Harmon, 2010, Contemporary Artists Explore Cartography, Princeton Architectural Press.)

From the 12-14th centuries, S. Munster's Cosmographia (1588) mapped the northern regions map from north Atlantic region. One of the last wood-engraved maps, done in the style of copper-plate engraving.

![Figure 0-4 Northern regions map](source: Whitfield, 1994, The image of the world, Pomegranate Art books Press.)

---

1 Katharine Harmon and Gayle Clemans, (Sep, 2010), The Map as Art: Contemporary Artists Explore Cartography, Princeton Architectural Press
In the 16th century 1507, Waldseemüller's world map, the first map to incorporate new world discoveries. This map is based on the Ptolemaic projection, but does not show the entire globe\textsuperscript{1}.

![Figure 0-5 Ptolemaic projection map](Source: Gretchen N. Peterson, 2009, GIS Cartography, CRC Press.)

In the 16th century 1508, World map of Rosselli, the first map to show the entire globe. A mythical southern continent is shown, and ocean areas are much too small. Nonetheless, it is a true world map\textsuperscript{2}.

![Figure 0-6 World map of Rosselli](Source: Gretchen N. Peterson, 2009, GIS Cartography, CRC Press.)

\textsuperscript{1} Gretchen N. Peterson, 2009, GIS Cartography: A Guide to Effective Map Design, CRC Press; 1 edition

\textsuperscript{2} IBID
In the 16th century 1530, Heart-shaped world map of Apian. A fully expanded Ptolemaic projection of the world results in this heart-shaped map. Popular during the Renaissance, this kind of map is a novelty today.

Figure 0-7 fully expanded Ptolemaic projection of the world
(Source: Gretchen N. Peterson, 2009, GIS Cartography, CRC Press.)

In the 16th century 1569, the modern cartography really started to develop. One very important person in the development of cartography was Gerhardus Mercator, who lived in the 16th century was the leading cartographer of the mid-16th century. He developed a cylindrical projection that is still widely used for navigation charts and global maps. He published a map of the world in 1569 based on this projection. Many other map projections were soon developed. World map in Mercator projection by van Keulen, about 1720. On this projection, all straight lines are true bearings. This results in great size distortion toward the poles.

Figure 0-8 World map in Mercator projection
(Source: Gretchen N. Peterson, 2009, GIS Cartography, CRC Press.)

2 IBID
XVI
Then cartography progressed fast from the 16th to 19th century, but the really modern cartography didn’t develop until about a hundred years ago. Nowadays the world are quite skilled in this area, and can do very complicated, as well as simple, maps. Users are often using GIS and satellite images in map making, and to get better and better instruments making it able to describe the earth with higher and higher accuracy\textsuperscript{1}.

Geographic information systems (GIS) emerged in the 1970-80s period. GIS represents a major shift in the cartography paradigm. In traditional (paper) cartography, the map was both the database and the display of geographic information. For GIS, the database, analysis, and display are physically and conceptually separate aspects of handling geographic data. Geographic information systems comprise computer hardware, software, digital data, people, organizations, and institutions for collecting, storing, analyzing, and displaying georeferenced information about the Earth\textsuperscript{2}.

\begin{flushright}
\textsuperscript{1} Gretchen N. Peterson, 2009, GIS Cartography: A Guide to Effective Map Design, CRC Press; 1 edition
\end{flushright}

\begin{flushright}
\textsuperscript{2} Katharine Harmon and Gayle Clemans, (Sep, 2010), The Map as Art: Contemporary Artists Explore Cartography, Princeton Architectural Press
\end{flushright}
Introduction:
A worldwide revolution in information and communication technology is taking place. This transformation in communication and technology is fundamentally changing and affecting our life style. Traditionally, data providers have supplied data in open ASCII formats with systems simultaneously loading and translating it into the proprietary binary format. Data can be exchanged between systems where an import option exists for the particular formats. There are also bespoke translation tools available to cover every possible option. Exchange between formats has advanced further in recent years and the term interoperability has become important. Within a single organization there can be several different software products being used and it is imperative that information can be shared between them.

Sustainable urban development is essential to enhance the quality of life of citizens and to decrease the impact of cities upon resources outside the urban context. Redeveloping and planning green spaces and urban structure become the fundamentals of the sustainable urban planning of the city. An effective urban planning using recent technology is required to contribute to the social and physical development of the cities through promoting the land value. The thesis aims to develop a method to select the most suitable spaces for green areas, to maintain ecological balance and organization of the urban green areas, using Geographic Information System that assist in effective planning in green areas. Land suitability analysis, ecological threshold method, and landscape ecology principle is going to be applied on one of the Egyptian new cities in desert environment (10th of Ramadan), as the practical part is going to suggest a method of green network planning that would help in enhancing the connectivity and reduce the fragmentation through integrated greenway system. Results are going to reveal that the green ways could be developed to play a more significant role to bring nature into the city. Finally an ecological base for building and eco-city of 10th of Ramadan is proposed.

The thesis is structured of seven chapters; the first chapter reviews the city as an open system that should strike the balance between modern development and retention of the historic heritage, the second chapter discusses urban planning process through the interaction between human activity and land uses including those factors producing pollution and stress. The third reviews the city structure as an object of general urban planning testing the structure of particular city zones, plot fragment, besides their groups as an object of detailed or spatial urban planning. The forth chapter discusses the land

1 www.gao.gov/fraudnet/fraudnet.htm
2 wsdot.wa.gov/eesc/environmental/programs/watershed/snobas/other_links/final_report.cfm.
suitability analysis for urban green areas, the ecological factor threshold method, and the landscape-ecology principles in planning comprehensive green structure through the different international experiences. The fifth chapter deducted the methodology that has been concluded from the previous theoretical chapters to be applied on the case study. Chapter six brings up the case study using the GIS as a tool to determine the most suitable areas for urban green network to reach the carbon oxygen balance in the city. The last chapter has reached several general conclusions through the use of the theoretical study and the practical one while depicting their various parts and it also illustrated several recommendations for the urban planner while planning his new city.

**Research Problem:**
Recent surveys have shown that the good quality of Egyptian life has been lost in our cities, as general planning doesn't contribute to the citizen needs and no carbon oxygen balance has been reached within the new cities, so urban planners should adopt to elect proper locations for the urban green spaces and to evaluate this selections in order to optimize the benefits of urban green spaces. It has been widely believed that urban green spaces an important component of urban ecosystems, and provides many environmental and social services that contribute to the quality of life in cities.

**Research Goal:**
Egyptian citizen dreams of a balanced environment for now to enjoy their lives and for the new generations to live in a healthy city. These dreams will take us to the research goal which is going to formalize methodologies to select suitable areas to be included in urban green spaces through:

- Land suitability analysis based on GIS.
- Quantifying green areas based on the ecological factor threshold method to maintain ecological balance.
- Applying landscape-ecology principles in organizing green spaces in urban areas.

The previous selection for urban green areas was mainly based on expert’s knowledge and strongly influenced by the existing City Master Plans. Referring to the fact that there was no formal method for this type of site selection process, so the research would introduce a new technique for this type of site selection.
Research Methodology

To reach the previous mentioned objective; the following methodologies will be adopted:

- The theoretical approach, the comparative, analytical approach, and the deductive approach.

The Theoretical Approach:

The theoretical approach will appear throughout the first three chapters of the thesis. This approach is depending on reviewing literature, books, and magazines.

This approach will be applied through, discussing the different concepts of the city as an open system, reviewing urban planning process through the interaction between human activity and land uses including those factors producing pollution and stress and amount of CO2 emitted from each activity, and illustrating city structure as an object of general planning, and its zones as an object of detailed or spatial planning.

The Comparative, Analytical Approach : ( Inductive approach)

The analytical approach will appear throughout chapter four and five of the thesis. This approach is depending on illustrating and analyzing the power of using GIS as a unique system in the land suitability analysis to reach ecological city, and also this approach depends on analyzing and processing international experiences of the ecological city.

This approach will be applied through, analyzing the city data, and urban green areas using GIS as an essential tool used for the land suitability analysis, ecological factor threshold method, and landscape-ecology principles in planning comprehensive green structure.

The Deductive Approach:

The deductive approach will appear throughout the chapter six, and seven. This approach is depending on deducting a methodology from the theoretical part and applying it on the case study to convert the desert city to ecological city through a network of urban green areas within the new city.

Research Hypotheses:

With the help of the new techniques and programs right decisions should be taken from urban planners in order to create a green network ecologically more effective than the sum of the individual green spaces, which will lead to form a base for an ecological city in XX
the future that will maintain carbon oxygen balance. As current urban green areas do not maintain ecological balance and organization of the green spaces, and the future plan seems to lack a theoretical basis, or a holistic framework, at different scales.

**Research Contribution**

Identifying suitable sites for conserving and developing green spaces is the first important step to reach balanced environment to live in a healthy city, so the thesis is going to introduce a new method and technique for developing green spaces in urban areas through Land suitability analysis based on GIS, quantifying green areas based on the ecological factor threshold method to maintain ecological balance, and applying landscape-ecology principles in organizing green spaces in urban areas.

![Diagram](image)

*Figure 0-9 Shows research contribution method (Source: Researcher.)*

**Research Case Study:**

There are several types of the new cities, Desert new cities, Agriculture new cities, Coastal new cities; the research is going to deal with the desert new cities.

**Research Scope and Limitation:**

- The research will focus on the land suitability analysis for urban green areas.
- This research will introduce the different planning theories that contribute to the CO2 emitted from different land uses along the city.
- The research is going to deal with the theories that illustrate the landscape ecology principle for urban green areas along the city.
- The research case study will focus on converting the desert new city to ecological cities by maintaining its current land uses and developing a network of urban green areas.
Problems Facing the Researcher:

The main problem that faced the researcher was lack of official resources for the case study, thereby the researcher’s main dependence was personal relationship to gather all the necessary information.

Definitions:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>An inhabited place of greater size, population, or more important than a town or village.</td>
</tr>
<tr>
<td>City plan</td>
<td>An organized arrangement (as of streets, parks, and business and residential areas) of a city with a view of convenience, appearance, healthful environment, and future growth – city planning.</td>
</tr>
<tr>
<td>City planner</td>
<td>One that makes city plans - a professional who participates in such activity; urbanism.</td>
</tr>
<tr>
<td>Town</td>
<td>A cluster of aggregation of houses recognized as a distinct place with a place name; a large densely populated urban area.</td>
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<tr>
<td>Settlement</td>
<td>A small village.</td>
</tr>
<tr>
<td>Village</td>
<td>A settlement usually larger than a hamlet and smaller than a town.</td>
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<tr>
<td>Urban</td>
<td>Constituting a city.</td>
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<tr>
<td>Urban ology</td>
<td>A study dealing with specialized problems of cities (as planning, education, sociology, politics).</td>
</tr>
<tr>
<td>Urbanization</td>
<td>The quality or state of being or becoming urbanized.</td>
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<tr>
<td>Urban Sprawl</td>
<td>The spreading of the urban development’s (as houses and shopping centers) on undeveloped land near a city.</td>
</tr>
<tr>
<td>Urban Planning</td>
<td>The act or process of making or carrying out city plan.</td>
</tr>
<tr>
<td>Metropolis</td>
<td>A large important city.</td>
</tr>
<tr>
<td>Attribute</td>
<td>Representation of an essential trait, quality or property of an object or entity.</td>
</tr>
<tr>
<td>Cartographic database</td>
<td>A set of cartographic data arranged systematically and methodologically.</td>
</tr>
<tr>
<td>Cartography</td>
<td>A method in geographic cognition as well as a field of scientific and...</td>
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</tbody>
</table>
Land Suitability Analysis for Urban Green Areas

Using New Methods and Techniques

<table>
<thead>
<tr>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial activity involving plane representation by graphic models of spatial natural and anthropogenic objects and phenomena, the production and publishing of cartographic products, and creation of geographic information databases.</td>
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<tr>
<td>Coordinate reference system</td>
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<td>Data</td>
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<td>Feature attribute</td>
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<td>Interoperability</td>
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<td>Land use</td>
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<td>Map</td>
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<td>Map projection</td>
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<td>Map scale</td>
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Research Contents:
The research comprises seven chapters presenting the following:

**Chapter One: City as a system**

Living in a healthy city is considered as an essential demand, which enables all its citizens to meet their own needs and to enhance their well-being, without damaging the natural world or endangering the living condition of other people, now or in the future. Serving this idea, this chapter is going to review the city as an open system, discusses the type of the cities, common characteristics of inhabitant and their impact on the different parts in the urban areas within a city. It handles also economic basis of the city and its impact on the skilled workforce, the mobility along the cities of the government, and the impact of the mobility on the government enterprises. Finally, the chapter discusses the sources of pollution along the city and the traffic safety.

The urban planning process is considered the tool that is used to plan the previous city elements in an organized strategy to build the eco-city. This will be discussed in the next chapter.

**Chapter Two: Urban Planning Process**

Urban and regional planning underlies the fabric of society as users deal with it today. Without planning, cities, towns, rural areas, and residential communities will not run efficiently. While communities today face many challenges, such as pollution and traffic, it can be addressed by careful and creative planning. It is the planner’s job to address such problems and provide viable solutions for today and the future. Serving this idea, this chapter discusses traditional and digital urban planning process, through interaction between human activities and land uses. It reviews also the territory planning as a preventive measures rather than investment. It also handles urban planning goals from the point of view that urban planning is not a onetime action but a continuous process, and finally discusses urban planning participant, and handles the stages and actions that are followed by urban planner in order to evaluate the general and detailed planning.

City structure is an object of general planning, and its zones are an object of detailed or spatial planning. This topic will be dealt with in the next chapter.

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1 Herbert Girardet, 1999, Creating Sustainable Cities (Schumacher Briefing, No. 2.), Chelsea Green Publishing.
Chapter Three: City Structure and Pollution Emission

Cities with differentiated or integrated functions, open or closed structures, monocentric or polycentric, compact or discreet, can acquire a variety of forms according to either the natural conditions surrounding the city, or the planning form of it. Serving this idea, the first part of this chapter reviews city structure, city development concepts from the point of view of functional zones concept and functional integration concept, city development structure in terms of city development concept.

As urban planners play the roles of developing functional and aesthetically pleasing cities with the highest and best use of land, and at the same time ensure that they are ecological friendly. It is important to develop low carbon cities to ensure low CO2 emissions in the urban areas, so the second part of this chapter illustrates every section in the new cities that is responsible for the carbon emission, these sections divide into three groups, the first group highlights on living territories and land uses carbon emission, the second group highlights on transportation system carbon emission, the last group highlights on industrial zones carbon emission. Finally this chapter reviews the natural and built ecological system in urban environment using a network of green areas.

Redeveloping and planning green spaces and urban structure are among the essentials of mass planning of a city. Accurate planning with the help of GIS is willing to be a big step in the physical and social development of the cities. The systematic view towards the subject of city planning, has not found its specific position in many countries. Most of our cities are designed, planned and administrated by inexpert individuals. It will be right if the skillful experts with the help of technical and scientific tools bring an end to the disordered state of most cities. There for, redeveloping and planning green spaces using new methods and techniques is going to be illustrated in the next chapter.

Chapter Four: Land Suitability Modeling for Urban Green Areas

Placing value on land and space within a city is an essential part of urban planning. "Placing values is important in urban planning because it shows community support" (Johnson, 1989). An example, if a community places high value on increasing its economy, the community may promote and support industrial or other business growth within the community. Community residents can show support for urban parks in the same fashion. Those communities that place high value on their park systems will often display and

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promote their parks with economic support. For this reason, parks and the general welfare of a city can often be related. If a community is growing economically, then that community may provide a fine park system. Supporting to the idea of placing value on land and space, this chapter is going to discusses, urban green areas system and definition, its hedonic value, and the importance of green areas and its benefits to the city. Finally this chapter handles three assumptions for database model one for Hanoi and the other for Serio-Oglio, and a international experience for Masder new City in Dubai

By reviewing the international examples for developing urban green areas within a city using an efficient methodology of structuring of geo-information, the next chapter is going to discusses all the standards that have been gathered from the previous theoretical part to be applied on the case study.

**Chapter five: Methods Applied on the Case Study.**

After reviewing the, city as an open system, urban and regional planning that underlies the fabric of society as users deal with it today, Cities with differentiated or integrated functions, open or closed structures, monocentric or polycentric, compact or discreet, that acquire a variety of forms according to either the natural conditions surrounding the city, geographic information system as an important tool that deal with new desert cities to convert it to ecological cities, and finally three of the international experiences of the ecological city, this chapter is going to gather all the important standards that have been deducted from the theoretical part to be applied on the practical one.

After gathering all the essential standards, the next chapter is going to discuss an Egyptian case study (10th of Ramadan), using new methods and techniques in order to convert the desert city to ecological city.

**Chapter Six: Case Study Results and Discussion.**

Urban green spaces, an important component of urban ecosystems, provide many environmental and social services that contribute to the quality of life in cities. One of the key tasks of planners is how to optimize the benefits of urban green spaces. This study introduces a new technique for developing green spaces in urban areas through:

- *Land suitability analysis based on GIS*: identifying suitable sites for conserving and developing green spaces is the first important step to ensure their roles and functions.
• **Quantifying green areas based on the ecological factor threshold method to maintain ecological balance:** Applying the ecological factor threshold method will help quantify how much green area is necessary to maintain an ecological balance in urban areas.

• **Applying landscape-ecology principles in organizing green spaces in urban areas:** the roles and functions of urban green spaces can be enhanced if they are organized by combining a variety of green space types for multiple purposes called a green network or urban green structure.

**Chapter Seven: Conclusions and Recommendations.**

The research has reached several general conclusions through the use of the theoretical study or the practical one while depicting its various parts. The research also has reached concluded methodology for the urban planner in order to reach a new city with carbon oxygen balance.
Research Structure:

Figure 0-10 Whole Structure of the thesis
(Source: Researcher)
Chapter 1
City as a system
1.1. Introduction:

Towns and cities attract people who wish to live there, work there, and go there as tourists or for cultural reasons. It has traditionally been the area for concentration of substantial resources and networks of influence. This chapter reviews a city as an open system that should strike the balance between modern development and retention of the historic heritage, the chapter also discuss the type of the cities, common characteristics of inhabitant and their impact on the different parts in the urban areas within a city, economic basis of the city and its impact on the skilled workforce, the mobility along the cities of the government and the impact of the mobility on the government enterprises, and finally the chapter discus the sources of pollution along the city and the traffic safety.

Beginning in the 19th century, associated with the Industrial Revolution, streams of people migrated into cities, drawn by jobs and wealth, theoretically leaving poverty behind, this was due to the development of urbanization and urban sprawl. The process is still continuing in many European countries. In others, especially in recent years, decentralization or reverse migration from the city towards suburbs has taken place - not only at weekends, but also more permanently by the search for a healthier, less polluted environment, a different job or more amenable surroundings.

Figure 1-1 Population density in Egypt

(Source: http://www.reddit.com/r/TrueReddit/comments/fcbh6/hyperbole_aside_what_is_the_internet_kill_switch/)

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2. Leonardo de vinici, (2004), GIS in urban planning, Sweden press
1.2. Definition of a City:
Many pioneers and planners defined the city from different points of view starting from 19th century till now. According to Alan S. Berger 1978, a city is considered as spatially limited of people organized into residential areas that form a larger aggregate, city based on the number of people live in a given area implies the use of legally or politically defined areas in which people are counted.\(^1\)

According to Goodall, B. 1987, Cities are considered as advanced systems for sanitation, utilities, land usage, housing, and transportation and more. This proximity greatly facilitates interaction between people and businesses, benefiting both parties in the process.\(^2\)

According to Alan Freeman, city cannot be political or take political or administrative boundaries as a starting point, but should instead arise from socio-economic study of what a city actually consists of.\(^3\)

While Herbert Girardet, city is organized so as to enable all its citizens to meet their own needs and to enhance their well-being without damaging the natural world or endangering the living condition of other people, now or in the future.\(^4\)

Also Brail, R.K. and Klosterman, R.E. 2001, stated that a city definition comprised three subsystems, the needs and accomplished functions of inhabitants, enterprises and authorities, preconditions and possibilities essential for the realization of needs and fulfillment of functions, and consequences of the activities of two previous subsystems.

Lately in 2007 Jonas, Andrew and Kevin Ward, stated that cities are increasingly surrounded by suburban communities such as towns and villages that are within commuting distance of the dominant city, rural municipalities that are developing industrial and commercial lands as well as housing tracts, and neighboring cities that are functionally inter-related with the economic sphere of the region. These city regions collectively constitute a regional matrix of residential, industrial, commercial, agricultural, recreational, and municipal services. It is the synergy of a diverse set of elements within a region that creates the ebb and flow of work and leisure, of social and political structures, and of quality of life and the collective health of communities.\(^6\)

It can be concluded that cities are places where people can live healthier and economically productive lives while reducing their impact on the environment. They work to

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\(^2\) Jane Jacobs, (1993), The Death and Life of Great American Cities (Modern Library Series), Modern Library
\(^3\) IBID
\(^4\) Herbert Girardet,(1999), Creating Sustainable Cities (Schumacher Briefing, No. 2.), Chelsea Green Publishing.
harmonize existing policies, regional realities, economic and business markets with their natural resources and environmental assets. Cities strive to engage all citizens in collaborative and transparent decision making, while being mindful of social equity concerns.

1.3. Type of cities:
A city should strike a balance between modern development and retention of the historic heritage; integrate the new without destroying the old; support the principle of sustainable development. A town without its past is like a man without memory. People leave traces of their lives and their work and their personal history in cities, in the form of neighborhoods, buildings, trees, churches, libraries. They constitute the collective legacy of the past, enabling people to feel a sense of continuity in their contemporary lives and prepare for the future.

Cities can be classified according to two accepts:

A. The first aspect classified the city according to the various sectors and activities that took place inside the city.
B. The second aspect classified the city according to population based on the national census figures.

1.3.1. The First Aspect:
The first aspect classified the city according to the various sectors and activities that took place inside the city. According to this aspect cities may be divided into three types, ultimate city, traditional city, and nontraditional city.

A. Ultimate City:
An ultimate city is one which succeeds in reconciling the various sectors and activities that take place (traffic, living working and leisure requirements); which safeguards civic rights; which ensures the best possible living conditions; which reflects and is responsive to the lifestyles and attitudes of its inhabitants; where full account is taken of all those who use it, who work or trade there, who visit it, who seek entertainment, culture, information, knowledge, who study there.

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1 Leonardo de vinici, (2004), GIS in urban planning, Sweden press.
2 IBID
B. Traditional City:
Is a city where the inhabitants engage in a variety of activities rather than in agriculture, forestry and fishery; it is a political, organizational, cultural and provisional center of a certain territory; the residential area exercises the prevalence of anthropogenic milieu and a more intensive utility in comparison to its contiguous areas.

C. Non Traditional City:
Is a city defined in the population census returns suggested by the United Nations Statistical Department, to conceive the concept resident agglomeration. In international terms, an agglomeration is made up of a group of houses with the in-between distance of no more than two hundred meters. On condition that this area houses no fewer than 2,000 residents, it fulfills the requirements of city agglomeration.

1.3.2. The Second Aspect:
The second aspect classified the city according to population based on the national census figures. According to this aspect cities may be divided into four classes1.

A. The First Class:
First class cities are those with more than 100,000 inhabitants. Once a city becomes a first class city, it will not lose that status unless its population decreases by 25 percent from the census figure.

B. The Second Class:
Second Class cities have populations of more than 20,000, but not more than 100,000.

C. The Third Class:
Third Class cities have populations of more than 10,000, but not more than 20,000.

1.4. Entireties of City System:
City system may be divided into three entireties which are elements, communication, and environment2.

A. Elements: may be considered as community, social, economic and technical systems or subsystems. Parts of the city identified as separate functional zones, districts, complexes or other territorial units.

B. Communication: may be considered as relations, dependencies, influence commonly reveals itself in terms of flows of people, means of transport, information, finance between interior and exterior city elements.

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2 http://mis.ucd.ie/staff/pkeenan/gis_as_a_dss.html
C. Environment: may be considered as natural and anthropogenic (organic and artificial) interior milieu, in which the majority of city processes take place, as well as the exterior of the city vital to the very existence of the city life.

Communication and elements are therefore greatly influenced by not every entirety but only the one pertaining all essential features could take the name of a system, the change of any city element (subsystem) causes the changes in other elements (subsystems), their interrelations and the relations with the exterior of the city.

A city system can be divided into inferior territorial subsystems, the latter subsequently being split into smaller units (zone-district-groups of buildings-sole building) this could be the subsystem of the lowest position. If necessary, a building can be regarded as a separate system. City subsystems follow a hierarchical pattern. A city system can also be divided into functional subsystems, e.g. social, transportation, green areas, water supply and etc.

It can be concluded that the performance of a city system is not predestined in advance. The system functions under the influence of a range of accidental factors, city management among them. However, this does not deny common truth that the city is a

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manageable system. The processes of analysis and planning contain all defined features and factors pertinent to a city system¹.

1.5. **Inhabitants:**

The size of the population in a city is generally the outcome of long lasting processes² as the development of economic basis, natural increase in population (birth and death ratio) and finally the mechanical increase in population (the ratio of those who moved in and those who moved out). The change in the administrative boundaries of a city is considered as a process not only taking place in the city but also on the national scale.

1.5.1. **The Common Characteristics of Inhabitant Structure:**

The common characteristics of inhabitant structure differentiation in urban areas are considers as³:

A. Legal and illegal economic migrants from poorly developed countries. They usually concentrate in central city parts, dilapidated and the cheapest.

B. Young unemployed and permanently jobless people migrating from villages to countries usually sit together in rented apartments in economic districts.

C. Asocial families and individuals, drug-users, the homeless, vagrants also rally in the premises of railroad and coach stations, market places communal places and warehouses, in neglected or poorly supervised houses and buildings.

D. National minorities quite regularly form local, isolated communities.

E. Prestige city districts, residential estates of embassies, rich and famous people, intellectuals and civic servants, emerge.

F. Special projects are made; separate housing estate districts or large groups of estates are built and utilized exceptionally by the rich in the suburbs or city vicinity, physically isolated from the outside and well-guarded.

In its complexity the city community exceeds the description in terms of age, marital status, gender, income and other traditional features; it is closely linked to specific problem groups of people.

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³ IBID
1.5.2. The Employment of Inhabitants:
Both the employment and the level of unemployment of inhabitants are significant features of welfare standards of the city. The unemployment rate of 3-5 % is usually considered to be a normal, even an economically auspicious phenomenon. The higher the unemployment rate, the more acute social problems, which, in their turn reflect poor economic situation within both the city and the country\(^1\).

In terms of employment, such characteristic groups of inhabitants are: all inhabitants, able bodied inhabitants, workforce, engaged (employed) inhabitants, jobless people.

A. Able-bodied population: The proportion of able-bodied population is bigger in the cities, which are younger due to higher birth rate and immigration of young people.

B. Workforce: Comprises all potential employees, with the exception to those still studying and able bodied, unemployed inhabitants due to various reasons (physical disability, engaged in personal household chores, housewives; parasites and etc.)

C. Engaged: Employed inhabitants encompass the ones employed by private and public sectors and municipal departments; freelance professionals (e.g., writers, artists, who make a living from author’s emoluments) and those who work under license.

D. Unemployed: The unemployed include the ones who have been made redundant or are at the initial stage of their employment, town people in search of a suitable job.

It could be concluded that employment survey is one of the components of the planning process. It could aid in the identification of a city as economic basis and its vitality, functional type, specialization and autonomy and finally the levels of industry novelty.

1.5.3. Health of Inhabitants:
The health of inhabitants depends on a variety of factors. A part of them can be called environmental factors, such as apartment and back yard; work, study, rest and other milieu, which surround any inhabitant at any period of his lifespan\(^2\).

Urban environment, if compared to rural is in many respects far more hazardous because of high concentration of pollutants, excessive noise pollution, vibrations, electromagnetic waves, dust and etc. Urban environment involves stressful situations, tension and conflict probability.

The concept of healthy environment is continuously changing. Formally it is defined by standardized pollution, noise, insulation, hygiene and similar norms. The limits are indicators and show when certain measures should be taken to reduce a negative impact of

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polluted environment on human health. The best way is to destroy the source of pollution; another and less effective is to eradicate the consequences; and the most passive one is to take away the source of air, noise or some other type of pollution, which has a negative impact, from the residential area. 

It can be concluded that, the concept of healthy environment associates with sufficient living space, and attempts are to avoid congestion. Healthy environment is impossible without good quality drinking water, network of gutter and cleaning systems, waste disposal and adequate maintenance of private and public spaces, green network spaces.

1.5.4. Economic Development:

The economic basis of a city contains those enterprises, those work places, to be more precise, the output and services of which are exported. Agriculture and forestry, fishery and hunting, mining industry (the primary sector), these are the activities uncharacteristic of cities; people, who are employed in these spheres, number in only a few percent. In all cities there is also a reduction in employment figures for traditional industrial and construction spheres, substituted by services and a wide range of work places in enterprises producing modern technologies, information technologies among them.

So it may be considered that economic development is a process in which services are provided, produced goods are sold, and in this way wealth is established. It is created mainly by the private sector. By the end of the millennium economic activity was highly concentrated geographically. This reflects differences in policies across countries, natural geographic advantages and disadvantages, and agglomeration and scale economy effects.

![Figure 1-3 GNP density](source: Malczewski, (1999). GIS and multicriteria decision analysis Inc. New York.)

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Urban economic development is in need of certain conditions. The most essential are related with:

A. Workforce: Skilled workforce gains an extreme significance, as it is capable of analyzing and problem solving; it is easily retrained or improved. The supply of such workforce is an urban merit, which provides the probability of investment. Strange as it might seem, mobility is one of the qualities of workforce, except for the cases, which involve brain drain - specialist emigration to richer countries. It is therefore in the interests of the city is to maintain highly modern educational and vocational training systems1.

B. Technologies: These are extremely rapidly changing and provide for higher labor productivity and quality. Science, knowledge and analysis is of utmost importance. Its costs usually exceed those of production. Technological innovations make enterprises more competitive. It is in the interests of every city to possess personal successfully operating scientific laboratories, universities, to support their co-operation with business and similar enterprises2.

C. Social and technical infrastructures: The urban supply of infrastructure services is evaluated in terms of three main aspects: quality, reliability and accessibility. Traditionally important is technical infrastructure: streets, roads, railways, ports, stations, network system of electric power, water, drainage, gas and heating; water reservoirs; cleaning, solid and hazardous waste collection and storage (utilization) systems; public transport system. Unconventional infrastructure: mobile telecommunication network, satellite communications, the Internet and etc; science parks, technological centers. Social infrastructure: nursery and primary schools, medical, cultural and educational establishments and etc3.

D. Financial: Capital is essential to launch and develop business. It can be either private or borrowed. The capital should be accessible, without it the possibilities for the urban economic development are scarce. It should be the focus of the national government interests, whose objective should also be the establishment of a positive legal basis, local municipalities also rendering considerable indirect assistance in the process4.

2 IBID
4 IBID
E. Management: Efficient management is crucial for the success of both business and city. City management can virtually predetermine not only whether the business environment is favorable or not, but also the entire development of urban economy\(^1\).

1.5.5. Security of Urban Inhabitants.

In the process of the arrangement of the city structure, its supervision and reconstruction, such well-established crime prevention means could be recommended according to the following points\(^2\):

A. Special attention should be given to city supervision (residential areas especially). This should be done in order to prevent the debasement of territories as well as the buildings located in them as it could give rise to the concentration of asocial people.

B. Residential areas and districts with integrated functions should be small. Huge, 150-200-hectare districts are quite inappropriate.

C. Design variety of a residential area (types of houses and apartment blocks and their status rented private and municipal apartments) should be sought for. This would help to avoid the concentration of age, social and ethnic groups in big territories. The probability of confrontation of such territories would be much scarcer, too,

D. Residential areas of integrated functions should be promoted. Houses, employment and service enterprises, located in an integral way, limit the interests of inhabitants and enhance their interrelations as well as their bond to the place, stimulate patriotism and consequently unofficial surveillance of the territory. Functional integration of the area should be used for as even as possible a serviceability of the territory in daytime and, in the absence of other obstacles, late in the evenings.

E. In order to strengthen the inhabitants’ union with their district, the boundaries of the territories serviced by post, bank, school, police and other establishments should match those of the residential district.

F. District boundaries should possess obvious visual identification signs. Relief or other natural characteristics could be employed for this purpose; a street, a railway, a green belt could run the boundary.

G. Functional organization of a city center should provide the possibility for the city residents and visitors to enjoy its benefits both in the daytime and at night. The activities in the city center or its part should escape a specialized nature, which would


mean rallying in the center only one single inhabitant group and thus assisting its domination there.

1.6. Mobility:
City dynamics is an emergent state of citizen’s microscopic movements in an evolving environment. The urban mobility modeling is a paradigmatic problem due to the implications for the life quality. The citizen’s propensities are the real causes of mobility, whereas the transportation networks allow realizing the mobility request.¹

However, in recent decades, mobility has become a value in itself. Travel distances have increased along with travel speeds and people generally now have to cover greater distances than they used to in order to fulfill the same needs as before in getting to school and to work, doing the shopping, visiting friends and family, etc.

Internal migration is responsible for redistribution of nearly 25 percent of Egypt’s population and for the rapid growth of Egypt cities specially Cairo and Alexandria. Internal migration in Egypt has generally been from south to north or from south and north to Cairo and Alexandria.²

There are two types of mobility along cities and villages, localization and communicational:

1.6.1. Localization:
While selecting the place of residence, accidentally or purposely an individual assesses job possibilities, healthy environment, access to service centers and schools and etc; career promotion and status acquisition chances and the like. This feature of mobility is equally pertinent to enterprises, but not to all, only to small-sized, modern ones, engaged in technologies.

The supply of more favorable business conditions, lower costs and a wide range of technical, economic, environmental and similar factors encourage benefiting from the advantages of mobility. Localization argumentation is also decisive on an investor’s choice to invest in one place but not in another.³

There are Three Types of Localization Mobility:
A. Inhabitant Migration: The most common direction is from rural areas to smaller towns, followed by further movement to bigger towns, cities and the final settlement

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² Jailan Zayan, (2007), Egypt - Culture Smart!: the essential guide to customs & culture, Kuperard, P 120-143
in one or other most prestigious cities or due to social, economic or political reasons result in emigration to other countries.

B. Seasonal Migration: Two of them are most common: a temporal change of the place of residence by workforce and pensioners and the seasonal migration of workforce related to the sectors of construction industry, agriculture and forestry.

C. Internal City Migration: It is caused by the change in life conditions (family size increase or decrease, decline in the environment quality), financial prospects, and office dislocation.

Figure 1-4 Migration directions in Egypt
(Source: John Urry, (2007), Mobilitie, Polity.)

It can be concluded that localization mobility is considered as the main feature that gives information about a city status, its rate of growth, possible investment and problems, so the policy challenge is not how to keep households from moving, but how to keep them from moving for the wrong reasons. Instead of trying to fight the pull of agglomeration economies on workers and their families, governments should work to eliminate the factors that push people out of their home areas. By doing so they can improve the quality of migration and encourage economic growth. Labor mobility driven by economic reasons leads to greater concentration of people and talent in places of choice and adds more to agglomeration benefits in these places than to congestion costs.
1.6.2. Communicational:

An individual’s mobility in search of a job, an assignment, rest, services by various means of transport, namely, by plane, bus, train, on a bicycle, or on foot. The concept of communicational mobility can also be applied to cargoes (raw materials, industrial output and goods, rubbish and etc.).

Types of Communicational Mobility (It means the business trips to other cities and countries).

A. Pendulum Migration: job related or with other purposes trips from surrounding areas to the city and vice versa, one-day trips from a city to other cities or villages. Its intensity is measured by the number of arrivers per 1,000 permanent inhabitants. The main reasons are lack of jobs and a shortage of adequate services.

B. Inhabitant Mobility inside the City: It is measured by the number of trips per day per one statistical inhabitant (over seven years of age).

It can be concluded that communicational mobility is considered as a feature that gives information about the importance of the city to the settlement system, the significance of communication network, types of transport and the development of street system.

During the recent ten decades the inhabitant mobility has increased ten times and still shows an upward trend. High-rate inhabitant mobility is a feature of modern civilization caused by a variety of factors, such as industrial changes and new tendencies in business sectors (specialization, concentration, co-operation), territorial development of a city, the advancement of means of transport, cars especially, recovery in the standard of living and etc.

1.7. Environmental Pollution.

Pollution is a feature of modern civilization. To present, man has been incapable of creation of waste-free technologies. The more advanced countries, the higher pollution emission, though living conditions there are far better than in poorer countries.

Most Important Sources of Pollution:

A. Products of any human activity (economic, industrial and the like), administered materials, processes present in agriculture, forestry, mining, energetic, processing industry, construction, crafts, communication, commerce and etc.

B. Any product (whole or its part) sooner or later becomes waste / pollutant (car, building, food item, petrol and etc).

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C. Rubbish in dumps or other locations (air, soil…) produce new types of pollution products.

D. Every residential house and its plot as well as public areas in a city are the producers of pollutants\(^1\).

![Figure 1-5 Carbon dioxide emission along the world](image)

**Figure 1-5 Carbon dioxide emission along the world**

(Source: Leonardo de vinici, 2004, GIS in urban planning, Sweden press.)

Environment pollution has reached dangerous proportions and can predestine human health and life, vitality and declension of natural complexes. The prognosis on continuous pollution is poor, making an assumption of possible global ecological catastrophe. Its main characteristics are the ozone layer disintegration and climate warming. In 2001, the Council of the United Nations declared that the climate is warming on a faster scale than expected, human activity (burning of natural resources, industrial pollution, deforestation) being the main cause. The average temperature could possibly increase by 5.8°C, whereas the sea level by 88 centimeters, which could have an irreversible impact on a number of earth systems\(^2\).

Conversely, optimists find the evidence for express catastrophic climate warming ungrounded and believe that mankind will succeed not only in the restriction of climate warming consequences but also in their clever utilization\(^3\). International agreements, declarations, recommendations and other documents focused on the solution to the problems related to global environment pollution are legion and still show a growing tendency. One of them suggests that European countries apply such means:

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\(^1\) Leonardo de vinici, (2004), GIS in urban planning, Sweden press.


\(^3\) IBID
A. Benefit from economic checks and balance system, financial resources, such as tax proceeds for carbon monoxide emission and power consumption including.
B. Eliminate hindrances to economical power consumption for building heating needs.
C. Employ modern renewable energy sources.
D. By the year 2010, achieve an optimal level of energy consumption in all European countries.
E. Diminish the exhaust-induced greenhouse effect in the transport sector.
F. Increase the potential of farming and forestry to absorb carbon dioxides.
G. Rectify dump management strategy with a goal to reduce methane emission amidst.

Such means are important for every town but an individual town has its special characteristics of environment pollution\(^1\).

It can be concluded that urban planning decisions could suggest possible ways of the reduction of pollution impact which could be:
A. Development of functional and physical urban structure.
B. Proper land usage.
C. Rendering the preserved territory status.
D. Establishment of sanitary zones.
E. Sustainability of adequate proportional balance between natural and anthropogenic environment.

1.8. Traffic safety:
The primary objective of urban planning is to evaluate the problem of traffic safety and suggest the solutions, which would assist in the elimination of unfavorable factors as well as in the establishment of safe traffic conditions by pursuing the following patterns\(^2\).

1.8.1. Types of Street Modeling:
There are three types of traffic pattern as traffic segregation, complete traffic segregation, and traffics integration\(^3\).
A. Traffic segregation: horizontal (plane-based) and vertical (spatial), the former being much simpler but less effective in comparison to the latter (though much more costly). A combination of both is also possible.

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\(^3\) IBID
B. Complete traffic segregation: is an intentionally created space only for pedestrians and cyclists. Underground space or elevated platforms or similar erections could be designed only for pedestrian traffic. The territories with complete segregation usually take up small space, most frequently in city centers or around them or other in conflict areas with high-scale congestion of people and transport.

Complete traffic segregation in residential territories can be reached in two efficient ways, either by forming closed areas (small or large backyards) with the help of construction design or other means, or by integrating in the fragments of a residential territory two junction-free networks separate for pedestrians and for means of transport.

C. Traffic integration: The principles of integration are based on the following peaceful coexistence of traffic users like the functioning of boundaries for pedestrian use and those related to public transport system, the certain limited-size territory usually in C or higher category streets used by pedestrians and “local” cars and finally the cul-de-sacs employed by pedestrians and cars, used for car parking or by children as a playground.
1.8.1. **Types of Street Modeling:**

A. The most dangerous are the streets with houses on both sides, especially with shops, offices, service centers and similar buildings - the objects to attract pedestrians\(^1\).

![Figure 1-7 a street with houses on both sides](Source: URL http://www.historyofpia.com/forums/viewtopic.php?f=3&t=10658&start=60)

B. Much safer are streets having only one side lined with buildings, except those, on the other side of which objects of attraction (parks, recreational territories playgrounds for children’s leisure and sport) are located\(^2\).

C. Relatively safest are streets free from buildings, to be more precise, those with the buildings located 100 or more meters away from them\(^3\).

![Figure 1-8 Building located away from street](Source: URL http://www.tourism-review.com/10-places-to-see-before-they-disappear-news1409)

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\(^1\) Leonardo de vinici,( 2004), GIS in urban planning. Sweden press


\(^3\) IBID
It can be concluded that the dangerousness or safety of streets depends on the intensive or low transversal flow of pedestrians and its induced conflict with the flow of means of transport, so modeling streets design should be performed in a way that provide safety for the users either by using the segregation or integration pattern.
1.9. Conclusion:

A. Cities are considered as places where people can live healthier and economically productive lives while reducing their impact on the environment. They work to harmonize existing policies, regional realities, economic and business markets with their natural resources and environmental assets. Cities strive to engage all citizens in collaborative and transparent decision making, while being mindful of social equity concerns.

B. To perform the city system in an efficient way several of factors should be taken into consideration by the urban planner, these factors are:

- City is a manageable system, which consist of three important entireties elements, communication, and environment.

- City complexity structure for inhabitant’s distribution not only deepened on age, marital status, gender, income and other traditional features; but also it is closely linked to specific problem groups of people.

- Employment of inhabitants in a city aid to the identification of economic basis and vitality of the city, functional type of the city, specialization and autonomy of the city, and levels of industry novelty of the city.

- Sufficient living space, avoid congestion inside the city, and offering good quality drinking water, network of gutter and cleaning systems, waste disposal and adequate maintenance of private and public spaces leads to a concept of having healthy environment.

- City economic development depend on the presence of four important elements should be present within a city to ensure this development; these elements are skilled workforce, technologies, social and technical infrastructures, financial, and management.
• Localization mobility is considered as the main feature that gives information about a city status, its rate of growth, possible investment and problems, so the policy challenge is not how to keep households from moving, but how to keep them from moving for the wrong reasons.

• The significance of communication network, types of transport and the development of street system, are considered the most important factor that affect the communicational mobility, and gives information about the importance of the city to the settlement system.

• Development of functional and physical urban structure, proper land usage, rendering the preserved territory status, establishment of sanitary zones, and sustainability of adequate proportional balance between natural and anthropogenic environment, are considered as a possible ways of the reduction of pollution.

• Dangerousness or safety of streets depends on the intensive or low transversal flow of pedestrians and its induced conflict with the flow of means of transport, so modeling streets design should be performed in a way that provide safety for the users either by using the segregation or integration pattern.

In order to reach the pervious points within a city, the next chapter is going to deal with the urban planning process which is considered as a way used to reach these points to have an efficient city system.
Chapter 2
Urban Planning Processes

2.1. Introduction

2.2. Definition of Traditional, Digital Urban Planning, Territory Planning, and Spatial Planning

2.3. Urban Planning Objectives and Objects

2.4. Urban Planning Goals

2.5. Types of Urban Planning

2.6. Urban Planning Participants

2.7. Evaluation of General and Detailed Plan

2.8. Conclusion
2.1. Introduction:
In planning, urban planner should consider the interaction between human activities and land uses, including those factors producing pollution and stress. This approach should be focused on sustainable policies supporting clear environmental, social and economic objectives; as cities reflect both the best and worst of human aspirations, as the ‘Gaia Atlas of Planet Management’ states the sheer pressure of people living together always creates problems: “... poverty as well as wealth, crime as well as justice, disease as well as medicine”\(^1\).

Urban and regional planning underlies the very fabric of society as users deal with it today. Without planning and foresight, cities, towns, rural areas, and residential communities will not run efficiently. While communities today face many challenges, some of them, such as pollution and traffic, can be addressed by careful and creative planning. It is the planner’s job to address such problems and provide viable solutions for today and the future\(^2\).

Along with the development of digital city, traditional urban planning is surely going to be developed to digital urban planning. But there is no authoritative definition of digital urban planning till now, so this chapter is going to define digital urban planning, and discus the territory planning as a preventive measures rather than investment, urban planning goals from the point of view that urban planning is not a onetime action but a continuous process, urban planning participant, and finally discuss the stages and actions that follow by urban planner in order to evaluate the general and detailed planning\(^3\).

2.2. Definition of Traditional, Digital Urban Planning, Territory Planning, and Spatial Planning:
Cities are dynamic living organisms that are evolving through interplay of regulatory and entrepreneurial activities. Thus city planning has always been difficult. Today the rapidly changing society makes the job of predicting future needs of city dwellers, and those who depend on the services cities provide, even more problematic. Particular problems include: transport, pollution, crime, conservation and economic regeneration. In addressing the complexities of city planning it is important to consider the physical structure of the city alongside less tangible economic, social, environmental and cultural factors\(^4\). Urban planning

\(^3\) IBID
is designed to regulate the use of land and other physical resources in the public interest and can make a tremendous difference in the quality of life\(^1\).

2.2.1. **Traditional Urban Planning:**

According to the European: Traditional urban planning is the science of assessment by professionals and analysts of projects, programmers, strategies or plans shaping the physical, social, economic and environmental structures within a city. It should be based on balance, between growth and conservation; the achievement of sustainable development and the resolution of conflict\(^2\).

According to John Stillwell: Traditional urban planning process should be divided into two parts; the first is a strategic planning, and the second is physical planning\(^3\).

A. The strategic planning contains the awareness of the processes taking place in the city, their importance and consequences both for the present and for the future, societal needs, development objectives, possibilities and ways for process regulation.

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B. The physical planning (with reference to norms, analogs, requirements, though leaving room for creativity) of everything formally covered by the notion physical environment (houses, streets, other structures and other spaces, green areas) having in mind the idea that planned environments are adequate for urban communities in terms of both present day needs and strategic objectives.

It can be concluded that traditional urban planning should always be associated with a process of evaluation, assessing what is proposed, reviewed and analyzed, after the event, whether predictions and decisions were justified. Such evaluation thus concerns feasibility, political acceptability, and conformity with higher levels of policy.

2.2.2. Digital Urban Planning:
According to Haoying Han c, Lei Wu: Digital Urban Planning is a new kind of urban planning based on information of infrastructure, spatial data infrastructure, planning and managing system of digital city. During the process of digital urban planning, all the basic materials of the city are digital information. The purpose of digital urban planning is to determine the development goals, urban land use, urban spatial pattern, information infrastructure, spatial data infrastructure, and other integrated construction project of both realistic city and digital city1.

![Figure 2-3 Gwanggyo city centre](Source: URL http://myportfolio.usc.edu/retherfo/2010/09/pinpointing_the_downfalls_of_our_cities_enlightening_resources.html)

Two key-points need to be considered in the definition of digital urban planning:

A. One is that digital urban planning is related to digital city. All the planning process is based on digital city system, which includes information about infrastructure, spatial data infrastructure, planning and managing system of digital city. And during the

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1 Anrong Dang a *, Huizhen Shi b, Haoying Han c, Lei, (2005), Paper of study on the system of technical methods for digital urban planning.
whole planning process, digital information will be the agent object which makes digital urban planning different from traditional urban planning in all the aspects of technical method application, information processing procedure, and results expression style.

B. The second key-point is that the purpose of digital urban planning determines its contents, which not only include the physical and social planning related to realistic city, but also include technical and information planning related to digital city. Therefore, digital urban planning is really refers to the future urban planning based on the digital city. And those current urban planning which use some kinds of technology, such as GIS and CAD, partially based on digital map, and only for physical planning is not belong to digital urban planning.

The contents of digital urban planning can be deduced as two aspects. One is Physical and Social Planning which is pay more attention to the realistic city, while the other is Technical and Information Planning which is mostly concern to digital city.

![Contents of Digital Urban Planning](source: Paper of study on the system of technical methods for digital urban planning.)

The contents of physical and social planning of digital urban planning should not only include the whole contents of current urban planning but also need to be expanded according to the development of digital city.

The contents of technical and information planning are related to and focused on the digital city. Basically, the technical and information planning should depend on the existing status and development trends of digital city. The development of spatial information technology, computer science, internet technology, digital communication technology, and

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1 Anrong Dang a *, Huizhen Shi b, Haoying Han c, Lei, (2005), Paper of study on the system of technical methods for digital urban planning.
database management technology are all need to be considered during the digital urban planning process\(^1\).

It can be concluded that, three important points should worked out.

A. First one is that the digital urban planning is the future urban planning along with the development of digital city.

B. Second one is that digital urban planning is a newly urban planning for digital city supported by information infrastructure, spatial data infrastructure, urban planning and managing information system of digital city.

C. Third one is the content of digital urban planning, which includes two aspects, physical and social planning for realistic city, technical and information planning for digital city.

### 2.2.3. Territory Planning:

According to Anrong Dang, Territory planning is the planning of preventive measures rather than investments; it is the instrument of management not an objective. Rational land uses and the need for it, are based on territory planning; it attempts to encourage both the economic development of society and preservation of the natural environment; it should also foster the curtailment of the differences among regions on an economic scale as well as preserve and guarantee sensible consumption of natural resources\(^2\).

![Figure 2-5 Application of customer service model](http://www.marketmotion.com.au/map_detail.html)

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\(^1\) Anrong Dang a *, Huizhen Shi b, Haoying Han c, Lei, (2005), Paper of study on the system of technical methods for digital urban planning.

According to Rick Phillip: Territory planning is usually a long term planning, it helps to maximize the user’s time and ensure their consistently build territory revenue by calling on a good mix of new prospects and existing customers\(^1\).

While Freddy M.E. Jacobs, the main purposes of territory planning can be gathered in four points; the first point is the balanced economic and social development of regions and zones by keeping their specificity, the second point is the improvement of the people’s life quality, the third point is the management in a liability way of the natural resources and environment protection, and the fourth point is the reasonable territory utilization\(^2\).

Keith Hoggart (2005) stated that, the documentation for territory planning can be reviewed according to the design of the planning territory, whether this design concerns the national territory, or the zone territory, or the country one\(^3\):

A. Design of planning national territory; it has director character and means the synthesis of segmental strategic programs with medium and long term for entire territory of the country. The Design of planning national territory sections are: Communication ways, Waters, under protection zones, Localities network, Zone with natural risk, Tourism, Rural development. Other sections can be approved according to law.

B. Design of planning zone territory; it has director role and it is conceived concerning to solve specific problems of some territories. These territories can be between localities or intercity, consisted of basis administrative territorial units, localities, cities; between countries, including country segments or whole countries; regional, consisted of several countries.

C. Design of planning country territory; it has director character and represents the geographical view of the social and economic development program of the country. The design of planning country territory is correlated with the design of planning national territory, the design of planning zone territory, segmental governmental programs, as well as with other development programs.

It can be concluded that territory planning is considered as the general interest complex activity systems that contribute to balance spatial development, natural and built


\(^2\) IBID

inheritance protection as well as the improvement of the life quality in urban and rural sites.

2.2.4. Spatial Planning:
In Poland the main stream for the science of spatial planning illustrates that spatial planning is an activity, whose aim is to analyze the existing situation, create the theory of this process as well as to define its trends and essence in physical terms related to social and economic issues. The main task of spatial planning is a rational reconstruction and employment of spatial structures with an eye on established natural, social, economic and cultural conditions in spaces under consideration.

![Figure 2-6 Riga Spatial Planning](http://www.gsf.fi/projects/astra/02_latvia_salaca_river_basin.html)

According to John Stillwell: A spatial planning outcomes are wide range of plans, surveys, and conception. The most specific feature of spatial planning is that it has to perform the functions of coordination of divergent economic sectors (branches) and the assessment of hierarchical subordination of different spaces.

While Louis Albrechts stated that spatial planning is not a single concept, procedure or tool. It is a set of concepts, procedures and tools that should be tailored to whatever situation is at hand if desirable outcomes are to be achieved. Spatial planning making is as much about the process, institutional design and mobilization as about development of substantial theories. This broad area is reflected in the place and the role of planners in spatial planning.

Lately Portuguese Constitution illustrated that spatial planning aiming to ensure the adequate location of activities, a balanced social and economic development and the enhancement of the landscape, is an essential responsibility of the State, to be carried out with

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2 John Stillwell, StanGeertman, Stian Openshaw(eds.), (2004), Geographic information and planning, Berlin: Springer.
citizen participation, in a framework of sustainable development. The definition of spatial planning policy is a competence of the government, the autonomous regions and the local authorities. It can be concluded that, the objective of spatial planning is to safeguard the correct development of the country, its regions, cities and municipalities in terms of a rational consumption of land and environments as well as social and economic potentials.

2.2.5. The Functions of the Master Plan / Development:
Urban, territory, and spatial planning all guides to master plan, the functions of the Master Plan / Development are as follows, to guide development of a city in an orderly manner so as to improve the quality of life of the people, to organize and coordinate the complex relationships between urban land uses, to chart a course for growth and change which be responsive to change and maintain its validity, over time and space, and be subject to continual review, to direct the physical development of the city in relation to its social and economic, characteristics based on comprehensive surveys and studies on the present status and the future growth prospects, and to provide a resource mobilization plan for the proposed development works.

2.3. Urban Planning Objectives and Objects:
Urban planning is not a onetime action but a continuous process, so urban planning objective can be as follows:

A. Cater for the basic needs of people, businesses and other activity structures.
B. Guarantee the reliability of the functioning of urban systems.
C. Provide favorable conditions for urban development.
D. Encourage the creation of new job positions for employees with different skills, both for men and women, especially the ones related to modern technologies.
E. Provide conditions for buying, renting, building, reconstructing of a place of residence or equip with a rescue place corresponding to both personal and municipal possibilities.

3 IBID
F. Create a convenient city: comfortable and accessible public transport; sufficient permeability of streets, crossroads and car parks; qualified and easily accessible cultural, medical, social and other services.

G. Preserve the sustainability of a secure city, i.e. guarantee the protection of a person and property, keep safe from the dangers of natural and techno-related disasters.

H. Create and sustain healthy environment: clean air, water, soil, acoustic comfort and etc.

I. An open city: convenient local transport services and international links with other towns and countries; easily accessible information on any issue related to urban matters; open to innovations and co-operation with partner-cities.

J. Well-balanced social and economic development of the environment, i.e. the development allowing the satisfaction of present needs but also maintaining a sensible approach towards the potential in view of future generations.

The object of urban planning and its scope are mainly based on planning objectives. With respect to planning objectives, planning objects can be as follows:

A. **City as a system**, in such a case, by means of research and analysis, non-formal urban system boundaries are established (e.g. the limits of dominant influence, urban agglomeration and urban region). The urban system frequently is the object of general planning.

B. **Subsystem of a city**, e.g. subsystems of transport, green areas, etc.

C. **Element of a city**, e.g. separate structures (bridge, complex of buildings, etc), among them rectilinear constructions (streets, engineering networks, etc) with their land parcels and the spaces designed for green areas, parks, etc.

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It can be concluded that any object of urban planning is a stable part of the system; every element of higher or lower rank is always analyzed and planned in relation to its environment and connections. Thus, a conclusion can be drawn that it is possible to define the significance of every separate element in the total functioning of the city, i.e. a formal urban element, indicated in the planning task like bridge, can cause the revision of a much broader and more complex object, the entire urban system or subsystem for a bridge like the entire transport system or the functioning of the total street network with its consequences.

2.4. Urban Planning Goals:
Since urban planning is not a onetime action but a continuous process, so urban planning goals can be as follows:1

A. Propose a plan to the urban community, integrated a well-balanced development solutions or their alternatives adequate for the known or presumed needs and interests of inhabitants, private and administrative institutions.

B. The full assent of the inhabitants and the approval by municipal politicians, development decisions (in general, strategic and detailed plans) become the guidelines for strategic management and practical actions on the part of the executive bodies.

C. Whereas for private structures, development decisions are the requirements or conditions information about possible conditional changes in future business or other activities.

D. Inhabitants should see it as a basis for their personal assessment of closer or more remote urban future and plan their actions.

Urban planning goals should present the following rights for the citizens:2

A. Security: to a secure and safe town, free, as far as possible, from crime, delinquency and aggression.

B. An unpopulated and healthy environment: to an environment free from air, noise, water and ground pollution and protective of nature and natural resources.

C. Employment: to adequate employment possibilities; to a share in economic development and the achievement thereby of personal financial autonomy.

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D. Housing: to an adequate supply and choice of affordable, salubrious housing, guaranteeing privacy and tranquility.

E. Mobility: to unhampered mobility and freedom to travel; to a harmonious balance between all street users public transport, the private car, the pedestrian and cyclists.

F. Health: to an environment and a range of facilities conducive to physical and psychological health.

G. Sport and leisure: to access for all persons, irrespective of age, ability or income, to a wide range of sport and leisure facilities.

H. Culture: to access to and participation in a wide range of cultural and creative activities pursuits.

I. Multicultural integration: where communities of different cultural, ethnic and religious backgrounds co-exist peaceably.

J. Good quality architecture and physical surroundings: to an agreeable, stimulating physical form achieved through contemporary architecture of high quality and retention and sensitive restoration of the historic built heritage.

K. Harmonization of functions: where living, working, traveling and the pursuit of social activities are as closely interrelated as possible.

L. Participation: in pluralistic democratic structures and in urban management characterized by co-operation between all the various partners, the principle of subsidiary, information and freedom from over-regulation.

M. Economic development: where the local authority, in a determined and enlightened manner, assumes responsibility for creating, directly or indirectly, economic growth.

N. Sustained development: where local authorities attempt to achieve reconciliation of economic development and environmental protection.

O. Services and goods: to a wide range of accessible services and goods, of adequate quality, provided by the local authority, the private sector or by partnerships between both.

P. Natural wealth and resources: to the management and husbanding of local resources and assets by a local authority in a rational, careful, efficient and equitable manner for the benefit of all citizens.

Q. Personal fulfillment: to urban conditions conducive to the achievement of personal well-being and individual social, cultural, moral and spiritual development.

R. Equality: where local authorities ensure that the above rights apply to all citizens irrespective of gender, age, origin, belief, social, economic or political position, physical or psychological handicap.
It can be concluded that, the all above described goals are the collections of problems, which can be characteristic of the urban wholeness. Every single city is, however, exceptional thereby the uniqueness of the entirety of its urban planning objectives not necessarily only for financial reasons or the opinion of urban community. Some specific objectives, closely linked to the city history, its cultural heritage; urban functions and competition, co-operation with other cities in one or another field, are frequently present.

2.5. Types of Urban Planning:
Many of the problems faced by cities such as rural-urban migration cannot be solved within cities alone. The population living in rural areas should also be taken into account. Urban planners need new ways of thinking about the interrelation between rural and urban areas, especially with respect to planning issues. Today, from a strategic planning perspective, it can be realized that urban centers are not only focal points for their own economic growth but also service centers for surrounding areas. The relationship between urban centers and surrounding areas is one of interdependence rather than competition or struggle\(^1\).

In most countries, rural areas have been excluded from the planning process even though cities depend on surrounding areas for natural resources. Although this fact has been recognized, the value of rural areas as a natural environment which contributes to bettering the quality of life of a territory has not always been appreciated. Moreover, the role of rural areas in local, regional and global economies is of utmost importance since productive and natural rural areas are necessary for achieving sustainable development. In order to create an interconnected, unified territory, planners should take into account the interdependence of rural areas and urban hubs\(^2\). These considerations force the planners to re-think about the role of cities in global planning processes. There are three types of urban planning process, strategic planning, physical planning, and general planning.

2.5.1. Strategic planning:
Strategic planning is a process of identification of urban development objectives and tasks in all urban sectors. Municipality usually has here an exceptional interest; therefore it is the body, which, in most cases, initiates such planning. Municipal staff, experts and specialists in

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\(^2\) IBID
strategic planning also participates in the process, the result being the collective product of their creative thinking\(^1\).

Urban strategic planning is a specific instrument of management which encourages citizen participation in local policy decisions. The partnerships which emerge from urban strategic planning are especially created for designing and managing sustainable projects for the city. But these processes of citizen involvement are not spontaneous: it is the local government which is primarily responsible for fostering opportunities for civil society organization participation. Furthermore, the process of participations should include actors with a strong technical orientation who have the capacity for dealing with the needs and requirements of society. This kind of public-private partnerships requires clearly established rules so that collective and individual benefits are produced which in turn strengthen the actors’ motivation for continuing to participate in a project\(^2\).

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\(^2\) IBID.
Urban strategic planning allows local governments to enlist the participation of social actors, to achieve consensus about policies and projects and to encourage partnerships aimed at proposing, implementing and evaluating projects. Urban strategic planning is only possible, however, if the government is willing to share the power and respect the decisions which emerge from the process of negotiation. There are three basic sources of input: political decisions and the know-how of both professionals and social actors.

During the stages of a strategic plan (Diagnosis, Planning, Strategic Management, Monitoring and Evaluation) social and political actors work together using a specific methodology. In the Strategic Management stage of the plan, the actors define their own responsibilities in the projects and design monitoring systems such as Urban Indicators Systems. Depending on the changes in the social context, the agenda is adapted to suit different conditions or circumstances.²

2.5.2. Physical planning:

Physical planning is the transfer of concrete decisions of strategic planning onto the cartographic material of an urban plan (or onto a digital city map) or a search for a particular decision in a city, its fragment or plot plan with reference to previously formed principles. Physical planning is the most vivid and inevitable display of planning decision. In these planning physical objects, huge territories and plots; buildings, structures, networks are being operated with. By this and by close follow-up of regulatory norms, analogues, the professional know-how, mathematical and other models, it is possible to create independent products design plans of cities, districts, streets and etc. A part of them are proximate to those or the designs, under which construction works are performed.²

Figure 2-10 Brown University Campus
(Source: URL http://www.brown.edu/Administration/cpab/)

36
2.5.3. General planning:

General planning is most developed in width and in depth; it also possesses the elements of all other types (strategic, physical) of planning. There are three main parts of general planning, the first part is considered as identification of development tasks and objectives (strategic planning), and the second part is considered as a search ways and means for the realization of objectives, investigation of agreeable location possibilities for planned objects, financing resources and investors among them. Verification modules, business plans, possibility studies, investment projects can go along with such planning; studies of legal aspects of investments are made; institutions for the investment implementation are sought, and finally the third part is considered as an arrangement of the urban plan structure and other planning tasks directly related to the objectives of the development and ways (means) of their realization.

![Figure 2-11 Oregon state plan](Source: URL http://arcweb.sos.state.or.us/state/planbd/pics/bandon.htm)

It can be concluded planning of a city passes through three respective stages, strategic, physical and general planning.

![Figure 2-12 Stages of urban planning](Source: Researcher)

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Urban strategic planning involves long term projects and generates sustainable development through careful investment in and management of public and private resources for infrastructure. Urban strategic planning helps enable cities to meet their needs and improve the quality of life. In order to build sustainable environmental services and infrastructure, local governments must have tools of management, financing and control over these services.

The second stage after strategic planning comes the physical planning which is considered as a form of urban land use planning that attempts to achieve an optimal spatial coordination of different human activities for the enhancement of the quality of life.

The third stage after physical planning comes the general planning which is considered as a plan of a city, county or area that establishes zones for different types of development, uses, traffic patterns, and future development.

2.6. Urban Planning Participants:
There are two groups of planning participants, the first group comprises all those, who reveal their needs and interests, and the second group encompasses professional planners, whose main objective is to create a model of an urban system adequate to the obvious needs and interests for a shorter or longer future.

2.6.1. The first group of planning participants:
The first group of planning participant consists of three categories of participants which are municipal authorities, private structures, and inhabitants.

A. Municipal authorities: (governmental alongside) and similar structures, which perform the functions ascribed to them (urban development, public utilities, transport, education, health care, protection of people, preservation of the environment and public structures, services of technical infrastructure and etc.)
The functions, which are the object of municipalities, predetermine their role in urban planning: organize planning process, consideration and approval of planning documents and their close follow-up in the process of implementation. Governmental institutions set the planning requirements (laws, regulations, norms and the like)

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38
B. **Private structures**: Their presence and role in urban planning is predetermined by one single factor which is profit. In its absence the nature of activity is usually changed, an enterprise closed or transferred to another location and etc. Private structures attempt to escape risk but are greatly interested in beneficial and stable business conditions, current and future, effective technical and engineering infrastructure, skilled workforce, favorable legal and financial business facilities.

C. **Inhabitants**: who are interested in concrete things: housing, employment, health care, education and other pursuits; agreeable and healthy environments, leisure facilities, quality of public services. Laws guarantee every single citizen’s right to participate in and influence urban planning process. This right is normally exercised in several ways: planning of personal grounds is in the competence of the owner; he/she has easy access to plans and can make suggestions or express disagreement. Informal factors, such as a response of inhabitants to a particular urban or local situation, i.e. change of workplace or residence and etc., are also present\(^1\).

![Figure 2-13 A picture for inhabitants](Source: URL http://www.melanoandassociates.com/services/group-facilitation-and-strategic-planning)

**2.6.2. The second group of Planning Participants:**

The second group of planning participant consists of two categories of participants which are professional planners and community participation.

**A. Professional planners:**

Their work scope basically depends on municipal and governmental authorities, private structures and inhabitants, i.e. on the customer of the service as well on those who regulate the process. And also mutual contractor-planner effort. They both create the ordered product plans, which after their approval become obligatory or at least recommended documents. The work performed by professional planners serves as an informative feedback for the

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government, private structures and individuals and consequently has great impact on their decision-making. Efficient planning is possible only if it is a mutual effort of professionals in a variety of spheres: economists, sociologists, civil and other engineers, architects, system managers, geologists, geographers, demographers, specialists of informational technologies and etc. Experience and skills of every single specialist in these or other fields suits best in the processes of analysis and forecast or in specific planning (e.g. demographic, social, transport, environmental and the like), the latter being of secondary importance for the assessment of the nature and aims of the urban system and related integrated planning. The key objective is to find a solution, i.e. a city plan. This process is in need of specialists-planners of a different sort.

B. Community participation:

In the planning process community participation is perceived in the following manner, Open information to the community on a launched plan and its goals; access to documents under preparation and those already approved as well as the availability of their copies; access to arranged plans displayed publicly, Public discussion of arranged documents, The right to make suggestions, express opinion or complaints, The right to lodge a complaint to the planning supervisory institutions if suggestions, complaints or ideas were ignored, Free distribution of general plans or their briefs, and finally the right to lodge a claim if the introduction of a detailed or a general city plan has to some extent restricted the benefits of real estate¹.

It can be concluded that planning participation divided into two main teams the first team mainly has the authority of the money and giving the rights to the planners to go on working their plans, the second team is the one responsible for creating the ideas to have an integrated planning related to the surrounding urban system.

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¹ John Stillwell, StanGeertman, Stian Openshaw(eds.), (2004), Geographic information and planning, Berlin: Springer.
2.7. **Evaluation of General and Detailed Plan:**

The evaluation of both a general and a detailed plan of the city undergo several stages and follows different actions\(^1\).

**2.7.1. Feasibility of a Plan:**

The feasibility of a plan is the total of the planner’s arguments, which is made available for other evaluation stages and which testify to an assumption that plan decisions will:

A. Improve living conditions and employment benefits.

B. Provide diversification and quality of services.

C. Be beneficial to economic development and business.

D. Enhance sensible land consumption and etc.

Feasibility criteria are the same planning objectives, whereas the decisions, with a certain probability, will make their exact implementation possible.

**2.7.2. Governmental Supervision of Planning:**

Governmental supervision of planning is the control of a timely performance of all procedures, contained in the law on territorial planning and other by-laws; whether planning decisions are in accordance with the government prescribed norms.

**2.7.3. Societal & Financial Evaluation:**

Societal evaluation includes opinions, proposals and complains of various forms. They can be set forth by individuals, public organizations and professional associations. The community being active, proposals and advice can be legion; statistically every fiftieth suggestion is usually of considerable value.

Financial (economic) evaluation is an assessment of the financial capacity of the town to implement into practice the decisions contained in the general or detailed plan; whether the planning decisions would attract private investment; whether the charges for urban services are in accordance with inhabitant solvency.

**2.7.4. Organizational & Political Evaluation:**

Organizational evaluation is an assessment of whether the municipality and its enterprises and agencies have sufficient expertise and are capable of the implementation of planned decisions.

Political evaluation is the final evaluation of the designed plan, made by municipal authorities, council, board, and mayor (based on: feasibility arguments, governmental

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planning supervision material, societal, expert and evaluation). Once authorized, planning decisions become obligatory and valid to a contrastive political resolution.
2.8. Conclusion:

A. Planning is the science responsible for designing an efficient city system, it has been concluded that there are several types of planning each has its own responsibilities and characteristics.

- Traditional urban planning is the science of assessment by professionals and analysts of projects, programmers, strategies or plans shaping the physical, social, economic and environmental structures within a city, and it should be associated with a process of evaluation, assessing what is proposed, reviewed and analyzed, after the event, whether predictions and decisions were justified or not.

- Digital urban planning is a kind of urban planning based on spatial information and managing system of digital city, and considered as future urban planning along with the development of digital city, and includes two aspects, physical and social planning for realistic city, and technical and information planning for digital city

- Territory planning is considered as the general interest complex activity systems that contribute to balance spatial development, natural and built inheritance protection as well as the improvement of the life quality in urban and rural sites.

- Spatial planning is to safeguard the correct development of the country, its regions, cities and municipalities in terms of a rational consumption of land and environments as well as social and economic potentials.

B. Any object of urban planning is a stable part of the system; every element of higher or lower rank is always analyzed and planned in relation to its environment and connections. Thus, a conclusion can be drawn that it is possible to define the significance of every separate element in the total functioning of the city, I.e. a formal urban element, indicated in the planning task like bridge, can cause the revision of a much broader and more complex object, the entire urban system or subsystem for a bridge like the entire transport system or the functioning of the total street network with its consequences.
C. There are three main respectively stages in urban planning process:

- **Urban strategic planning** involves long term projects and generates sustainable development through careful investment in and management of public and private resources for infrastructure.

- **Physical planning** which is considered as a form of urban land use planning that attempts to achieve an optimal spatial coordination of different human activities for the enhancement of the quality of life.

- **General planning** which is considered as a plan of a city, county or area that establishes zones for different types of development, uses, traffic patterns, and future development.

D. Planning participation divided into two main teams the first team mainly has the authority of the money and giving the rights to the planners to go on working their plans, the second team is the one responsible for creating the ideas to have an integrated planning related to the surrounding urban system.

E. Finally to evaluate any general and detailed plan the evaluation should pass by different organizations to reach a plan for an efficient city system, these evaluations are:

- Governmental evaluation.
- Societal evaluation.
- Financial evaluation.
- Organizational evaluation.
- Political evaluation.

Since city structure is considered as an object of general planning, and the pervious chapters deal with urban planning process in order to reach an efficient city system. So the next chapter is going to deal with structure of particular city zones, plot fragment, or their groups as an object of detailed or spatial planning and the pollution emitted from the city structure.
Chapter 3
City Structure and Pollution Emission

3.1. Introduction

3.2. City Structure and Planning
3.3. City Development

3.4. Living Territory and Land Uses Carbon Emissions
3.5. Transport System Carbon Emission

3.6. Industrial Zones Carbon Emission
3.7. Global CO2 Emission by Sector

3.8. Improving the Natural and Built Ecological System

3.9. Conclusion
3.1. **Introduction:**

The urban process is largely characterized by the urban function and unless one perceives the city as one specialized part of the larger economy he falls to understand its essential character. Hence in order to understand a city, it is necessary to focus on the basis on which the city operate and try to look on its social structure\(^1\). So this chapter is going to examine the nature of the city in relation to its function and social structure.

The function of the city is interrelated with various factors such as social structure, technology, etc. Nevertheless one can treat the function, as the starting point to trace the paths of urban phenomena and proceed towards understanding the urban social structure\(^2\).

The ecosystem is a multifaceted concept that can be applied to a variety of different situations. In very fundamental senses, ecosystems are the planet’s life support systems for the human species and for all other forms of life. Urban green spaces are an important component of the complex urban ecosystem, which makes significant contributions to the environment, ecology, and cultural and economic life. The human population derives direct and indirect benefits from ecosystem functions of spaces. Urban green spaces can sequester carbon dioxide emissions and produce oxygen, purify air and water, regulate microclimate, reduce noise, protect soil and water, maintain biodiversity, and have recreational, cultural and social values. Therefore urban green spaces improve the urban environment, contribute to public health and improve the quality of urban life\(^3\).

Landscape ecology views large land areas in terms of the distribution of energy, material, and species as they relate to the sizes, shapes, numbers, kinds and configuration, of component ecosystems. The planning and management of urban green space development is of significance to urban sustainable development. Leitao and Ahern (2002) argued for common framework that applies ecological knowledge in landscape and urban planning\(^4\). Jin and Chen (2003) applied landscape ecology principle to the green spaces planning of Nanjing city and Beijing city, China\(^5\). Pauleit et al. (2003) proposed a more flexible approach named the accessible natural green space standard model to promote the natural green environment of towns and cities, and devised a decision support framework for its

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\(^1\) John Stillwell, StanGeertman, Stian Openshaw(eds.), (2004), Geographic information and planning, Berlin: Springer.
\(^2\) Gillian Mary Hanson, (2004), City and Shore: The Function of Setting in the British Mystery, McFarland.
implementation. Li and Wang (2003) proposed a method for the evaluation, planning and prediction of ecosystem services of urban green spaces, taking Yangzhou city in China as the case study.

The basic amount of green space required in planning can be obtained by the principles of ecological balance. There are three methods of controlling the amount of green space, namely the recreation space ration method, the ecological factor plat method, and the ecological element threshold method. The recreation space ration method pursues the function of recreation and came from the former Soviet Union. It did not take the limit of land resources into account in most developing countries. The ecological factor plat method is widely employed in Landscape planning or landscape ecological planning in western developed countries. By contrast, the ecological factor plat method is applicable merely for the environment areas of biodiversity where habitats are less distributed by human activities. This is not the case in most countries. Based on the situation of China, the ecological threshold method is in practice the best way to control the amount of green spaces.

This chapter divide into two main theoretical parts, the first part reviews city structure as an object of general planning and the structure of particular city zones, plot fragment, or their groups as an object of detailed or spatial planning, this part also discus city development concepts from the point of view of functional zones concept and functional integration concept, and city development structure in terms of city development concept.

As urban planners play the roles of developing functional and aesthetically pleasing cities with the highest and best use of land, and at the same time ensure that they are ecological friendly. It is important to develop low carbon cities to ensure low CO2 emissions in the urban areas, so the second part of this chapter illustrates every section in the new cities that is responsible for the carbon emission, these sections divide into three groups, the first group highlights on living territories and land uses carbon emission, the second group highlights on transportation system carbon emission, the last group highlights on industrial zones carbon emission. Finally this chapter reviews the natural and built ecological system in urban environment using a network of green areas.

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I. First Part of the Chapter is going to review the component of the city structure and its development concepts and its relation with urban planning.

3.2. City Structure and Planning:
City structure is an object of general planning; the structure of particular city zones, plot fragments or their groups is the object of detailed or special planning.

3.2.1. Component of City Structure
City structure is predetermined by the following components, Natural environment and manmade environment. Natural environment consist of forests, groves, parks and other plantations; rivers, lakes, ponds, bays, islands, hills, hollows, swamps, and etc. Manmade Environment consists of zones, districts, linear structure, and transport structure.1

Zones may consist of residential area, city center, business area, industrial area, protective center, cultural center, educational area, scientific area, training center, storage center, transport area, recreational area, sport area, and etc. Districts are considered as smaller-size zone segments, zones may consist of a number of districts. Linear structures and their networks may consist of streets of divergent hierarchical importance and category, roads, energy transmission lines, railways, canals and etc. Transport structures are considered as, air, sea ports, wharves, stations, and stops, of international, national, regional, urban or local importance.2

It can be concluded that both natural and manmade environment are considered as the component of any city structure.

3.2.2. Relation between City Structure and Planning:
City structure follows the general planning to make it more beneficial for the accomplishment of strategic objectives, which determine the principles of functional organization of the city, and its conception. Physical city structure follows the detailed or special planning, it consists of city zones, districts, linear structures and their networks, large transport or other physical structure components, arranged in some particular order or randomly in the natural or modified environment.3

To make the city structure function more effective, it is necessary to ensure, the compatibility of neighboring zones and districts, the harmonization of the zone’s purpose, districts, and other structural components with natural conditions, and finally the evaluation

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2 IBID
in normative terms for the zone, district or structure arrangement in accordance to safety of people, noise reduction, reduction of air, water, soil pollution, fire precautions, energy (fuel) consumption and conservation, and people's leisure\(^1\).

It can be concluded that city as a whole structure is related to the general planning and the physical structure of the city is related to the detailed planning where it can work efficiently by harmonization between the different elements of the city.

### 3.3. City Development:

City development plans are considered as a primary role to provide cities with means to build and maintain strategic partnerships for health, and to develop a platform to encourage all sectors to focus their work on health and quality of life. The city development planning process is therefore the key tool of the healthy city project in working towards the goals and aspirations to reach the ecological city.

#### 3.3.1. City Development Concepts:

Two concepts of city development or functional organization were prevalent in the previous century, which are functional zoning, and functional integration\(^2\).

The concept of functional zoning is based on the principle of dissociation, the division of city entirety into parts, zones, districts, in which an attempt to purify separate functions is made.

![Figure 3-1 Moscow functional zoning plan](Source: URL http://www.stroi.ru/eng/default.aspx?m=31&d=31)

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The other concept is functional integration which is the antonym of dissociation. It is the combination of functions into one entirety, examples of which can be a building, their group, a quarter, a city fragment or a whole city, the activity of which is always related with that of adjacent territories. The aim of functional integration concept is to make every city part, zone, district, even a separate building function as a multi-functional totality, become autonomous, independent of services, employment possibilities provided by other city parts. It also means to be independent of the means of transport, for integration relies, to a greater extent, on the pedestrian possibility. The planner’s aim is to plan in such a way that in the city and in every separate element of city structure all necessary conditions for integrated structures to be created.

3.3.2. City Development Structure:
To maintain the functional and physical structure of city development concepts, city structure can be divided according to five main theories which are open and closed structure theory, monocentric and polycentric structure theory, compact and discreet structure theory, new cities structure theory, and finally cities of mixed structure theory:

A. Open and closed structures:
Irrespective of the development intensity, the city of an open structure can retain its structure in case there are no natural or other hindrances in the territory under development.
The development of the city with closed structure changes its structure not only because of the takeover of new territories but also due to the need to reorganize the structure of the original/previous part of the city.

B. Monocentric and Polycentric Structure:
In terms of the type of functional relations, such structures can be presented. The Centre in such cases is usually understood as a traditional city center, its sub-center (center of a city part) or the so-called peripheral center, which owing to their attraction dominate over individual service enterprises or their groups.

According to Bertaud (2004): “As cities grow in size, the original monocentric structure of large metropolises tends to dissolve progressively into a polycentric structure.

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2 Gillian Mary Hanson, (2004), City and Shore: The Function of Setting in the British Mystery, McFarland.
over time. Large cities are not born polycentric; they may evolve in that direction. Monocentric and polycentric cities are animals from the same species observed at different times during their evolutionary process. No city is ever 100% monocentric, and it is seldom 100% polycentric (i.e., with no discernable “downtown”). Some cities are dominantly monocentric, others are dominantly polycentric and many are in between. Some circumstances tend to accelerate the mutation toward polycentricism, a historical business center with a low level of amenities, high private-car ownership, cheap land, flat topography, grid street design, and others tend to retard it, a historical center with a high level of amenities, rail-based public transport, radial primary road network, and difficult topography preventing communication between suburbs.¹

Figure 3-2 Schematic representation of trips patterns within a metropolitan area

Figure 3-3 Rhein-Ruhr Polycentric structure

Figure 3-4 Berlin-Brandenburg monocentric structure

It can be concluded that, no city is purely monocentric or purely polycentric, no city spatial structure is permanent, monocentric and polycentric cities are different and both type of structure have advantages and disadvantages, and finally different municipal objectives might fit better the monocentric or the polycentric model.

C. Compact and Discreet Structure:

A significant feature of this structure is its building integrity. These structures can be the result of natural processes, i.e. having been fostered by environmental conditions and land value. Or it is a planned and completed structure. Cities-satellites or new cities around London, Moscow, Paris, Helsinki and other megalopolises, dating from approximately fifty years before, all make a discreet structure. It is also the concept of the city development regulation1.

D. New Cities Structure:

Cities of various forms and different characteristics are seldom of a pure structure. It is specified only to newly built cities or their parts2.

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2 Frederick Turner, (2010), Turner's guide to and description of Philadelphia's new city hall or public buildings, the largest and grandest structure in the world, Nabu Press.
E. Cities of Mixture Structure:
The majority of cities have a mixture of structures. In them, divergent structure types and forms have been combined in varying proportions, original city parts, lacking clear structure, among them\(^1\).

![Figure 3-6 The “finger plan” for the Copenhagen region](source)

It can be concluded that cities with differentiated or integrated functions, open or closed structures, monocentric or polycentric, compact or discreet can acquire a variety of forms, according to either the natural conditions surrounding the city, or the planning form of it.

II. Second Part of the Chapter is going to discuss every section in the new cities that is responsible for the carbon emission.

3.4. Living Territories and Land Uses Carbon emissions:
Urban planners play the roles of developing functional and aesthetically pleasing cities with the highest and best use of land, and at the same time ensure that they are ecological friendly. It is important to develop low carbon cities to ensure low CO\(_2\) emissions in the urban areas\(^2\). This section is going to state several theories for calculating CO\(_2\) emitted for different land uses along the city that has been used before in several countries.

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\(^1\) Frederick Turner, (2010), Turner's guide to and description of Philadelphia's new city hall or public buildings, the largest and grandest structure in the world, Nabu Press.

A. Energy Consumption and CO2 Forecasts Obtained from the Department of Energy:

Energy forecasts were obtained from the Department of Energy, Energy Information Administration’s publication Annual Energy Outlook 1995. The percentage increases for each fossil fuel category were extrapolated from national averages, based on population, and are not Colorado-specific\(^1\).

Table 3-1 Forecast for Carbon Dioxide Emissions from Fossil Fuel Use

(Source: Colorado Department, 2002, Colorado Greenhouse Gas, Denver)

<table>
<thead>
<tr>
<th>Sector/Fuel</th>
<th>Energy Consumption (million BTU)</th>
<th>CO2 Emissions (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESIDENTIAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distillate Fuel</td>
<td>193,844.35</td>
<td>15,480.41</td>
</tr>
<tr>
<td>LPG</td>
<td>8,389,219.08</td>
<td>575,559.15</td>
</tr>
<tr>
<td>Kerosene</td>
<td>153,742.05</td>
<td>12,138.32</td>
</tr>
<tr>
<td>Bituminous Coal</td>
<td>588,888.50</td>
<td>59,854.63</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>116,791,700.00</td>
<td>6,796,216.08</td>
</tr>
<tr>
<td>Biomass</td>
<td>1,984,168.84</td>
<td>1,555.09</td>
</tr>
<tr>
<td>Total</td>
<td>7,460,803.68</td>
<td></td>
</tr>
<tr>
<td>COMMERCIAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td>1,785,778.36</td>
<td>138,722.83</td>
</tr>
<tr>
<td>Distillate Fuel</td>
<td>3,290,344.45</td>
<td>262,766.91</td>
</tr>
<tr>
<td>LPG</td>
<td>1,550,199.36</td>
<td>106,354.53</td>
</tr>
<tr>
<td>Kerosene</td>
<td>73,290.42</td>
<td>5,786.46</td>
</tr>
<tr>
<td>Bituminous Coal</td>
<td>1,173,452.91</td>
<td>119,269.75</td>
</tr>
<tr>
<td>Anthracite</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>87,870,948.00</td>
<td>5,113,291.01</td>
</tr>
<tr>
<td>Total</td>
<td>5,746,191.50</td>
<td></td>
</tr>
<tr>
<td>UTILITIES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bituminous Coal</td>
<td>540,659,105.21</td>
<td>54,952,591.45</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>7,319,180.00</td>
<td>425,909.79</td>
</tr>
<tr>
<td>Total</td>
<td>55,378,533.80</td>
<td></td>
</tr>
</tbody>
</table>

B. Emissions Associated with the Construction of Buildings:

The manufacture of the materials required for the construction of buildings uses energy and, consequently, emits CO2. The following table shows the aggregate emissions of a conventional building built using the most common construction system. It consists of a reinforced concrete structure, a layer of exterior walls, flat roofing and bricks interior partitions.

Table 3-2 Aggregate emissions of a conventional building.

(Source: Anna Pagès Ramon, (2008), moving the entire building sector towards low CO2 Emissions, Technical University of Catalonia)

<table>
<thead>
<tr>
<th></th>
<th>kg CO2 / m2</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation</td>
<td>93.67</td>
<td>16.9</td>
</tr>
<tr>
<td>Structures</td>
<td>168.88</td>
<td>30.4</td>
</tr>
<tr>
<td>Exterior walls and Roofs</td>
<td>102.99</td>
<td>18.5</td>
</tr>
<tr>
<td>Interior walls</td>
<td>25.54</td>
<td>4.6</td>
</tr>
<tr>
<td>Exterior cladding</td>
<td>9.84</td>
<td>1.8</td>
</tr>
<tr>
<td>Interior cladding</td>
<td>35.94</td>
<td>6.5</td>
</tr>
<tr>
<td>Doors and windows</td>
<td>58.40</td>
<td>10.5</td>
</tr>
<tr>
<td>Services</td>
<td>56.92</td>
<td>10.2</td>
</tr>
<tr>
<td>Other</td>
<td>3.20</td>
<td>0.6</td>
</tr>
</tbody>
</table>

C. CO2 Emissions Associated with the Use of Different Types of Buildings:

The energy consumption and emissions associated with the use of various types of buildings. The following table, convert energy consumption into CO2 emissions, and the following factors were applied:

Gas: 1 kWh = 204 g CO2

Electricity: 1 kWh = 501 g CO2

These factors show that gas is 2.5 times more efficient than electricity for a given quantity of energy consumed.

---

1 Anna Pagès Ramon, Albert Cuchi Burgos, (2008), 399: Moving the entire building sector towards low CO2 Emissions, Technical University of Catalonia

2 IBID
Table 3-3 Energy consumption and CO2 emissions associated with the use of different types of buildings
(Source: Anna Pagès Ramon, (2008), moving the entire building sector towards low CO2 Emissions, Technical University of Catalonia)

<table>
<thead>
<tr>
<th>Building type</th>
<th>Electricity (%)</th>
<th>Fuel (%)</th>
<th>kWh/m²</th>
<th>Kg CO2/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-storey Residence</td>
<td>25</td>
<td>75</td>
<td>107</td>
<td>30</td>
</tr>
<tr>
<td>Detached house</td>
<td>25</td>
<td>75</td>
<td>43</td>
<td>12</td>
</tr>
<tr>
<td>Office</td>
<td>86</td>
<td>14</td>
<td>145</td>
<td>67</td>
</tr>
<tr>
<td>Hospital</td>
<td>50</td>
<td>50</td>
<td>251</td>
<td>88</td>
</tr>
<tr>
<td>Commercial Space</td>
<td>100</td>
<td>0</td>
<td>327</td>
<td>164</td>
</tr>
<tr>
<td>Hotel</td>
<td>52</td>
<td>48</td>
<td>403</td>
<td>144</td>
</tr>
<tr>
<td>School</td>
<td>31</td>
<td>69</td>
<td>43</td>
<td>13</td>
</tr>
<tr>
<td>Sports centre</td>
<td>20</td>
<td>80</td>
<td>303</td>
<td>80</td>
</tr>
<tr>
<td>Sports centre with swimming pool</td>
<td>45</td>
<td>55</td>
<td>31</td>
<td>10</td>
</tr>
</tbody>
</table>

D. CO2 Emissions Associated with the Land uses:
There are different land uses along the city emit CO2, from these land uses that the research is going to deal with, oxidation lakes, agriculture land, forests, and public dumps¹.

Table 3-4 CO2 Emitted According to Land Uses

<table>
<thead>
<tr>
<th>Land Use</th>
<th>CO2 Emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxidation Lakes</td>
<td>1300 mg/ m² * H</td>
</tr>
<tr>
<td>Agriculture Land</td>
<td>11.2 Kg/ m²</td>
</tr>
<tr>
<td>Forests</td>
<td>52 gm / m²</td>
</tr>
<tr>
<td>Public Dumps</td>
<td>220 mg/ m² * H</td>
</tr>
</tbody>
</table>

3.5. Transport System Carbon Emission:
Transportation sources emit several different gases that contribute to global warming, including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and hydrofluorocarbons (HFCs). Carbon dioxide is by far the most prevalent GHG emitted by transportation sources. According to the U.S. Green House Gases Inventory, nationally over 95% of transportation Green House Gases Inventory emissions were in the form of CO2 in 2004. The remainders of transportation GHG emissions were in the form of N2O, 2.2%; CH4, 0.1%; and HFCs, 2.3%. Given the importance of CO2, it is usually appropriate and acceptable for transportation Green House Gases analyses to focus solely on this gas\(^1\).

3.5.1. Methodologies of Calculating CO2 Emissions:
This section is going to state several ways of calculating CO2 emissions for different type of transportation according to different theories that has been used before in several countries.

A. CO2 Emitted in Direct Proportion to Fuel Consumption:
Calculating the CO2 emissions associated with transportation is conceptually quite simple. CO2 is emitted in direct proportion to fuel consumption, with some variation by type of fuel. As a result, estimating the GHG implications of transportation projects primarily involves estimating the amount of fuel – gasoline, diesel, jet fuel, and other fuels – used by motor vehicles and other transportation sources\(^2\).

There are two ways used for calculating CO2 according to the fuel consumed:

*The First way:*

The amount of CO2 produced is a product of the amount of fuel combusted, the carbon content of the fuel, and the fraction of carbon that is oxidized when the fuel is combusted. A simple formula for the calculation of CO2 for each fuel is as follows:

\[
\text{CO2 emitted} = \text{Fuel Combusted} \times \text{Carbon Content Coefficient} \times \text{Fraction Oxidized} \times \left(\frac{44}{12}\right)
\]

Fuel combustion (in gallons for liquid fuels or cubic feet for natural gas) is converted into units of energy (Btus). The carbon content of fuel varies by type of fuel, and is usually expressed in terms of units of carbon per Btu. The fraction of the carbon oxidized is a lesser consideration since it has traditionally been assumed to be 99 percent for all fossil fuel

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1 American Association of State Highway and Transportation Officials (AASHTO), (2006), *Assessment of Greenhouse Gas Analysis Techniques for Transportation Projects*, Standing Committee on Environment
2 Ibid
3 The factor $44/12$ is the weight of CO2 in relation to the amount of carbon in the fuel, assuming all carbon burned eventually oxidizes to form CO2. Consequently, the key analysis that needs to be conducted to estimate CO2 is to determine the amount of fuel consumed by fuel type (e.g., motor gasoline, diesel, jet fuel, compressed natural gas, etc.)\(^1\).

Consequently, the key analysis that needs to be conducted to estimate CO2 is to determine the amount of fuel consumed by fuel type (e.g., motor gasoline, diesel, jet fuel, compressed natural gas, etc.), so the previous equation can be much more accurate.\(^2\)

<table>
<thead>
<tr>
<th>Fuel Types Commonly Used by Different Transportation Modes</th>
<th>Light-duty vehicles</th>
<th>Heavy-duty vehicles</th>
<th>Buses</th>
<th>Rail</th>
<th>Aircraft</th>
<th>Maritime vessels</th>
<th>Other Non-road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor gasoline</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Diesel (Distillate)</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Jet fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aviation gasoline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Other fuels*</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^*\)Other fuels include: compressed natural gas (CNG), liquefied petroleum gasoline (LPG), and other alternative fuels.

The previous table identifies the following transportation mode:

Light-duty vehicles (e.g., passenger cars, light-duty trucks), Heavy-duty trucks (e.g., freight trucks), Buses (e.g., transit buses, as well as school buses or intercity buses), Rail (e.g., transit, passenger rail, or freight), Maritime vessels (e.g., Boats and ships), Other non-road mobile sources (e.g., airport ground service equipment, construction equipment, agricultural equipment).

---

\(^1\) American Association of State Highway and Transportation Officials (AASHTO), (2006), Assessment of Greenhouse Gas Analysis Techniques for Transportation Projects, Standing Committee on Environment

\(^2\) I.J. Lu, S.J. Lin, and C. Lewis, (2007), Decomposition and decoupling effects of carbon dioxide emission from highway transportation in Taiwan, Germany, Japan and South Korea [An article from: Energy Policy], Elsevier
The Second way:

The specific numbers are referring to diesel fuels.\(^1\)

General formula:

\[
cc \times T \times X \text{ [kg/l]} = \text{[kg CO2/liter of fuel]}
\]

Values for diesel fuel:

- \( cc = \) carbon content in fuel in mass percentage = 86 % = 0.86
- \( T = \) fuel density = 0.820 [kg/l]
- \( X = \) molecular weight relation for CO2 = \( \frac{12u + (2 \times 16u)}{12u} = \frac{44}{12} \)

Result for diesel fuel:

\[
0.86 \times 0.82 \times \left( \frac{44}{12} \right) \text{ [kg/l]} = 2.6 \text{ [kg CO2/liter of fuel]}
\]

It can be concluded that, this calculation in practice is quite complex since transportation agencies do not typically collect data to track vehicle fuel consumption by fuel type. In a limited number of cases, fuel data are available and can be used directly in calculating CO2. The availability of direct measures of fuel consumption, however, is generally limited for transportation agencies, and fuel consumption estimates may not be available at all for project-level, corridor, or regional analysis.

B. CO2 Emitted according to Vehicle Type:

This analysis is intended to evaluate the environmental performance of Highway Motor Coach operations, by comparing the energy use and carbon dioxide (CO2) emissions of motor coaches with the energy use and CO2 emissions of other common transportation vehicles/modes.\(^2\)

For all modes both energy use and CO2 emissions are expressed in terms of units per passenger mile operated. The metrics used for energy intensity are passenger miles per diesel-equivalent gallon (pass-mi/DEG) and btu2 per passenger mile (btu/pass-mi). The metric used for CO2 emissions is grams of emissions per passenger mile (g/pass-mi). Carbon dioxide is a greenhouse gas that has been linked to global warming. The transportation sector is a significant contributor to total man-made CO2 emissions from the burning of fossil fuels. For the transportation sector fuel use and CO2 emissions are linked and are generally proportional for each travel mode.\(^3\)

---

\(^1\) Helen Lindblom & Christian Stenqvist, (2007), SKF Freight Transports and CO2 emissions a Study in Environmental Management Accounting, ISSN 1404-8167

\(^2\) M.J. Bradley & Associates 1000 Elm Street, (2007), Comparison of Energy Use & CO2 Emissions From Different Transportation Modes, Manchester, NH 03101.

\(^3\) IBID
Including motor coaches, a total of twelve transportation modes are included in the analysis, as follows in the following table.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Pass-mi/Gal</th>
<th>Btu/Pass-mi</th>
<th>CO2 g/pass-mi</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Coach</td>
<td>184.4</td>
<td>749</td>
<td>56</td>
<td>Motor coach fleets are designed for long-distance travel.</td>
</tr>
<tr>
<td>Van pool</td>
<td>101.9</td>
<td>1354</td>
<td>101</td>
<td>A transit mode that uses vans, small buses and other vehicles, to provide transportation to a group of individuals.</td>
</tr>
<tr>
<td>Heavy Rail</td>
<td>155.3</td>
<td>889</td>
<td>156</td>
<td>A transit mode that uses self-propelled electric-powered passenger cars operating on an exclusive rail right-of-way.</td>
</tr>
<tr>
<td>Commuter Rail</td>
<td>85.8</td>
<td>1608</td>
<td>177</td>
<td>A transit mode that uses electric or diesel-powered locomotives pulling passenger cars, and operating on an exclusive rail right-of-way, for local short-distance travel.</td>
</tr>
<tr>
<td>InterCity Rail</td>
<td>66.0</td>
<td>2091</td>
<td>179</td>
<td>A transit mode that uses electric or diesel-powered locomotives pulling passenger cars, and operating on an exclusive rail right-of-way, for long distance travel between cities.</td>
</tr>
<tr>
<td>Car Pool 2 person</td>
<td>55.4</td>
<td>2492</td>
<td>185</td>
<td>The private automobile mode includes all use of a personally-owned car or light truck for commuting and other travel.</td>
</tr>
<tr>
<td>Light Rail</td>
<td>120.5</td>
<td>1146</td>
<td>202</td>
<td>A transit mode that uses self-propelled electric-powered passenger cars operating on an exclusive or shared above-ground rail right-of-way to provide scheduled service within an urban area.</td>
</tr>
<tr>
<td>Trolley bus</td>
<td>104.4</td>
<td>1321</td>
<td>233</td>
<td>A transit mode that uses electric powered rubber-tired vehicles for fixed route scheduled service within an urban area.</td>
</tr>
<tr>
<td>Car–Avg Trip</td>
<td>43.8</td>
<td>3154</td>
<td>235</td>
<td>The private automobile mode includes all use of a personally-owned car or light truck for commuting and other travel.</td>
</tr>
<tr>
<td>Transit Bus</td>
<td>32.5</td>
<td>4245</td>
<td>299</td>
<td>A transit mode that includes the use of primarily diesel-powered, rubber-tired vehicles for fixed route scheduled service within an urban area.</td>
</tr>
<tr>
<td>Car 1 person</td>
<td>27.7</td>
<td>4983</td>
<td>371</td>
<td>The private automobile mode includes all use of a personally owned car or light truck for commuting and other travel.</td>
</tr>
<tr>
<td>Ferry Boat</td>
<td>12.6</td>
<td>10987</td>
<td>818</td>
<td>A transit mode that uses marine vessels to carry passengers and/or vehicles over a body of water.</td>
</tr>
</tbody>
</table>

Pass-mi/Gal = Passenger Miles per Diesel Equivalent Gallon
C. CO2 Emitted According to Total Annual Fuel Used by Each Mode of Transportation:
The first step in this analysis is to convert Total Annual Fuel used by each mode to units of Diesel Equivalent Gallons (DEG), using Equation 1 for liquid fuels and Equation 2 for electricity:

*Equation 1*

\[
\text{Annual DEG} = \frac{\text{Fuel Energy Content (btu/gal)}}{\text{Diesel Energy Content (btu/gal)}} \times \text{Annual Fuel (gal)}
\]

*Equation 2*

\[
\text{Annual DEG} = \frac{\text{Annual Energy (kwh)}}{3,412 \text{ btu/kwh}} \div \frac{\text{Diesel Energy Content (btu/gal)}}
\]

The second step is illustrating the energy content of the relevant fuels as shown in the following table:

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Energy (Btu/gal)</th>
<th>Density (lb/gal)</th>
<th>Weight % Carbon</th>
<th>CO2 g/gal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>138000</td>
<td>7.1</td>
<td>87%</td>
<td>10274</td>
</tr>
<tr>
<td>Gasoline</td>
<td>114000</td>
<td>6.0</td>
<td>85%</td>
<td>8482</td>
</tr>
<tr>
<td>LPG</td>
<td>91330</td>
<td>4.4</td>
<td>82%</td>
<td>6042</td>
</tr>
<tr>
<td>LNG</td>
<td>73500</td>
<td>3.2</td>
<td>75%</td>
<td>4017</td>
</tr>
<tr>
<td>Kerosene</td>
<td>135000</td>
<td>6.9</td>
<td>86%</td>
<td>9935</td>
</tr>
<tr>
<td>B20 Biodiesel</td>
<td>135613</td>
<td>7.0</td>
<td>84%</td>
<td>9748</td>
</tr>
</tbody>
</table>

The third step is calculating the energy intensity metrics presented in the analysis using Equations 3 and 4:

*Equation 3*

\[
\text{Passenger Miles per DEG (Pass-mi/DEG)} = \frac{\text{Annual Passenger Miles}}{\text{Annual DEG}}
\]

*Equation 4*

\[
\text{Btu per Passenger Mile (btu/pass-mi)} = \frac{\text{Annual DEG} \times 138,000 \text{ btu/DEG}}{\text{Annual Passenger Miles}}
\]

---

2 IBID
The forth step is calculating all the liquid and gaseous fuels carbon dioxide emissions per gallon of fuel burned using Equation 5 and also calculating total carbon dioxide emissions for each mode using Equation 6. The fuel properties used in Equation 5 are shown in the previous table.

**Equation 5**

\[
\text{CO}_2 \text{ (g/gal)} = 44 \left( \frac{\text{CO}_2 \text{mw}}{\text{Cmw}} \right) \div 12 \times 453.6 \text{ g/lb} \times \text{Fuel Density (lb/gal)} \times \text{Fuel Wt % Carbon}
\]

**Equation 6**

\[
\text{Total CO}_2 \text{ (g)} = \text{Sum (CO}_2 \text{ (g/gal)} \times \text{Annual Gallons)} \text{All fuels + Electricity (kwh)} \times 600.6 \text{ g CO}_2/\text{kwh}
\]

The fifth step is calculating the Carbon dioxide emissions per passenger mile using Equation 7.

**Equation 7**

\[
\text{CO}_2 \text{ per Passenger Mile (g/pass-mi)} = \frac{\text{Total CO}_2 \text{ (g)}}{\text{Annual Passenger Miles}}
\]

### D. Energy Consumption and CO2 Forecasts Obtained from the Department of Energy:

Energy forecasts were obtained from the Department of Energy, Energy Information Administration’s publication Annual Energy Outlook 1995. The percentage increases for each fossil fuel category were extrapolated from national averages, based on population, and are not Colorado-specific.

<table>
<thead>
<tr>
<th>Sector/Fuel</th>
<th>Energy Consumption (million BTU)</th>
<th>CO2 Emissions (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>252,915,896.83</td>
<td>19,647,012.70</td>
</tr>
<tr>
<td>Distillate Fuel</td>
<td>58,010,592.50</td>
<td>4,632,725.92</td>
</tr>
<tr>
<td>LPG</td>
<td>417,545.10</td>
<td>28,646.52</td>
</tr>
<tr>
<td>Aviation Gasoline</td>
<td>1,170,106.21</td>
<td>88,347.70</td>
</tr>
<tr>
<td>Jet Fuel</td>
<td>48,077,585.64</td>
<td>3,795,845.58</td>
</tr>
<tr>
<td>Lubricants</td>
<td>3,468,306.64</td>
<td>280,755.95</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>12,866,760.00</td>
<td>748,728.56</td>
</tr>
<tr>
<td>Ethanol</td>
<td>86,955,424.00</td>
<td>6,597,047.15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>86,955,424.00</strong></td>
<td><strong>35,819,110.08</strong></td>
</tr>
</tbody>
</table>

E. CO2 Emitted in Direct Proportion to Its impact per km (or passenger-km, tone-km)

Emissions factors are required to estimate the CO2 impact per km (or passenger-km, tone-km) from passenger and freight transport. The Annexes to the Defra Company Reporting Guidelines (CRG), released in July 2005. The factors derived refer to CO2 emissions per km and are derived from speed emission curves also used by the UK’s National Atmospheric Emissions Inventory (NAEI) / Greenhouse Gas Inventory (GHGI).¹

This part is going to state the CO2 emission of the ground based transportation according to the vehicles type and size, (Petrol and diesel cars, Regular taxis and taxi Cairo cap, Petrol and diesel vans, Local buses and long distance coaches, Motorcycles, Railways.)

**Petrol and Diesel Cars.**

Defra Company Reporting Guidelines has categorized petrol cars engine size into three categories small (<1.4), medium (1.4 – 2.01), and large (>2.01), the CO2 emission per Km for these type of cars respectively are 180.9, 213.9, 295.8 grams, and the consumption of petrol per km for these type of cars respectively are 12.8, 10.8, 7.8 liter.

Diesel Cars has been categorized according to engine size into three categories small (<1.7), medium (1.7 – 2.01), and large (>2.01), the CO2 emission per Km for these type of cars respectively are 151.3, 188.1, 258.0 grams, and the consumption of diesel per km for these type of cars respectively are 17.4, 14.0, 10.2 liter.²

**Regular taxis and taxi Cairo cap.**

Defra Company Reporting Guidelines has reported CO2 emission for taxi and Cairo cap per passenger Km respectively 161.3, 175.7 grams.³

**Petrol and diesel vans.**

Defra Company Reporting Guidelines has reported CO2 emission per Km for petrol van size up to 1.25 tone 224.4 grams, and CO2 emission per Km for diesel van size up to 3.5 tone 271.8 grams.⁴

**Local buses and long distance buses.**

Defra Company Reporting Guidelines has reported CO2 emission per passenger Km for local bus 115.8 grams, and CO2 emission per passenger Km for long distance bus 81.8 grams.

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¹ Guidelines to Defra’s GHG Conversion Factors, (2008), Methodology Paper for Transport Emission Factors
² IBID
³ IBID
⁴ IBID
Motorcycles.
Defra Company Reporting Guidelines has categorized petrol motorcycle engine size into three categories small (up to 125 cc), medium (125 to 500 cc), and large (over 500 cc), the CO2 emission per Km for these type of motorcycle respectively are 72.9, 93.9, 128.6 grams, and the consumption of petrol per km for these type of cars respectively are 31.6, 24.5, 17.9 liter.

Railways.
Defra Company Reporting Guidelines has reported CO2 emission per passenger Km for Railways, with average passenger occupancy 901.

3.5.2. Transportation Green House Gases (GHG) Analysis Tools:
A range of tools are available that can be used to analyze GHG emissions from the transportation sector. These tools, however, vary significantly in their capabilities and ease of use for transportation GHG analysis. Most of them were not designed primarily for transportation GHG analysis, and as a result, the methodologies and procedures employed are not always easy to use for transportation GHG analyses and do not always account for the full range of factors that influence GHG emissions. This section identifies tools or methods that can be used to analyze the GHG implications of transportation projects. The following tools are grouped into three categories, based on their primary function, Transportation GHG calculation tools; Transportation strategy analysis tools; and Energy-focused forecasting tools.

A. Transportation GHG Calculation Tools
These tools are designed to develop emissions estimates based on user-provided inputs, such as vehicle miles traveled (VMT) and/or fuel consumption (or to develop emission factors that can be combined with VMT estimates to develop emissions estimates). Some tools are designed with VMT as a primary input, while others are designed with fuel consumption as the primary input. They vary in terms of the transportation sources they address, level of sophistication, and ability to address a range of different types of inputs and analyses. Many of these tools were developed by the U.S. Environmental Protection Agency (EPA), and several have common methodologies or build upon each other. These tools are divided into three sub-groups.

1American Association of State Highway and Transportation Officials (AASHTO), (2006), Assessment of Greenhouse Gas Analysis Techniques for Transportation Projects, Standing Committee on Environment
2IBID
1. **Multi-sector Inventory Tools:** These tools are designed to develop GHG inventories or projections for all economic sectors, including transportation:

**State Inventory Tool (SIT):** Developed by the U.S. EPA, the SIT is designed to develop a comprehensive GHG inventory (CO₂, CH₄, N₂O, and HFCs) at the state level, using a combination of state-specific inputs and default data. It requires inputs of transportation fuel consumption and VMT.

**State Inventory Projection Tool (SIPT):** Developed for the U.S. EPA, the State Inventory Projection Tool builds on inventory estimates from the SIT by allowing users to forecast GHG emissions through 2020. Projections are based in part on projected fuel consumption reported by the U.S. Energy Information Administration.

2. **Direct GHG Emission Calculation Tools:** These tools focus solely on transportation sources, and are designed to develop emission factors or emission estimates for gases emitted during vehicle use:

**MOBILE6 Model:** This is the EPA-approved model that generates on-road motor vehicle emission factors for use in transportation analysis at the state, region, or project level. In addition to criteria pollutants, the model generates CO₂ emission factors, which can be combined with VMT data to estimate CO₂ emissions. The CO₂ emission factors only account for vehicle type and model year; the emission factors do not account for impacts of vehicle operating conditions (e.g., travel speeds) on CO₂ and expected changes in future vehicle fuel economy.

**NONROAD Model:** This EPA-approved emissions model is used to develop estimates of criteria pollutant and CO₂ emissions estimates for non-road sources, such as recreational vehicles, agricultural equipment, construction equipment, lawn and garden equipment, recreational boats, airport ground support equipment, railroad maintenance equipment and others. NONROAD does not address commercial marine vessels, locomotives, or aircraft.

**National Mobile Inventory Model (NMIM):** EPA developed NMIM to integrate the input data requirements, model runtimes, and post-processing requirements for MOBILE6 and NONROAD models into a single package.
EMFAC: The California Air Resources Board (CARB) developed EMFAC as the California version of MOBILE6. Using emission factors and vehicle activity inputs, EMFAC develops emission estimates for on-road vehicles to be used in developing emission inventories, projections, and other project level analyses. The CO$_2$ emission rates vary by vehicle speed.

3. Life-cycle GHG Emission Calculation Tools: Greenhouse Gases, Regulated Emissions, and Energy use in Transportation (GREET) Model - Developed by the Argonne National Laboratory (sponsored by U.S. DOE),

GREET: is designed to fully evaluate the energy and emission impacts of advanced vehicle technologies and new transportation fuels (considering the fuel cycle from wells to wheels and the vehicle cycle through material recovery to vehicle disposal).

Lifecycle Emissions Model (LEM): Developed by Mark Delucchi at the University of California, Davis, LEM estimates energy use, criteria pollutant emissions, and CO$_2$-equivalent greenhouse-gas emissions from transportation and energy sources.

Motor Vehicle Emissions Simulator (MOVES): Being developed in stages by the U.S. EPA, MOVES is eventually intended to replace MOBILE6, NONROAD, and NMIM. The existing version of MOVES estimates energy consumption (for use in calculating CO$_2$), N$_2$O, and CH$_4$ from on-road vehicles from 1999 to 2050, and accounts for the impacts of vehicle speeds, age, and stock on emissions. It also includes estimates of direct and upstream emissions, based on the GREET model. MOVES can be used to develop regional, statewide, and national GHG emissions estimates, and can be used to generate emissions factors for project-level analyses.

B. Transportation/Emissions Strategy Analysis Tools
These tools are designed to estimate the travel and emissions impacts of specific types of transportation strategies, based on inputs about the transportation programs or strategies (e.g., type of strategy, other parameters of specific strategies). Most of the analytical strength of these tools is in the estimation of travel impacts; the user does not need to calculate a change in VMT or speeds, since the model performs that analysis. The CO$_2$ calculation
procedures are generally very simple, and often do not account for complex implications of vehicle operating characteristics on emissions\(^1\).

These tools include:

**COMMUTER Model**: Developed by the U.S. EPA, the COMMUTER Model is designed to analyze the impacts of transportation control measures (TCMs), such as transit employer-based transportation demand management programs and transit improvements, on VMT, criteria pollutant emissions, and CO\(_2\). The CO\(_2\) calculations are simple, and based on default emission factors from MOBILE6.

**Intelligent Transportation Systems Deployment Analysis System (IDAS)**: The Federal Highway Administration (FHWA) developed IDAS as a sketch planning tool to estimate the impacts, benefits, and costs resulting from the deployment of ITS components; it estimates emissions of CO\(_2\) and criteria pollutants.

**C. Energy/Economic Forecasting Analysis Tools**

These tools are designed to forecast energy consumption, typically based on economic factors such as economic growth and fuel prices. Most of these tools are designed for national-level analysis, and cannot be readily used for metropolitan area or project-level analyses. Although these tools have strengths in terms of examining the implications of economic factors on transportation energy consumption, they typically are not geared toward analyzing the impacts of transportation investments and rely on data inputs that are not typically used in the transportation planning process.\(^2\)

These tools include:

**National Energy Modeling System (NEMS)**: Developed by the Energy Information Administration (EIA) within the U.S. Department of Energy (DOE), NEMS represents the behavior of energy markets and their interactions with the U.S. economy to develop annual projections and evaluate national energy policies. A transportation demand module (TRAN) within the model forecasts the consumption of transportation sector fuels, which can be used to calculate CO\(_2\).

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\(^1\)American Association of State Highway and Transportation Officials (AASHTO), (2006), *Assessment of Greenhouse Gas Analysis Techniques for Transportation Projects*, Standing Committee on Environment

\(^2\)IBID
VISION: Developed by the Argonne National Laboratory (sponsored by U.S. DOE), VISION is an excel-based model that provides estimates of the potential energy use, oil use, and carbon emission impacts to 2050 of advanced light- and heavy-duty highway vehicle technologies and alternative fuels.

World Energy Protection System (WEPS) Transportation Energy Model (TEM): Developed by U.S. DOE, as a component of WEPS (a world energy consumption model), the Transportation Energy Model (TEM) generates forecasts of transportation sector energy use by transport mode at a national and multi-national region level. The WEPS accounting framework incorporates assumptions about the future energy intensity of economic activity (ratios of total energy consumption divided by gross domestic product [GDP]), and about the rate of incremental energy requirements met by different energy sources.

Systems for the Analysis of Global Energy Markets (SAGE): Developed by the U.S. DOE to replace WEPS, SAGE develops projections of energy consumption to meet energy demand, estimated on the basis of each region’s existing energy use patterns, the existing stock of energy using equipment, and the characteristics of available new technologies, as well as new sources of primary energy supply.
According to the previous stated model, the following table is concluded to state the applicability of tools for transportation of greenhouse gases analysis.

- Designed for this type of analysis.
- □ Not designed for this type of analysis but could potentially be applied.
- - Not applicable.

Table 3-9 Applicability of Tools for Transportation GHG Analysis.

<table>
<thead>
<tr>
<th>Model</th>
<th>Geographic Level of Analysis</th>
<th>Type of Analysis</th>
<th>Transportation mode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>State</td>
<td>Region</td>
<td>Local</td>
</tr>
<tr>
<td>MOBILE6</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>NONROAD</td>
<td>■</td>
<td>-</td>
<td>■</td>
</tr>
<tr>
<td>NMIM</td>
<td>■</td>
<td>■</td>
<td>-</td>
</tr>
<tr>
<td>SIT</td>
<td>■</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SIPT</td>
<td>■</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CLIP</td>
<td>-</td>
<td>-</td>
<td>■</td>
</tr>
<tr>
<td>MOVES</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>COMMUTER</td>
<td>-</td>
<td>-</td>
<td>■</td>
</tr>
<tr>
<td>IDAS</td>
<td>-</td>
<td>-</td>
<td>■</td>
</tr>
<tr>
<td>NEMS</td>
<td>-</td>
<td>-</td>
<td>■</td>
</tr>
<tr>
<td>VISION</td>
<td>-</td>
<td>-</td>
<td>■</td>
</tr>
<tr>
<td>WEPS</td>
<td>-</td>
<td>-</td>
<td>■</td>
</tr>
<tr>
<td>SAGE</td>
<td>-</td>
<td>-</td>
<td>■</td>
</tr>
<tr>
<td>GREET</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>LEM</td>
<td>-</td>
<td>-</td>
<td>■</td>
</tr>
<tr>
<td>EMFAC</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>NYSDOT</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
</tbody>
</table>
3.6. Industrial Zone Carbon Emission:
Greenhouse gas emissions are produced as a by-product of various non-energy-related industrial activities. That is, these emissions are produced from an industrial process itself and are not directly a result of energy consumed during the process. For example, raw materials can be chemically transformed from one state to another. This transformation can result in the release of greenhouse gases such as carbon dioxide (CO2), methane (CH4), or nitrous oxide (N2O). This section is going to present different CO2 emission for different industries in different countries. This section is going to state several theories for calculating CO2 emitted for different industries along the city that has been used before in several countries.

A. Industrial Carbon Emission in U.S.:
The processes addressed in this paragraph include iron and steel production, cement manufacture, ammonia manufacture and urea application, lime manufacture, limestone and dolomite use (e.g., flux stone, flue gas desulfurization, and glass manufacturing), soda ash manufacture and use, titanium dioxide production, phosphoric acid production, ferroalloy production, CO2 consumption, aluminum production, petrochemical production, silicon carbide production and consumption, lead production, zinc production, nitric acid production, and adipic acid production1.

In 2005, industrial processes generated emissions of 333.6 Terragram of CO2 equivalent (Tg CO2 Eq.), the following table is going to summarize CO2 emission in year 2005.

Table 3-10 CO2 emission for different industries
(Source: http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html)

<table>
<thead>
<tr>
<th>Industry Type</th>
<th>CO2 Emission in Year 2005 (Tg CO2 Eq.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement Manufacture</td>
<td>45.9</td>
</tr>
<tr>
<td>Iron and Steel Production</td>
<td>45.2</td>
</tr>
<tr>
<td>Ammonia Manufacture &amp; Urea</td>
<td>16.3</td>
</tr>
<tr>
<td>Lime Manufacture</td>
<td>13.7</td>
</tr>
<tr>
<td>Limestone and Dolomite Use</td>
<td>7.4</td>
</tr>
<tr>
<td>Soda Ash Manufacture and Consumption</td>
<td>4.2</td>
</tr>
<tr>
<td>Aluminum Production</td>
<td>4.2</td>
</tr>
<tr>
<td>Petrochemical Production</td>
<td>2.9</td>
</tr>
<tr>
<td>Titanium Dioxide Production</td>
<td>1.9</td>
</tr>
<tr>
<td>Ferroalloy Production</td>
<td>1.4</td>
</tr>
<tr>
<td>Phosphoric Acid</td>
<td>1.4</td>
</tr>
<tr>
<td>Zinc Production</td>
<td>0.5</td>
</tr>
<tr>
<td>Lead Production</td>
<td>0.3</td>
</tr>
</tbody>
</table>

B. Industrial Carbon Emission in Netherlands:

During the second half of the twentieth century the Netherlands transformed from a low-energy economy into an economy that is known for its high level of energy use. The most important changes took place between 1960 and 1975, just after the newly found natural gas reserves started to be exploited. Of course, the increase in fossil fuel use also caused a large increase in the CO2 emissions and the associated damages\(^1\).

The following table in going to state energy used and the CO2 emitted for year 2008 for the industrial process in Netherlands.

---

\(^1\) Ruben van der Helm, Rutger Hoekstra and Jan Pieter Smits, (2008), Economic growth, structural change and carbon dioxide emission: The case of Netherlands, Paper prepared for the 18th International Input-Output Conference, June 20-25th, Sydney, Australia
Table 3-11 Energy used and CO2 emitted for different industries and activities in Netherland
(Source: Ruben van der Helm, 2008, Economic growth, structural change and carbon dioxide emission, Australia)

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Detailed Classification</th>
<th>Energy Used PJ</th>
<th>CO2 emission MTone CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>Agriculture, forestry and fishery</td>
<td>139.9</td>
<td>8.4</td>
</tr>
<tr>
<td>Mining</td>
<td>Mining and quarrying</td>
<td>31.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Food</td>
<td>Food, beverages and tobacco</td>
<td>52.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Textiles</td>
<td>Textiles and leather</td>
<td>-10.3</td>
<td>-1.0</td>
</tr>
<tr>
<td>Paper and publishing</td>
<td>Paper and publishing</td>
<td>14.9</td>
<td>-0.7</td>
</tr>
<tr>
<td>Oil refineries</td>
<td>Oil refineries</td>
<td>100.9</td>
<td>7.3</td>
</tr>
<tr>
<td>Chemical industry</td>
<td>Chemicals, rubber and synthetic fibers</td>
<td>245.9</td>
<td>8.5</td>
</tr>
<tr>
<td>Basic Metals</td>
<td>Basic Metals</td>
<td>17.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Metal products, etc.</td>
<td>Metal products, electronics and transport equipment</td>
<td>24.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Other industry</td>
<td>Wood and wood products, building materials and other industry</td>
<td>26.9</td>
<td>0.1</td>
</tr>
<tr>
<td>Utilities</td>
<td>Energy and water supply</td>
<td>249.3</td>
<td>34.9</td>
</tr>
<tr>
<td>Air and water transport</td>
<td>Air and water transport</td>
<td>211.8</td>
<td>16.1</td>
</tr>
<tr>
<td>Road transport</td>
<td>Road transport and transport services</td>
<td>118.3</td>
<td>8.0</td>
</tr>
<tr>
<td>Others</td>
<td>Construction, government and other services</td>
<td>477.9</td>
<td>17.8</td>
</tr>
</tbody>
</table>

C. Energy Consumption and CO2 Forecasts Obtained from the Department of Energy:

Energy forecasts were obtained from the Department of Energy, Energy Information Administration’s publication Annual Energy Outlook 1995. The percentage increases for each fossil fuel category were extrapolated from national averages, based on population, and are not Colorado-specific\(^1\).

Table 3-12 Forecast for Carbon Dioxide Emissions from Fossil Fuel Use

(Source: Colorado Department, 2002, Colorado Greenhouse Gas, Denver)

<table>
<thead>
<tr>
<th>Sector/Fuel</th>
<th>Energy Consumption (million BTU)</th>
<th>CO2 Emissions (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerosene</td>
<td>135,099.09</td>
<td>10,666.41</td>
</tr>
<tr>
<td>Distillate Fuel</td>
<td>20,687,411.78</td>
<td>1,652,096.70</td>
</tr>
<tr>
<td>LPG</td>
<td>5,171,318.12</td>
<td>354,788.62</td>
</tr>
<tr>
<td>Other Liquids</td>
<td>11,134,038.98</td>
<td>889,164.35</td>
</tr>
<tr>
<td>Bituminous Coal</td>
<td>23,053,300.53</td>
<td>2,343,137.47</td>
</tr>
<tr>
<td>Lubricants</td>
<td>1,958,891.90</td>
<td>158,570.34</td>
</tr>
<tr>
<td>Asphalt and Road Oil</td>
<td>28,609,727.08</td>
<td>2,362,662.79</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>89,985,126.00</td>
<td>5,236,316.97</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>13,007,403.65</strong></td>
</tr>
</tbody>
</table>

D. Non-combustion, On-site Fossil Fuel Combustion, and Purchased Electricity CO2 Emissions:

CO2 emissions in this part are estimated in units of MMTCO2E, a unit of measurement that takes into account the relative potency of the gas by applying global warming potentials (GWP) of each gas. For example, the GWP of CO2 is 1, while the GWPs of CH4 and N2O are 21 and 310, respectively. For a listing of GWPs for other GHGs and a full explanation of GWPs. Each sector of industry, emission estimates are provided per year in the following table, for which a complete dataset is available to estimate emissions for fossil fuel combustion, non-combustion activities, and electricity purchases.¹

## Table 3-13 CO2 Emissions for Key Industrial Sectors (MMTCO2E)


<table>
<thead>
<tr>
<th>Emission Source</th>
<th>CO2 Emission (MMTCO2E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alumina and Aluminum</td>
<td>51</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>11</td>
</tr>
<tr>
<td>Non-Combustion</td>
<td>5</td>
</tr>
<tr>
<td>Electricity</td>
<td>36</td>
</tr>
<tr>
<td>Cement</td>
<td>83</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>32</td>
</tr>
<tr>
<td>Non-Combustion</td>
<td>43</td>
</tr>
<tr>
<td>Electricity</td>
<td>8</td>
</tr>
<tr>
<td>Chemicals</td>
<td>322</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>203</td>
</tr>
<tr>
<td>Non-Combustion</td>
<td>18</td>
</tr>
<tr>
<td>Electricity</td>
<td>101</td>
</tr>
<tr>
<td>Construction</td>
<td>131</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>100</td>
</tr>
<tr>
<td>Electricity</td>
<td>31</td>
</tr>
<tr>
<td>Food and Beverages</td>
<td>100</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>51</td>
</tr>
<tr>
<td>Electricity</td>
<td>49</td>
</tr>
<tr>
<td>Forest Products</td>
<td>120</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>62</td>
</tr>
<tr>
<td>Electricity</td>
<td>58</td>
</tr>
<tr>
<td>Iron and Steel</td>
<td>114</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>22</td>
</tr>
<tr>
<td>Non-Combustion</td>
<td>55</td>
</tr>
<tr>
<td>Electricity</td>
<td>37</td>
</tr>
<tr>
<td>Lime</td>
<td>23</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>9</td>
</tr>
<tr>
<td>Non-Combustion</td>
<td>12</td>
</tr>
<tr>
<td>Electricity</td>
<td>1</td>
</tr>
<tr>
<td>Metal Casting</td>
<td>18</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>7</td>
</tr>
<tr>
<td>Electricity</td>
<td>11</td>
</tr>
<tr>
<td>Mining</td>
<td>41</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>15</td>
</tr>
<tr>
<td>Electricity</td>
<td>27</td>
</tr>
<tr>
<td>Oil and Gas</td>
<td>349</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>276</td>
</tr>
<tr>
<td>Non-Combustion</td>
<td>30</td>
</tr>
<tr>
<td>Electricity</td>
<td>43</td>
</tr>
<tr>
<td>Plastic and Rubber Products</td>
<td>44</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>8</td>
</tr>
<tr>
<td>Electricity</td>
<td>36</td>
</tr>
<tr>
<td>Semiconductors</td>
<td>9</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>1</td>
</tr>
<tr>
<td>Electricity</td>
<td>8</td>
</tr>
<tr>
<td>Textiles</td>
<td>32</td>
</tr>
<tr>
<td>Fossil Fuel Combustion</td>
<td>10</td>
</tr>
<tr>
<td>Electricity</td>
<td>21</td>
</tr>
</tbody>
</table>
E. CO2 Emissions According to the Type and Quantity of Industrial Product:
Manufacturing is the single largest source of energy-related carbon dioxide emissions, one of the ways of calculating CO2 emitted from manufacturing is relating the emission to the quantity and type of industry product, the following table is going to summarize CO2 emitted for some of the industrial products\(^1\).

<table>
<thead>
<tr>
<th>Element</th>
<th>Value in [kg CO2 / t]</th>
<th>Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2 emissions from paper manufacturing</td>
<td>23</td>
<td>Direct emissions from the mill, internal transports, chemical pulp, DIP-rejects</td>
</tr>
<tr>
<td>CO2 emissions from fiber production</td>
<td>4</td>
<td>Emissions from forestry, recovered paper processing</td>
</tr>
<tr>
<td>CO2 emissions from other raw materials</td>
<td>98</td>
<td>Manufacturing of Filler - PCC, manufacturing of paper chemicals</td>
</tr>
<tr>
<td>CO2 emissions from purchased energy</td>
<td>519</td>
<td>Electrical energy, thermal energy (steam)</td>
</tr>
<tr>
<td>CO2 emissions from transports</td>
<td>32</td>
<td>Transport of raw materials to the mill, transport of finished products to printer</td>
</tr>
</tbody>
</table>

F. CO2 Emissions According to the Number of Factories & Type of Industrial Products:
Manufacturing is considered as a complex process, whether in its consuming energy or emitting carbon dioxide, so the following table is going to state the CO2 emission for each type of industry related to the number of factories producing each industrial product, considering that the areas of these factories and their production capacity is average in comparison to others. The following table shows CO2 emission and the number of factories concerning the industrial products, based on the latest end-use energy consumption statistics from EIA’s and Manufacturing Energy Consumption Survey (MECS)\(^2\).

---
\(^2\)Mark Schipper, (2006), Energy-Related Carbon Dioxide Emissions in U.S. Manufacturing, Energy Information Administration (EIA)
### Table 3-15 Carbon Dioxide Emissions from Manufacturing by Industry and Industry Group.


<table>
<thead>
<tr>
<th>Industry and Industry Group under North American Industry Classification System (NAICS)</th>
<th>Carbon Dioxide Emissions (Million Metric Tons)</th>
<th>Number of Factories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum</td>
<td>304.8</td>
<td>799</td>
</tr>
<tr>
<td>Petroleum Refineries</td>
<td>277.6</td>
<td>1,778</td>
</tr>
<tr>
<td>Chemicals</td>
<td>311.0</td>
<td>799</td>
</tr>
<tr>
<td>Other Basic Organic Chemicals</td>
<td>80.5</td>
<td>1,408</td>
</tr>
<tr>
<td>Plastics Materials and Resins</td>
<td>63.3</td>
<td>1,747</td>
</tr>
<tr>
<td>Other Basic Inorganic Chemicals</td>
<td>23.9</td>
<td>2,043</td>
</tr>
<tr>
<td>Industrial Gases</td>
<td>17.0</td>
<td>1,157</td>
</tr>
<tr>
<td>Nitrogenous Fertilizers</td>
<td>12.4</td>
<td>386</td>
</tr>
<tr>
<td>Carbon Black</td>
<td>5.3</td>
<td>52</td>
</tr>
<tr>
<td>Cyclic Crudes and Intermediates</td>
<td>5.1</td>
<td>100</td>
</tr>
<tr>
<td>Noncellulosic Organic Fibers</td>
<td>5.0</td>
<td>229</td>
</tr>
<tr>
<td>Synthetic Rubber</td>
<td>3.5</td>
<td>229</td>
</tr>
<tr>
<td>Phosphatic Fertilizers</td>
<td>2.5</td>
<td>109</td>
</tr>
<tr>
<td>Primary Metals</td>
<td>212.8</td>
<td>3,096</td>
</tr>
<tr>
<td>Iron and Steel Mills</td>
<td>126.0</td>
<td>944</td>
</tr>
<tr>
<td>Alumina and Aluminum</td>
<td>48.0</td>
<td>154</td>
</tr>
<tr>
<td>Iron Foundries</td>
<td>10.2</td>
<td>517</td>
</tr>
<tr>
<td>Nonferrous Metals, less Aluminum</td>
<td>10.8</td>
<td>283</td>
</tr>
<tr>
<td>Electrometallurgical Ferroalloy</td>
<td>3.1</td>
<td>65</td>
</tr>
<tr>
<td>Paper Mills, except Newsprint</td>
<td>44.4</td>
<td>2,294</td>
</tr>
<tr>
<td>Paperboard Mills</td>
<td>31.8</td>
<td>808</td>
</tr>
<tr>
<td>Wet Corn Milling</td>
<td>18.9</td>
<td>146</td>
</tr>
<tr>
<td>Sugar</td>
<td>5.3</td>
<td>47</td>
</tr>
<tr>
<td>Fruit and Vegetable Canning</td>
<td>3.4</td>
<td>1,227</td>
</tr>
<tr>
<td>Cements</td>
<td>39.0</td>
<td>628</td>
</tr>
<tr>
<td>Glass Products</td>
<td>16.2</td>
<td>1,641</td>
</tr>
<tr>
<td>Glass Containers</td>
<td>5.2</td>
<td>229</td>
</tr>
<tr>
<td>Flat Glass</td>
<td>4.0</td>
<td>772</td>
</tr>
<tr>
<td>Lime Manufacturing</td>
<td>10.3</td>
<td>202</td>
</tr>
<tr>
<td>Mineral Wool</td>
<td>4.7</td>
<td>322</td>
</tr>
</tbody>
</table>
3.7. Global CO2 Emission by Sector:
Climate change is caused by the emission of greenhouse gases. There are six greenhouses gases recognized under the Kyoto Protocol, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydro fluorocarbons (HFC), per fluorocarbons (PFC), and sulphur hexafluoride (SF6), that are released through various anthropogenic activities such as power generation, wastewater treatment, landfills, industrial processes, and fuel for transportation. Power generation for electricity, heat, and industrial activities makes up the bulk of global emissions, followed by land use change (e.g., deforestation and burning), agriculture (including livestock and use of fertilizers), and transportation (fossil fuels for automobiles)\(^1\).

![Figure 3-7 Global CO2e emissions by sector, (2004). (Source: Rogner et al. 2007)](image)

In Colorado emitted over 85 million tons of carbon dioxide from fossil fuel combustion. Fossil fuel consumption accounts for 98% of all carbon dioxide emissions\(^2\).

![Figure 3-8 CO2 Emissions from Fossil Fuel Consumption by Sector](image)

In U.S. emission estimates in this part may vary from EPA emission estimates for other purposes. Further, these emission estimates may be improved upon in the future as more GHG emissions are reported, and other estimates may be developed to incorporate additional life-cycle activities such as transport of materials into and out of the sector\(^1\).

Planning of low carbon cities involves creation of low carbon society by promoting low carbon emission. In order to achieve a low carbon emission, effort to reduce CO\(_2\) emission is most important as CO\(_2\) is the most significant anthropogenic greenhouse gas (GHG) emitted in urban areas. The increases of CO\(_2\) concentration are due primarily to fossil fuel use and land use change. Urban planning through land use planning and planning control can play vital role in implementing the idea of low carbon cities, particularly during the formulation of development plans. The following figure shows Malaysian carbon dioxide emissions according to the city sectors\(^2\).


\(^2\)Ho Chin Siong, Fong Wee Kean, (2007), Planning for Low Carbon Cities The case of Iskandar Development Region, Malaysia, Sustainable Urban Development Institute.
The net annual emission of greenhouse gases in Australia was 402.4 million tons of CO2 equivalents, of which Agriculture activity contributed 18% and Land Use Change and Forestry 12%, Industrial Process 2%, Waste 3%, and finally total energy 65%\(^1\).

![Figure 3-11 Contribution to total CO2 – Equivalent Emission by Sector](image)

(Source: H.B. So, Potential of Conservation Tillage Reduce Carbon Dioxide emission in Australian soils)

3.8. Improving the Natural and Built Ecological Systems in an Urban Environment by Green Network:

The ecological approach to landscape planning and the concepts of designing and implementing ecological systems have gained increasing attention in the last two decades. This approach could help in defining sustainable landscape development, aiming for a balance between both physical and natural systems in urban areas. The spatial structure of green and natural areas are studied and categorized based on the patch-corridor-matrix model\(^2\). The urban ecological systems can bridge the conflict between reserve conservation, fixing nature in space and time and development. They help to focus on an effective spatial scale as well\(^3\).

As the coherence of an ecological system is based on ecological processes it may be single purpose or multipurpose (Jongman, 1995). The multi-objective systems go beyond ecological improvements of the city and habitat needs of wildlife, to address recreation and beautification, promoting urban flood damage reduction, enhancing water quality and other

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\(^1\)H.B. So, R.C. Dalal; K.Y. Chan, Potential of Conservation Tillage Reduce Carbon Dioxide emission in Australian soils.


urban infrastructure objectives. Extending the ecological system concept with multifunctional indicators is a promising step towards sustainable city. Ecological systems, as natural or built potentials, play a leading role in achieving sustainable urban environment. By focusing on structures, functions and transformations of the environment, landscape ecology approach is an attempt to find patterns and interrelations between landscape elements, built and natural patches, corridors and the matrix (Forman, 1995; Ingegnoli, 2002). Ideas such as urban open space network (Turner, 1995; Cranz & Boland, 2004), park systems (Jongman & Pungetti, 2004; Maruani & Cohen, 2007) and greenway networks (McHarg, 1969; Ahern, 1995; Little, 1999; Fabos, 2004; Turner, 2006) are developed as initiatives to interweave the natural and built systems in ecological landscape design and planning (Makhzoumi & Pungetti, 1999).

3.8.1. Ecological View in Designing New York Green Space System:

Adopting a new ecological view of the metropolitan landscape in designing New York green space system (Flores et al., 1998) suggests a framework that emphasizes a dynamic view of a biologically rich urban environment with a focus on interactions among multiple sites across temporal scales. This approach is defined by presenting five key ecological principles as follows:

- **Content**: a wide spectrum of ecosystem functions that are strongly linked to ecosystem structure
- **Context**: a combination of localities that results in considerable variability in the kind of ecological context specific to each site
- **Dynamics**: suggests that with structural changes, ecosystem function also changes

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D. Heterogeneity: means ecosystems need not be pristine, only flexible, connected, and diverse with complement of species to generate the genetic, biological, and biogeochemical capacity to adapt and respond to a changing environment.

E. Hierarchy: help manage ecological complexity by organizing it into discrete functional components operating at different scales.

3.8.2. **Ecological View in Designing Beijing, China Green Space System:**

Comprehensive concept plan of urban greening based on ecological principles, a case study in Beijing, China (Li et al., 2005) attempts to answer how to establish an urban greening plan at the regional, city and neighborhood levels to achieve long-term sustainability. This three-level system constitutes an integrated ecological network for urban sustainable development of Beijing. For future development of the city, urban parks, forestry, agriculture, water and infrastructure should be planned and designed in an integrated way. It has the prospect of achieving the long-term goal of developing Beijing towards an Eco-City. Ecological principles and requirements for urban greening of Beijing define the temporal and spatial scale of green space planning. Three spatial scales have to be considered. At the regional scale, the entire area of Beijing Province is considered. Even the relationship to the neighboring city Tianjin is included in the plan. At the city scale, the urban area of Beijing with its suburbs and the surrounding peri-urban zone is taken into account, and at the neighborhood scale, some selected and typical areas within the fourth ring road are considered. The plan distinguishes between three time-scales for implementation. The ecological principles and requirements for the urban greening in Beijing are as follows:

**Ecological Principle in Beijing**

- Structure and function
- Clarity and consistency
- Functional and ecological diversity
- Biodiversity and eco-services
- Distribution of green space
- General acceptance and implementation of the plan

![Figure 3-13 Ecological principle in Beijing](Source: Researcher)

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2 IBID
A. Structure and function: changing the function of fragmented and isolated green space.

B. Clarity and consistency: an easily-communicable long-term vision and an integrated green space

C. Functional and ecological diversity: combining several ecological functions and are not nonfunctional.

D. Biodiversity and eco-services: enhancing ecosystem services by high green space quality and diversity and improve specific conditions for endangered species

E. Distribution of green space: creating public parks close to high-density residential areas and no pollution in fresh air-generation zones and fresh air corridors, establishing big forest areas and ecological buffer belts at the regional scale and vertical greening for high-density settlement.

F. General acceptance and implementation of the plan: publicizing the concept through the media, involving decision makers and the public as a strong driving force to promote green space development.

3.8.3. Ecological View in Designing London Green Space System:

Emphasis has been placed on planning vegetated urban fields in London. Other types of green space have been neglected (Turner, 1995). This attempt has distracted planners’ attention from the vital task of creating networks of environmentally pleasant open spaces.

The only continuous ecological corridors in London are the rivers, which constitute another layer to the Green Strategy. As London is conceived to have webs of public open space, it would have been possible to plan for more diverse habitats and natural processes. The greenway theory and parkways are introduced as parts of this ecological system and urban rivers are converted into blue-ways, by opening up access to the banks of rivers. Eco ways are established networks of ecological space in cities by using and merging urban water courses, public utility corridors, parklands and private gardens into a single integrated system of ecologically important components

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Network of Ecological Spaces in London

Figure 3-14 Ecological principle in Beijing

(Source: Researcher)

The following is concluded table to review the natural and built ecological systems in three metropolitan areas, (New York, Beijing, and London).

Table 3-16 The natural and built ecological systems in 3 metropolitan areas

<table>
<thead>
<tr>
<th>Region</th>
<th>Ecological Principles</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>Content</td>
<td>Creating regional reserves</td>
</tr>
<tr>
<td>(Flores et al., 1998)</td>
<td>Context</td>
<td>Invigorating green spaces in highly urbanized</td>
</tr>
<tr>
<td></td>
<td>Dynamics</td>
<td>Environments creating a regional network of green spaces</td>
</tr>
<tr>
<td></td>
<td>Heterogeneity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hierarchy</td>
<td></td>
</tr>
<tr>
<td>Beijing</td>
<td>Spatial Scales</td>
<td>Integrating isolated green space into network</td>
</tr>
<tr>
<td>(Li et al., 2005)</td>
<td>Time Scales</td>
<td>clarity and consistency of green space system enhances ecosystem services.</td>
</tr>
<tr>
<td></td>
<td>Connectivity</td>
<td>Bridge separating elements.</td>
</tr>
<tr>
<td>London</td>
<td>Connectedness</td>
<td>Creating networks of open space and ecological</td>
</tr>
<tr>
<td>(Turner, 1995)</td>
<td></td>
<td>corridors establish networks of ecological space, greenways and parkways</td>
</tr>
</tbody>
</table>

3.8.4. Role of Ecological Patches and Corridors in the Sustainability of Urban Environments:

Urban ecological systems can link terrestrial ecological, physical, and socioeconomic components of metropolitan areas (Pickett et al., 2001) in an ecological approach to landscape planning (Sanderson & Harris, 2000; Steiner, 2000) in urban environment. The experiences and theories demonstrate that ecological patches and corridors play a crucial role in the sustainability of urban environments and their transformations directly influence the ecological functions of the city. Some general points for structural and functional improvement of patches and corridors in the urban context are categorized in the following figure.

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It can be concluded that the existing natural patches and corridors in the urban environment are to be preserved and restored to increase the ecological functions of the city so that the natural flows can continue and penetrate into the built environment. The built patches and corridors within the urban context can act as main elements to make an ecologically functional system. The built patches are most influential factor in the densely built-up and populated city regions, and the built corridors can act as main connecting elements between the natural and built patches. Protecting the integrity between structural elements, preserving the original pattern of ecological systems, will help to establish and enhance the ecological processes and flows in the urban and suburban environment.
3.9. Conclusion:

A. Natural and manmade environment are considered as a component of any city structure. Whole structure of a city is related to the general planning, and the physical structure of a city is related to detail planning where it can work efficiently by harmonization between the different elements of the city.

B. Cities with differentiated or integrated functions, open or closed structures, monocentric or polycentric, compact or discreet can acquire a variety of forms, according to either the natural conditions surrounding the city, or the planning form of it. Important facts concluded according to the form of a city, these facts are:

- No city is purely monocentric or purely polycentric. Some cities are dominantly monocentric or dominantly polycentric and other are in between.
- No city spatial structure is permanent.
- Monocentric and polycentric cities are different and both type of structure have advantages and disadvantages.
- Different municipal objectives might fit better the monocentric or the polycentric model.
- Cities which is mono-functional or its functions are highly-integrated, its structures are then defined by the street network, which can be: rectangular, multiangular, radial, irregular and etc.

C. Climate change is caused by the emission of greenhouse gases. There are six greenhouse gases recognized under the Kyoto Protocol, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydro fluorocarbons (HFC), per fluorocarbons (PFC), and sulphur hexafluoride (SF6), that are released through various activities that take place inside the city. The second part in this chapter has divided the activities that are responsible for CO2 emissions into three main sections:

- Living Territory and Land Use Carbon Emission.
- Transport System Carbon Emission.
- Industrial Carbon Emission.
D. Three ways are concluded for calculating living territory and land use carbon emission:

1st way
- Depend on Calculating CO2 according to the energy consumption of the living territories and land uses.

2nd way
- Depend on Calculating CO2 according to the Construction of Buildings.

3rd way
- Depend on Calculating CO2 according to the area and different uses of the Buildings.

E. Five ways are concluded for calculating Transportation System carbon emission:

1st way
- Depend on Calculating CO2 according to the fuel consumed.
  - Fuel based: (Liter of fuel) x (kg CO2/liter of fuel) = kg CO2

2nd way
- Depend on Calculating CO2 according to the vehicle type.

3rd way
- Depend on Calculating CO2 according to the Total Annual Fuel Used by Each Mode
  - Tonne-km based: (l of fuel/km) x (kg CO2/l of fuel) * (tonne-km) / [(Cargo capacity of the transport) x (fill rate)] = kg CO2

4th way
- Depend on Calculating CO2 according to the Forecasts Obtained from the Department of Energy.

5th way
- Depend on Calculating CO2 according to its impact per km (or passenger-km, tone-km)
  - Vehicle-km based: (Number of vehicles) x (km one way) x (l of fuel/km) x (kg CO2/l of fuel) = kg CO2
F. Six ways are concluded for calculating industrial zones carbon emission:

1st way
• Identify the carbon emission of the Industrial zones in U.S.

2nd way
• Identify the carbon emission of the Industrial zones in Netherland

3rd way
• Depend on Calculating CO2 according to the Forecasts Obtained from the Department of Energy.

4th way
• Depend on Calculating CO2 according to non-combustion, On-site Fossil Fuel Combustion, and Purchased Electricity.

5th way
• Depend on Calculating CO2 according to the Quantity and type of Industrial Product.

6th way
• Depend on Calculating CO2 according to the number of factories & type of industrial product.

G. There is a strong link between urbanization, economic growth, and greenhouse gas emissions. Cities are engines of economic growth that contribute to a country’s development and hence improve the standard of living of the country’s citizens. Urban areas contribute to a significant portion of a country’s GDP through industrialization, manufacturing activities, and provision of services, the same activities that result in the creation of greenhouse gases. Urban areas also concentrate people and as their affluence increases GHG emissions are further driven up by people’s consumption patterns and lifestyle choices. On the other hand, a compactly designed city may well result in a lower volume of GHG emissions than would otherwise be obtained, it has been concluded the most important sector that is responsible for emitting GHG is the industrial activity, followed by utilities and transportation, then finally the living territories activities, and if the industrial activity is not one of the main activities in the city, then Utilities and transportation ranked as one of the main activities that is responsible for GHG emissions.

H. To provide a model for urban ecological systems based on landscape ecology approach, urban planners should take all natural and built structural elements into consideration. The remnant natural patches and corridors in the urban environment are to be preserved and restored to increase their ecological functions of the city so
that the natural flows can continue and penetrate into the built environment. The built patches and corridors within the urban context can act as main elements to make an ecologically functional system. The built patches are most influential factor in the densely built-up and populated city regions, and the built corridors can act as main connecting elements between the natural and built patches. Protecting the integrity between structural elements, preserving the original pattern of ecological systems, will help to establish and enhance the ecological processes in the new cities.

I. Some of the activities are considered as the major problems that the city faces, for improving their ecological systems, these activities are:

- Restoring the natural form and structure of the river valleys, natural matrix connectivity, and sensitive built areas such as roads crossing the river valleys.
- Cultivating vegetation and penetration of the natural and built ecological patches and corridors into the urban fabric as ecological rehabilitation activities.
- Improving rules and regulations against the alterations of ecologically important features for preservation purposes.
- Removing the pollutants through physical, chemical and biological processes and assisting vegetation growth through bioremediation techniques to mitigate some of environmental problems.
- Naturalizing the environment and optimizing the microclimatic conditions, providing the basis for the natural systems to thrive and flourish.
- Creating new or ecologically important features such as small green patches in the urban fabric establishing greenways along main roads and a hierarchical system of linear parks in the urban context.
Chapter 4
Land Suitability Modelling for Urban Green Areas.

4.1. Introduction

4.2. Urban Green Areas.

4.3. City’s Benefit from City Green Areas.

4.4. Assumptions for the Database Model Design (1)

4.5. Assumptions for the Database Model Design (2)

4.6. Conclusion
4.1. Introduction:

Redeveloping and planning green spaces and urban structure are among the essentials of mass planning of a city. Accurate planning with the help of GIS may bring about a big step in the physical and social development of the cities. The systematic view towards the subject of city planning it still has not found its specific position in many countries. Most of the Egyptian cities are designed, planned and administrated by inexpert individuals. It would be right if the skillful experts with the help of technical and scientific tools bring an end to the disordered state of most cities.¹

Environmental protection is undoubtedly one of the most important areas where GIS technologies are the most extensively used. Geographic Information Systems for environmental protection, due to their complexity and importance, require large number of diversified data. Consequently, quality of spatial data is fundamental for proper functioning of GIS. The data of highest possible accuracy and quality are being crucial for the offered system functions. Describing a model GIS for urban green areas, particular attention has been paid to the issue of standardization. Increasingly popular in many aspects of life, often global in scope applications of GIS providing various kinds of spatial data were forced to set and introduce standards for development of such systems. The standards for GIS for National green spaces are based, inter alia, on guidelines developed within the EU INSPIRE (Infrastructure for Spatial Information in Europe) initiative. Therefore the goals of the system creation include, between others, common data availability and easy data exchange between systems, the features demanded by the community of users and limited only by existing legal restrictions (e.g. special data protection).²

Urban green areas and open spaces have always been a valuable asset to human communities. They are multi-faceted in the kind of value that they have provided to local communities. For this reason, parks and open space have been given much attention during the planning processes in the urban environment. Urban green areas have not only provided recreation benefits to communities, but have provided much economic wealth to local communities. Community residents have noted the benefits of urban green areas. In many urban environments, residential property values have increased near urban green spaces as a direct result.³

It may be concluded that, placing value on land and space within a city is an essential part of urban planning. Placing values is important in urban planning because it shows

² Leszek Litwin1, Marcin Guzik2, (2002), Institute of Spatial and Cadastral Systems, Gliwice, Poland, Tatra National Park, Zakopane, Poland
community support (Johnson, 1989). An example, if a community places high value on increasing its economy, the community may promote and support industrial or other business growth within the community. Community residents can show support for urban green areas in the same fashion. Those communities that place high value on their urban green areas systems will often display and promote their urban system with economic support. For this reason, urban green areas and the general welfare of a city can often be related. If a community is growing economically, then that community may provide a fine urban green system.

4.2. Urban Green Areas:
Urban green areas are the most important form of nature protection. Their priority is “to study and protect all environment systems of the area including the conditions of their existence and to reconstruct damaged or destroyed elements of native nature.” The creation of Geographic Information Systems based on spatial databases is without a doubt a necessary condition for the realization of statutory obligations of urban green spaces.

4.2.1. Urban Green Areas System and Definition:
Urban green areas: are territories where there are no populated areas and settlements and which include natural ecological systems with great variety of vegetation, animal kinds and habitats, characteristic and extraordinary landscape and sites of the non-living nature. The purposes of these areas are to maintain the variety of the ecological systems and to protect the wild nature and the biological variety in the ecological systems, and to develop tourism and scientific, educational and recreational activities.

The Economic Value of urban green System: Cities are economic entities. They are made up of structures entwined with open space. Successful communities have a sufficient number of private homes and commercial and retail establishments to house their inhabitants and give them places to produce and consume goods. Cities also have public buildings, libraries, hospitals, arenas, city halls for culture, health, and public discourse. They have linear corridors streets and sidewalks for transportation, and they have a range of other public spaces, green areas, plazas, trails, sometimes natural, sometimes almost fully paved for

\[1\text{Dziennik Ustaw nr 114, (1991) “Nature Protection Act” - printed official gazette announcing current legislation}\]

\[2\text{Leszek Litwin1, Marcin Guzik2, (2002), Institute of Spatial and Cadastral Systems, Gliwice, Poland, Tatra National Park, Zakopane, Poland}\]

94
recreation, health provision, tourism, sunlight, rainwater retention, air pollution removal, natural beauty, and views.¹

Urban green spaces: are outdoor places with significant amounts of vegetation, which exist mainly as semi-natural areas, or are viewed as last remnants of nature in urban areas.²

4.2.2. Increasing Hedonic (Property) Value:
More than 30 studies have shown that green areas have a positive impact on nearby residential property values. Other things being equal, most people are willing to pay more for a home close to a nice green space. Economists called this phenomenon “hedonic value.” (Hedonic value also comes into play with other amenities such as schools, libraries, police stations, and transit stops. Theoretically, commercial office space also exhibits the hedonic principle; unfortunately, no study has yet been carried out to quantify it.)³

Figure 4-1 Meridian Hill Park in Washington, D.C. provides extra value to the thousands of dwelling units surrounding it, and to the city itself through higher property tax receipts.

(Source:http://www.expressnightout.com/content/2008/10/rating_dogfriendly_dc_parks_for_human_pi.php)

4.2.3. Importance of Green Areas:
Green areas are considered as urbanized environment which provide people with a feeling of place and identity. Green areas also can instill pride for a community or city, and often give a city an identity. Central Park in New York City is well recognized, and gives the city a unique character. Rochester is also known for its beautiful downtown park system, but at a much smaller scale. Visitors to the area often notice the city urban green space system immediately. Indeed, part of Rochester’s character and standard of living can be seen

through its city park system.\textsuperscript{1} Green areas play an important part of urban ecosystems; play a pivotal role in preserving biodiversity in urban areas. Moreover, green spaces sequester CO\textsubscript{2} and produce O\textsubscript{2}, they reduce air pollution and noise, regulate microclimates, and reduce the heat island effect in cities affect house prices maintain diversity; have recreational and social values and produce a vitamin “G” for health, well-being and social safety.\textsuperscript{2} Green areas can provide many opportunities to a community. Not only have urban green spaces provided a retreat from the noise and bustle of traffic and crowds, they have also provided a stage for a whole range of social activities.

Green areas often provide excellent areas for the public to socialize. They often provide a place for enjoyment, recreation, relaxation, family affairs, socialization, communication areas, and a place for gathering. Urban parks also provide aesthetic beauty and natural resource protection.\textsuperscript{3} Green areas offer much to everyone. Many types of people frequent green areas, including developers, property owners, children, businesses, students, government officials, homeless, the elderly and children. However, green areas should be properly planned and maintained in order for them to be successful. If green spaces are not properly planned, it can often bring negative factors into the area. Negative factors often associated with poorly planned urban green spaces include crime, noise and congestion. Poorly planned green spaces can also limit certain types of people from accessing it, such as the elderly or children.Green areas users show the social values that they put on local green spaces, and what those spaces bring to the standard of living through their support. People and society put high values toward green spaces that offer them satisfaction. They feel that a jog in the green space, a tennis match with a friend, and a neighborhood softball game are all appreciated, and see these urban spaces amenities as factors that improve and strengthen one’s standard of living.\textsuperscript{4}

From previous it has been concluded that identifying suitable sites for conserving and developing green spaces is the first important step to ensure their roles and functions. Site information can be gained by using land suitability analysis based on GIS which is a strong, efficient and effective application within land-use planning, habitat analysis, etc.\textsuperscript{5} Applying the ecological factor threshold method will help quantify how much green area is necessary

\begin{footnotesize}
\textsuperscript{1}Chezick, Jan. Interview. 25 Jan (1999).
\textsuperscript{3}Garris, Ed. Interview. 20 Jan 1999.
\end{footnotesize}
to maintain an ecological balance in urban areas.\textsuperscript{1} Using an urban forest effects model will help quantify key values of urban green spaces such as carbon storage and sequestration.\textsuperscript{2} More importantly, the roles and functions of urban green spaces can be enhanced if they are organized by combining a variety of green space types for multiple purposes called a green network or urban green structure.

4.3. City’s Benefit from City Green Areas:
A lot of researches ask a very important question, “How much value does an excellent city green areas system bring to a city?” the research is trying to answer this question by summarizing the city green areas network benefit in five points:

A. Income from Out-of-Town City Green network Visitor Spending (Tourists).
B. Direct use value.
C. Health value.
D. Reducing the Cost of Managing.
E. Removal of Air Pollution by Vegetation.

4.3.1. Income from Out-of-Town City Green Network Visitor Spending (Tourists):
Green areas play a major role in a city’s tourism economy. Some such as Independence National Historic Park in Philadelphia, Central Park in New York, Millennium Park in Chicago, or Balboa Park in San Diego are tourist attractions by themselves. Others are simply great venues for festivals, sports events, even demonstrations.\textsuperscript{3}

\begin{figure}[h]
\centering
\includegraphics[width=0.45\textwidth]{national_historic_park}
\caption{National Historic park in Philadelphia}
\end{figure}
\begin{figure}[h]
\centering
\includegraphics[width=0.45\textwidth]{central_park}
\caption{Central Park in New York}
\end{figure}

\begin{thebibliography}{99}
\end{thebibliography}
4.3.2. **Direct Use Value:**

While city green areas provide much indirect benefit, they also provide huge tangible value through such activities as team sports, bicycling, and skateboarding, walking, picnicking, bench sitting, and visiting a flower garden. Economists call these activities “direct uses.”

Most direct uses in city green areas are free of charge, but economists can still calculate value by knowing the cost of a similar recreation experience in the private marketplace. This is known as “willingness to pay.” In other words, if green areas were not available in a city, how much would the resident (or “consumer”) pay in a commercial facility? (Thus, rather than income, this value represents savings by residents.)

It may be concluded that while some might claim that direct use value is not as “real” as tax or tourism revenue, it nevertheless has true meaning. Certainly, not all green areas activities would take place if they had to be purchased. On the other hand, city dwellers do get pleasure and satisfaction from their use of green areas. If they had to pay and if they consequently reduced some of this use, they would be materially “poorer” from not doing some of the things they enjoy.

![The Frog Pond in the Boston Common](http://www.travelpod.com/travel-photo/jamiemeasure/1/1252903660/frog-pond-boston-common.jpg/tpod.html)

*Figure 4-4 The Frog Pond in the Boston Common is but one of the numerous park facilities that provide Bostonians with hundreds of millions of dollars of direct use value.*


4.3.3. **Health Value:**

Several studies have documented the economic burden of physical inactivity. Lack of exercise is shown to contribute to obesity and its many effects, and experts call for a more active lifestyle. Recent research suggests that access to green areas can help people increase their level of physical activity.

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98
4.3.4. Community Cohesion:

Numerous studies have shown that the more webs of human relationships a neighborhood has, the stronger, safer, and more successful it is. Any institution that promotes this kind of community cohesion whether a club, a school, a political campaign, a religious institution to a neighborhood and, by extension, to the whole city.

This human web, which Jane Jacobs termed “social capital,” is strengthened in some cities by green areas. From playgrounds to sports fields to park benches to chessboards to swimming pools to ice skating rinks to flower gardens, parks offer opportunities for people of all ages to interact, communicate, compete, learn, and grow. Perhaps more significantly, the acts of improving, renewing, or even saving green areas can build extraordinary levels of social capital. This is particularly true in a neighborhood suffering from alienation partially due to the lack of safe public spaces. While the economic value of social capital cannot be measured directly, it is instructive to tally the amount of time and money that residents devote to their green spaces.¹

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4.3.5. Removal of Air Pollution by Vegetation:

Air pollution is a significant and expensive urban problem, injuring health and damaging structures. The human cardiovascular and respiratory systems are affected, and there are broad consequences for health-care costs and productivity. In addition, acid deposition, among, and ozone increase the need to clean and repair buildings and other costly infrastructure\(^1\).

Trees and shrubs remove air pollutants such as nitrogen dioxide, sulfur dioxide, carbon dioxide, ozone, and some particulates. Leaves absorb gases, and particulates adhere to the plant surface, at least temporarily. Thus, vegetation in city green spaces network plays a role in improving air quality and reducing pollution costs\(^2\).

It can be concluded that, while reams of urban research have been carried out on the economics of housing, manufacturing, retail, and even the arts, there has been until now no comprehensive study of the worth of a city’s green space system, although green space can be assigned the kind of numerical underpinning long associated with transportation, trade, housing, and other sectors. The research will be able to obtain a major piece of missing information about how cities work and how green space fit into the equation.

4.4. Assumptions for the Database Model Design (1):

The purpose of this study is to answer the question of how to apply land suitability analysis modeling, the ecological factor threshold method, and landscape-ecology principles in planning comprehensive green structure. A case study was made for Hanoi, Vietnam and its results show that most of the planned green spaces in the 2020 Hanoi Master Plan are suitable for development. However, the recommended 18m\(^2\) green area per capita seems not to be enough to maintain ecological balance and organization of the green spaces in the 2020 plan seems to lack a theoretical basis, or a holistic framework, at different scales. From this perspective, this study propose that Hanoi should set aside an extra green area from 6842 to 10,228 ha, and that the 2020 Hanoi green structure plan at regional, city and neighborhood scales includes three green wedges, one green belt, various parks and other green ways to create a green network ecologically more effective than the sum of the individual green spaces\(^3\).

\(^2\)IBID
\(^3\)Pham Duc Uy, Nobukazu Nakagoshi, (2008), Application of land suitability analysis and landscape ecology to urban green space planning in Hanoi, Vietnam, Urban Forestry and urban greening.
4.4.1. Land Suitability Analysis:
Land suitability analysis for building a green space map was carried out based on, air pollution maps, water body system maps, existing land-use maps, maps of valuable historical and cultural landscapes, and Standards for planning and designing urban and industrial areas.

The Land suitability analysis was supported by the spatial analysis functions of GIS through steps including, identification and collection of spatial data, weighting with the analytic hierarchy process, data integration and GIS analysis, and finally output evaluation.

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2 IBID
Among the environmental functions of urban green spaces, the previous five maps have been chosen because of the following reasons:\(^1\):

A. Air quality was selected because of its importance and availability of data.

B. Land use system is a significant input because it expresses the human impact, and influences the feasibility of developing urban green spaces. The existing land use, which includes basic habitat information, has been classified into real green spaces or evergreen spaces (parks, public green spaces, riverside green spaces, roadside green spaces, attached green spaces), non-real green spaces or open green spaces (agricultural land, cultivated alluvial land), built-up areas.

C. Water body systems. Regarding water body systems and valuable landscapes (historic, cultural sites such as temples, palaces, etc. with reference to the traditional Egyptian way of life), almost all green spaces such as parks and public green spaces have been developed in conjunction with water bodies or historical and cultural sites.

D. Vietnam regulations and standards also play an important part in developing urban green spaces and they decide how green spaces will be developed.

In land suitability analysis, determining the suitability scores for each factor is a compulsory step, and in this study they were regulated from 1 to 3 as in the following figure where a higher score indicates an area more suitable for developing green spaces. In the land use map, for example, real green spaces receive the score 3 (highest suitability), open green spaces score 2, and others are attributed score 1 (lowest suitability)\(^2\).

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\(^1\) Pham Duc Uy, Nobukazu Nakagoshi, (2008), Application of land suitability analysis and landscape ecology to urban green space planning in Hanoi, Vietnam, Urban Forestry and urban greening.

\(^2\) IBID
Weighting is one of the most important steps in suitability analysis, as it precisely affects the output, and is complicated by interacting of factors with each other\(^1\). Analytic hierarchy process and pair wise comparison of the criteria are widely used to identify weighting scores, and they were applied in this study. The MATLAB 5.3 software was used to solve the matrix which results from analytic hierarchy process and pair wise comparison; and the spatial function of the Arc GIS 9 (Arc/Info, release version 9.3, ESRI, Redlands, CA 92373-8100, USA) platform was used to overlay the factors to make composite map which acts as a suitable green map.\(^2\)

### 4.4.2. The Ecological Factor Threshold Method:

The ecological factor threshold method is implemented based on the principles of ecological balance. Thus, the purpose of this step was to quantify how much green area is needed for the area of study in terms of maintaining ecological balance. Zhang et al. (2007) applied this method for planning urban green space systems based on analyzing the key ecological elements including: the population carrying capacity, carbon–oxygen balance, and the supply demand equilibrium of the water resources\(^3\).

As shown by Zhang et al. (2007) the population carrying capacity is the largest number of people that food and energy produced by ecosystems can support based on stated production conditions, land productivity, standard of living, and so forth.

In Hanoi, this has been identified in the 2020 Master Plan. The carbon–oxygen balance is the most influential factor. It relates to the total of carbon emission by human as well as natural activities, and to absorbing carbon dioxide and releasing oxygen in photosynthesis of green plants. In green space planning, the carbon–oxygen balance is carried on the basis of constant adjustment of green plants of green spaces and various kinds of oxygen consuming activities\(^4\).

Water resources are an essential factor for all creatures to exist and develop. Thus, the supply–demand equilibrium of water resources, which presents to an equilibrium of demands (domestic, industrial agricultural consumptions) and supplies (rainfall, groundwater, etc.) is important for sustainable development of human in general and vegetation or green spaces in particular.

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\(^2\) IBID.


\(^4\) IBID
4.4.3. Landscape Ecology Concepts for Green Structure Planning:

Landscape ecology has opened the door to and provides a basis for planning landscapes in general and green networks in particular. Forman and Godron (1986) proposed the model of patch, corridor and matrix as the three basic components of any landscape, and state that landscape ecology deals with the effects of the spatial configuration of mosaics on a wide variety of ecological phenomena. Landscape-ecology concepts and applied metrics are likely to be useful in addressing the spatial dimension of sustainable planning and they provide a theoretical basis for landscape and urban planning. The landscape-ecology principles used in planning land use and landscape architecture are patch size, number and location; edge parameters (i.e. the boundary with edge structure, and shape); corridors and connectivity; and network mosaics.

Jim and Chen (2003) who applied comprehensive green space planning to compact Nanjing city, China have shown that island biogeography theory (MacArthur and Wilson, 1967) and landscape ecology (Forman and Godron, 1986) provide fundamental strategies for green space system design. They comprise a network of greenways, green wedges and green extensions, which linked isolated green patches within and outside the city at three scales (metropolis, city and neighborhood). Li et al. (2005) also showed that according to the principles of landscape ecology, green wedges and green corridors may comprise a suitable green network system in planning urban greening in Beijing, China. Yokohari. Amati (2005) proposed that urban parks need to be regarded as core areas in the city, that an outer green belt is to surround the city; and that green corridors along rivers and streets will connect the cores and the outer areas. Thus, an organization of urban green spaces based on landscape-ecology principles, in respect to using linear (e.g., greenways) and non-linear elements (e.g., parks), encompasses the connectivity and networking of green spaces in urban areas better than considering them separately.

It is concluded that, ecological values of a green network are better than those of the sum of the green spaces individually, and the results of green structure planning based on landscape-ecology principles (connectivity, corridors, patch arrangement, network mosaics) are a connected green network including green wedges, green belts, green ways, green cores, green extensions, etc. These are more likely to resist uncontrolled urban development than

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4 Pham Duc Uy, Nobukazu Nakagoshi, (2008), Application of land suitability analysis and landscape ecology to urban greenspace planning in Hanoi, Vietnam
individual green spaces and enhance biodiversity. Moreover, applying landscape-ecology principles to green structure planning also conforms to four planning strategies which are protective, defensive, offensive or opportunistic; and to two patterns: nature in city and city in nature.

4.4.4. Constructing a Green Map Based on Land Suitability Analysis on Hanoi:

Based on the analytic hierarchy process and pair wise comparison, with the support of MATLAB software, the weighting score acquired for each factor and then used spatial analysis function of GIS to produce a composite map, the following table and figure shows Hanoi composite map.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Air pollution</th>
<th>Water systems</th>
<th>Industrial zones</th>
<th>Existing land use</th>
<th>Valuable landscape</th>
<th>Overlaying to create the composite map</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weighting score</td>
<td>0.2506</td>
<td>0.2555</td>
<td>0.1544</td>
<td>0.02959</td>
<td>0.0437</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-1 The weighting score for each factor to develop the composite map

(Source: Pham Duc, (2008), Application of land suitability analysis and landscape ecology to urban green space planning, Vietnam)

Figure 4-10 The composite green map for Hanoi.

(Source: Pham Duc, (2008), Application of land suitability analysis and landscape ecology to urban green space planning, Vietnam)


3 Pham Duc Uy, Nobukazu Nakagoshi, (2008), Application of land suitability analysis and landscape ecology to urban green space planning in Hanoi, Vietnam, Urban Forestry and urban greening.
A comparison of the composite map and the Hanoi Master Plan showed that there is compatibility between the two maps. It means that almost all the sites planned for developing green spaces in the 2020 Hanoi Master Plan are suitable.

![Figure 4-11 2020 Hanoi Master Plan.](source)

(Source: Pham Duc, (2008), Application of land suitability analysis and landscape ecology to urban green space planning, Vietnam)

### 4.4.5. Applying the Ecological Factor Threshold Method on Hanoi:

Regarding population capacity, according to the 2020 Hanoi Master Plan, Hanoi population will reach 4.5–5 million, of which the urban population would be around 2–2.5 million. This will be considered the population carrying capacity for the city. According to the Human Development Report 2006 (UNDP, 2006), the per capita carbon dioxide emission of Vietnam is 0.9 tons per year (equally: 0.6 tons of O2 consumption). Therefore, the total oxygen consumption by the urban population will reach around 1.2–1.5 million tons, with an assumption that there would be no change of this index until 2020. Regarding the supply–demand equilibrium for water resources, some studies have shown that the total amount of water supply in Hanoi is enough to match the development of the city until the year 2020.

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1 Pham Duc Uy, Nobukazu Nakagoshi, (2008), Application of land suitability analysis and landscape ecology to urban greenspace planning in Hanoi, Vietnam

The carbon–oxygen balance was analyzed based on the carbon dioxide consumption of trees. Tung (2002) estimated that in urban areas, there were around 500,000 trees over an area of 354.52 ha or an equivalent of 1321 trees per ha. The per capita green area in the 2020 Hanoi Master Plan in downtown areas is 18m² a total of 3600–4500 ha. Based on an estimate of Zhang et al. (2007), for ‘good’ green spaces (forests, parks, etc.), the annual per hectare O₂ production of trees is around 70 tons. Therefore, the total oxygen production up to 2020 equals to 252,000–315,000 tons. Considering the carbon–oxygen balance, a serious imbalance is readily apparent\(^1\).

To retain a balance, downtown Hanoi needs support from outside ecosystems with a green area from 13,542 to 16,928 ha. At present, in the suburban areas, Hanoi has a forestry area of 6700 ha. Therefore, Hanoi needs to develop an extra green area from 6842 to 10,228 ha. The next step would be to consider how to organize urban green spaces to optimize their benefits by using landscape-ecology principles.

### 4.4.6. Application of Landscape Ecology Principles on Hanoi:

A review of green structure in Hanoi. At present, Hanoi city resembles a hybrid of the basic forms (linear, centralized and gridiron), which express physical and cultural influences through time. According to the 2020 Hanoi Master Plan, the city will be planned and developed following a centralized form where the city center is marked by the ancient quarter\(^2\). The Hanoi government will control the urban sprawl process by constraining the development of the downtown area and by developing satellite cities. A review of the 2020 Hanoi Master Plan uses urban population density targets set at an average of 100 m²/ person, and includes an allocation of 18 m²/person (around 4500 ha) for green spaces, parks and sporting facilities. A greenbelt will be created with a width of 1–4km for natural and ecological preservation\(^3\).

In 2005, green structure planning was studied for a 150km² area of downtown Hanoi with the regional, city, and neighborhood scales. These studies were projected to the 2020. The 2020 green structure plan in Hanoi is thus a combination of linear and non-linear elements.

#### A. Green structure at region scale

Green wedges. “The green wedge is composed of parks, gardens, farmlands, rivers and wetlands. Green wedges and green corridors form an integrated ecological network by

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\(^2\) Pham Duc Uy, Nobukazu Nakagoshi, (2008). Application of land suitability analysis and landscape ecology to urban greenspace planning in Hanoi, Vietnam

\(^3\) IBID
connecting the urban center, forest parks, mountains and the outer regional spaces”’. Jim and Chen (2003) have shown that it is necessary to limit or prohibit the development activities inside and near green wedges. Based on the 2020 Hanoi Master Plan, landform data, landscape ecology principles, and an assessment of the planned green spaces, three green wedges were proposed to connect outer green spaces and inner green spaces as shown in the following figure. This is regarded as an offensive strategy of green structure planning, and brings nature into the city1.

![Proposed green wedges for Hanoi](image)

(B. Green structure at the city scale:

Greenbelts can be understood to be narrow strips of parkland more or less encircling part of a built-up metropolitan area or large urban area.2 As mentioned above, Hanoi intends to develop a greenbelt with a width from 1 to 4 km. However, it is difficult to use one green belt to resist urbanization because it is easily encroached on by the urban sprawl process and easily breached by urban leapfrog growth. Li et al. (2005) have pointed out the limitations of greenbelt planning in Beijing, China. Taylor et al. (1995) have presented the influence of greenbelts adjacent to urban area, in cases that have been ineffective in controlling urban growth outside of the greenbelt. From this perspective, the green structure of Hanoi should

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be augmented by an inner greenbelt at the present per-urban areas as shown in the following figure\(^1\).

Figure 4-13 The proposed greenbelt for Hanoi.

(Source: Pham Duc, (2008), Application of land suitability analysis and landscape ecology to urban green space planning, Vietnam)

This greenbelt is to be based on graph theory and gravity modeling with 33 green nodes, representing not only a zone for conservation but also a transitional zone with the function of resisting the urban sprawl, constraining the urban development, maintaining biodiversity, and enhancing recreation. Moreover, almost all industrial zones in Hanoi are mainly concentrated in this belt area including Caudien, Namthanglong, Thuongdinh, Vandien, Giapbat, Vinhtuy, Saidong, and Ducgiang. These industrial zones are embedded in Hanoi as a belt and make air pollution more serious. Therefore, maintaining this proposed greenbelt is necessary not only for the above benefits but also for improving the urban environment as required in the Vietnamese standard (TCVN 4616, 1987) for planning industrial zones\(^2\).

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\(^2\) Pham Duc Uy, Nobukazu Nakagoshi,( 2008). Application of land suitability analysis and landscape ecology to urban greenspace planning in Hanoi, Vietnam
Chapter 4  Land suitability modelling for urban green areas.

Parks and other public green spaces. At present, there are 54 important green spaces in the Hanoi downtown area. In fact, it is hard to expand them or build new ones in the built-up areas. As a result, maintaining them is very important in retaining nature in the city. Maintaining an inner green belt with 33 green nodes will help provide good opportunities to develop parks and other public green spaces. Planning parks and other public green spaces at the city scales reflects a defensive strategy for planning green structure. Such parks and public green spaces can be connected by corridors such as road greenways. According to the Vietnamese standard TCXDVN 362 (2005), the per capita area for parks and flower gardens is about 7–9 and 3–3.3 m², respectively or equivalent to a total of 2500–3075 ha.

C. Green structure at the neighborhood scale:
Attached green spaces. Each part of downtown Hanoi is a mixture of residential, industrial, business and organization-owned areas where each of them is allocated a plot of land with scant space for developing green space. These green spaces are distributed unevenly and are somewhat isolated. Attached green spaces are composed of organization-owned green spaces, residential green spaces, etc., which play an important role in providing opportunities for residents to get in contact with nature. Besides this, their function is to enhance local beauty, and to act as ecological stepping stones. One solution is to restore and insert these green spaces in built-up areas such as rooftop greening, balcony greening, sidewall greening. The development of this green space type represents an opportunistic strategy of sheltering trees in green structure planning.

Road greenways are an important component of greenway networks in urban areas. In Hanoi there are some species which have been associated with some roads for a long time and have become a symbol of these roads such as Alstonia scholaris (L.) R. One of the typical characteristics of roads in Hanoi is that they are narrow with scant space for pavement, especially in the ancient quarter. It is hard to plant or expand the area for trees in the available roadside settings; however the construction of new roads or reconstruction of old roads will give opportunity to develop greenways.

Riparian green spaces. As a result of landform or watershed development there are many lakes, rivers, creeks and canals in Hanoi. They play an important role in maintaining the urban environment, providing recreational areas, and in acting as corridors with functions that includes habitat, conduit, filter, source and sink. Riparian areas also play an important

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1 Pham Duc Uy, Nobukazu Nakagoshi,( 2008), Application of land suitability analysis and landscape ecology to urban greenspace planning in Hanoi, Vietnam IBID
2 IBID
role in controlling floods and supplying an important habitat area for wildlife. Therefore, the proposed riparian green spaces would follow along riverbanks or flood places of the Hong River, which are cultivated sometimes in the year as shown in the following figure.

![Figure 4-14The proposed greenways for Hanoi.](image)

(Source: Pham Duc, (2008), Application of land suitability analysis and landscape ecology to urban green space planning, Vietnam)

**D. Results of Hanoi Model:**

The previous model has introduced a useful, effective and efficient method for identifying suitable sites for developing green spaces in urban areas.

The combination of various green spaces to make a green network is very important in planning green structure because it is very difficult to use only one, or few different, kinds of green spaces to maintain all the benefits of greening in urbanized areas.

In the proposed Hanoi green structure at the regional scale, three green wedges play a pivotal role in bringing nature into the city and maintaining biodiversity. At the city scale, an inner greenbelt was proposed which offered the best potential for supporting an eco-network. Moreover, it can be combined with the planned outer greenbelt to control the urban sprawl process more effectively and efficiently. Planning green wedges and greenbelts represents offensive and defensive strategies in green structure planning, respectively. At the neighborhood scale, a network of road greenways and riparian green spaces was proposed. The greenways play a role as corridors in wildlife movement, and in bringing nature to move deeply into the city.
Taylor et al. (1995) have shown that the reason for failure of greenbelts in Canada was that the ecological principles of maintaining connectivity by providing spatially continuous corridors were not employed in the greenbelt approach in Ottawa. Thus the approach lacked many of the features inherent in more contemporary greenways. In other words, this green space system is facing with some obstacles such as rapid urbanization, weakness in controlling and managing urban development, land use change, and economic growth. However, such pressures can be managed if planners and decision makers, i.e. Hanoi government, understand the roles and importance of these green spaces in developing a sustainable urban area.

Finally, it is concluded that green network helps green patches enhance the connectivity and reduce fragmentation and isolation through the linked and integrated greenway system. This improves different attributes of fragmentation of green patches such as density, isolation, size, shape, aggregation, and boundary characteristics, and can act as a catalyst to preserve existing green spaces and generate new ones.

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4.5. Assumptions for the Database Model Design (2):

The second assumption database model is going to discuss an application of spatial multiple criteria decision analysis (SMCDA). An introduction to this field can be found in Malczewski (1999), who contributed to bridging the gap between geographical information systems, GIS, and multi-criteria decision analysis, MCDA. SMCDA was applied here in support of a real management problem.

The process considered was a complex decision problem, which involved multiple criteria and dealt with a large number of environmental factors and socio-economic constraints. Such factors and constraints were mainly site-specific; therefore the geographic attribute of various locations was to play a major role in site selection.

Moreover, the process that led to the final decision had to be as clear and transparent as possible to the municipal Councils and to the relevant stakeholders. This database model briefly presents the procedure developed and applied in support of the design and the evaluation phases of this type of park. The methodology used benefited from multi criteria decision analysis and spatial multi-criteria evaluation (or SMCE) and made the process more rational and transparent.

4.5.1. Case Study Application according to Database Model (2):

The Serio-Oglio study area is located in the Province of Bergamo in a plane between two rivers, the Serio River to the west and the Oglio River to the east. The size of the area is approximately 153km² and includes 13 municipalities, with a total of 49,650 inhabitants. The main land use is agricultural and the area falls between two parks of regional relevance, the Serio River Regional Park and the Oglio River Regional Park. A great variety of cultural, historic and architectural assets are disseminated over the entire area. In the southern part it is still possible to find many active fountainheads. These are water resurgences springing in the transitional area between the higher part and the lower part of the Po River Plain, where the terrain porosity decreases and the groundwater gets spontaneously to the surface creating wet zones with flora and fauna typical of marshlands. This natural phenomenon has been largely utilized in the past to supply irrigation canals and to grow fodder plants even in winter, because the temperature of the water is persistently between 101 and 151. The fountainheads are an important cultural heritage to be preserved and even if they are not completely natural, they represent a unique ecological environment.

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2 A. Zucca et al, (2008), Journal of Environmental Management 88
4.5.2. Methodology applied in the case study:

Decision making is a process involving a sequence of activities that starts with recognition of a decision problem and ends with recommendation for a decision. The quality of the decision depends on the sequence and quality of the activities that are carried out\(^1\).

According to Keeney (1992), two major approaches can be distinguished\(^2\):

A. The alternative-focused approach which starts with development of alternative options, proceeds with the specification of values and criteria and then ends with evaluation and recommendation of an option.

B. The value-focused approach on the other hand, considers the values as the fundamental element in the decision analysis. Therefore, it first focuses on the specification of values (value structure), then considering the values, it develops feasible options to be evaluated according to the predefined value and criteria structure.

This implies the order of thinking is focused on what is desired, rather than on the evaluation of alternatives. Naturally in decision problems, in which alternative options have to be developed first and then evaluated, the value-focused approach can be much more effective. However, if the decision problem starts with a choice of options, the alternative-focused approach seems more relevant.

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In this case study a value-focused approach was applied that was guided by the framework for planning and decision making developed by Sharifi et al. (2004). The approach included the sequence of activities shown in following table 1.

Table 4-2 A table shows the sequence of activities performed in this study


<table>
<thead>
<tr>
<th>Phase</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intelligence</td>
<td>a. Development of a conceptual framework including:</td>
</tr>
<tr>
<td></td>
<td>• Identification of the main objective, the sub-objectives and the contents of the local green spaces.</td>
</tr>
<tr>
<td></td>
<td>• Definition of the criteria structure: development of a criteria tree that can be used to assess the satisfaction of each sub-objective.</td>
</tr>
<tr>
<td></td>
<td>• Definition of constraints or characteristics of areas unsuitable for green spaces.</td>
</tr>
<tr>
<td></td>
<td>b. Verification of the criteria tree through:</td>
</tr>
<tr>
<td></td>
<td>• Analysis of the existing green spaces.</td>
</tr>
<tr>
<td></td>
<td>• Verification through field visits and discussions with green spaces authorities.</td>
</tr>
<tr>
<td>Design</td>
<td>c. Design of proper locations for the green spaces by:</td>
</tr>
<tr>
<td></td>
<td>• Performing a spatial multi-criteria evaluation using the criteria structure and the set of constraints to produce a suitability map.</td>
</tr>
<tr>
<td></td>
<td>• Designing primary green space elements, using the suitability map together with the topographic map, the aerial photographs and the expert’s knowledge.</td>
</tr>
<tr>
<td></td>
<td>• Designing alternative urban green spaces based on the field work.</td>
</tr>
<tr>
<td>Choice</td>
<td>d. Evaluation and ranking of the designed alternatives:</td>
</tr>
<tr>
<td></td>
<td>• Definition of a new criteria structure for the evaluation phase, including environmental, social and economic criteria.</td>
</tr>
<tr>
<td></td>
<td>• Performing spatial multi-criteria evaluation with ILWISs SMCE using the new criteria tree.</td>
</tr>
<tr>
<td></td>
<td>• Identification of the most appropriate locations for the park.</td>
</tr>
</tbody>
</table>

From the previous table it has been concluded that:

A. The problem formulation phase (intelligence): has led to the definition and specification of the green spaces.

B. The design phase has led to the identification of few potential sites based on the specified characteristics. This was obtained in three steps: first, using a criteria structure, a suitability map was generated; then primary green spaces elements were identified using the suitability map, expert’s knowledge together with other relevant ancillary information such as topographic maps, land-ownership and land-use maps, aerial photographs, and satellite images.

C. The choice phase has led to the final location for the urban green spaces. The costs and benefits of each site were analyzed and the potential green spaces were compared and ranked on the basis of their overall attractiveness (utilities).

In a spatial decision problem like the one considered here, options can be described by a defined set of maps providing information on each criterion. Therefore, the spatial decision problem can be visualized as a ‘‘table of maps’’, or ‘‘map of tables’’\(^1\), which has to be transformed into one final ranking of alternatives. Thus it is necessary to aggregate not only thematically but also spatially. The aggregation function can be simplified by distinguishing two operations:

A. Aggregation in the spatial dimension.

B. Aggregation in the thematic space.

These two operations can be performed either simultaneously or in successions as shown in the following figure.

\[\text{Figure 4-17 Decision paths in spatial decision problems described as “table of maps” or “map of tables” in van Herwijnen (1999).}\]


**In the first case, represented as Path 3 in the figure, all the information is processed by the decision maker alone and converted in a ranking. The other two options shown in the**

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figure are Path 1 and Path 2. Following Path 1, the spatial information is firstly aggregated to a non-spatial value for each theme separately. Then, traditional techniques of multi-criteria evaluation (MCE) can be used to derive the final utility for each alternative. Following Path 2 instead, first the theme maps are combined through MCA techniques to obtain a suitability map for each alternative, thus reflecting the performance of the alternative across the space. Then each map is aggregated to a single non-spatial value. Advantages and disadvantages of the two paths are described in detail by van Herwijnen (1999) and Sharifi et al. (2006). In general, the final result might be the same or it might be different, depending on the aggregation methods applied. Nevertheless, following Path 2 it is possible to perform a multi-criteria evaluation using spatial criteria along with non-spatial criteria, and that is done without losing the spatial dimension. In this study it has preferred to follow Path 2. This was in order to preserve as long as possible throughout the decision process the spatial information given by the spatial distribution of the values\(^1\).

4.5.3. Problem Formulation of Current Land use:

A. Development of a conceptual framework:

The Park Office of the Province of Bergamo needed to select the most suitable sites to build a green spaces of extra-municipal character (Parco Locale di Interesse Sovracomunale, or PLIS). To define the criteria structure for the design of suitable sites in the study area and establish a PLIS, it was first necessary to identify the main objectives of the green spaces. Consideration was given to the laws issued (L.R. 30 November 1983, n. 86, L.R. 5 gennaio 2000, n. 1), the literature (Di Fidio et al., 2001; Mauri, 2000; Provincia di Milano, 2002) and the previously established PLIS\(^2\).

The protection and improvement of the environmental quality of the territory appeared to be the main goal of urban green spaces. The goal could be met through the following objectives:

Protection of valuable areas was measured through the following criteria\(^3\):

Protection of agricultural areas: from a sustainable development point of view, it was not enough to protect single assets. It was also necessary to reduce pressures on the environment related to the human activities, and to enhance the regeneration capability of natural resources, favoring more sustainable forms of utilization. Agricultural areas could

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1 van Herwijnen, M., (1999). Spatial Decision Support for Environmental Management. Faculty of Economical Sciences and Econometrics, Free University of Amsterdam, Amsterdam.
3 IBID
play an important role in this. Moreover, they could have a connective function between natural areas.

Protection and enhancement of rural, historical and architectural assets: in a territory characterized by a strong human influence, the presence of some heritage elements could contribute to the environmental quality.

Protection of assets of high natural value: to protect biodiversity it was important to preserve the existing natural values, e.g., forests, geologic and geomorphologic assets, by including them in the park. It was also important to preserve the ecological corridors, and in some cases the urban green spaces as a whole could function as a connection belt between valuable natural areas of higher order.

Restoration of degraded situations was measured through the following criteria:

Restoration of degraded urban areas: the establishment of a PLIS could offer a good opportunity to restore degraded situations that are resulting from some particular human activities, such as quarry areas or former industrial areas.

Mitigation of and environmental compensation for impacts of new infrastructures: the green spaces could be a good opportunity to mitigate or to compensate for a new unavoidable human impact, such as a new motorway.

The formulation of objectives and their related criteria led to the identification of the characteristics and, as a result, to the definition of the green spaces.

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Figure 4-18 The criteria tree constructed for assessing the suitability of each area considered for the green spaces in the Serio-Oglio


B. Verification of the criteria tree:

In order to test the functionality of the criteria tree constructed, 32 previously established PLIS were analyzed to verify whether the framework developed is capable of describing them. According to the description of the existing green spaces available in Di Fidio et al. (2001) and after some field visits, this was measured through the counting of the number of objectives fulfilled by each park. The result is summarized in the following figure.

From the previous graph it can be concluded that all the parks satisfied one criterion or more criteria related to the protection of valuable areas. In particular, 29 green spaces (90%) aimed to the protection of natural areas, 20 green spaces (60%) included rural, historical and architectural assets, and 19 green spaces (about 60%) intended to preserve valuable agricultural areas. Moreover, 20 green spaces satisfied one or more criteria related to the recovery of degraded areas. In particular, 19 green spaces included former degraded urban areas and 12 green spaces (40%) provided a mitigation/compensation function.

4.5.4. Design of Potential Locations for Urban Green Spaces:

The design of potential urban green spaces was carried out through the following two steps, which can be found through the development of a suitability map, and the design of alternative locations for urban green spaces.

A. Development of suitability map:

To develop the suitability map, the theoretical framework described was directly converted into the branches and leaves of a criteria tree. For this the interaction and processing capabilities were exploited of a relatively new version of the software package ILWISs.
(ILWIS 3.3, 2005), the SMCE module for spatial multi criteria evaluation. The ILWIS SMCE criteria tree constructed is the following figure.

Figure 4-20 The criteria tree used in the analysis of the Serio-Oglio study area. On the left are constraints, factors and associated weights with descriptors. On the right the corresponding file names of the digital maps spatially representing constraints and factors. The interaction structure is from the ILWIS SMCE module (ILWIS 3.3, 2005), that introduces multi-criteria evaluation in a GIS environment


The previous figure included the concepts that follow:1:

**Constraints:** A constraint is a hard criterion that determines which areas should be excluded from or included in the suitability analysis. The excluded areas will get a nil (0) performance value in the composite index map, while the remaining areas will obtain a value between 0 and 1.

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Source Data</th>
<th>Derived Map</th>
<th>Standardization</th>
</tr>
</thead>
<tbody>
<tr>
<td>E &amp; F areas</td>
<td>City Master Plans</td>
<td>-</td>
<td>E and F areas are standardized to 1, all the others to 0.</td>
</tr>
<tr>
<td>Existing Green Spaces</td>
<td>Map of Protected Areas</td>
<td>-</td>
<td>Green spaces are standardized to 0, all the others to 1.</td>
</tr>
<tr>
<td>Waste Disposal</td>
<td>Map of Waste Disposals</td>
<td>Distance Map</td>
<td>Distance &lt; 200 is standardized to 0; all other values are standardized to 1.</td>
</tr>
<tr>
<td>Active Quarries</td>
<td>Map of Active Quarries</td>
<td>Distance Map</td>
<td>Distance &lt; 200 is standardized to 0; all other values are standardized to 1.</td>
</tr>
<tr>
<td>Contaminated Sites</td>
<td>Map of Contaminated Sites</td>
<td>Distance Map</td>
<td>Distance &lt; 200 is standardized to 0; all other values are standardized to 1.</td>
</tr>
</tbody>
</table>

1. E and F denominations in the City’s Master Plan correspond to green areas, agricultural areas, woodlands, water bodies and water meadows.
2. A distance map is a derived raster map where each pixel has a value correspondent to the distance from source pixels in the original map.

The following table presents the hierarchical structure of objectives and criteria and the factors which indicate the achievement of each criterion. For each factor, this table shows the related criterion, the available source maps used to represent the factor, the derived maps, and the standardization methods applied to derived or source maps. All factors represented were considered as costs, except for the presence of agricultural areas, which was assumed to be a benefit.

Factors: A factor is a soft criterion that contributes to a certain degree to the output (suitability). There are two types of factors, (i) benefit criteria and (ii) cost criteria. A benefit criterion contributes positively to the output (the higher are the values, the better it is), while a cost criterion contributes negatively to the output (the lower are the values, the better it is). As opposed to constraints, which cannot be compensated, poor performance of a factor can be compensated by good performance of another factor. Using compensatory decision rules, such as a weighted sum, this can still lead to good overall performance in the composite index map.

Group of factors: A group of factors defines an intermediate or a partial goal, given by a combination of factors. The result of this process is shown in the following figure. A higher weight was attributed to the protection of the valuable areas with respect to the recovery of degraded situations. Further, to all branches and leaves, equal weights were assigned as no further information was available to differentiate them.

---

Table 4-4 weights assigned to each factor and group in the design phase


<table>
<thead>
<tr>
<th>W</th>
<th>Group Factor</th>
<th>W</th>
<th>Group Factor</th>
<th>W</th>
<th>Group Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Protection of</td>
<td></td>
<td>Protection of</td>
<td></td>
<td>Protection of</td>
</tr>
<tr>
<td></td>
<td>Valuable Areas</td>
<td></td>
<td>Agricultural Areas</td>
<td></td>
<td>high natural</td>
</tr>
<tr>
<td></td>
<td>0.67</td>
<td></td>
<td>areas and assets</td>
<td>0.33</td>
<td>Distance from natural assets (point)</td>
</tr>
<tr>
<td></td>
<td>Protection of</td>
<td></td>
<td>Protection of</td>
<td>0.2</td>
<td>Distance from natural assets (line)</td>
</tr>
<tr>
<td></td>
<td>rural historic</td>
<td></td>
<td>rural historic</td>
<td>0.2</td>
<td>Distance from natural assets (area)</td>
</tr>
<tr>
<td></td>
<td>architectural</td>
<td></td>
<td>architectural</td>
<td>0.2</td>
<td>Distance from connection bands</td>
</tr>
<tr>
<td></td>
<td>assets</td>
<td></td>
<td>assets</td>
<td>0.2</td>
<td>Distance from water bodies</td>
</tr>
<tr>
<td></td>
<td>0.33</td>
<td></td>
<td>0.33</td>
<td>0.5</td>
<td>Distance from landscape assets</td>
</tr>
<tr>
<td></td>
<td>Restoration</td>
<td></td>
<td>Restoration</td>
<td>0.5</td>
<td>Protection of rural historic</td>
</tr>
<tr>
<td></td>
<td>of degraded</td>
<td></td>
<td>of degraded</td>
<td>0.4</td>
<td>architectural assets</td>
</tr>
<tr>
<td></td>
<td>situation</td>
<td></td>
<td>situation</td>
<td>0.2</td>
<td>Distance from assets protected by law</td>
</tr>
<tr>
<td></td>
<td>0.33</td>
<td></td>
<td>0.5</td>
<td>0.2</td>
<td>Distance from other assets</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td></td>
<td>0.2</td>
<td>0.2</td>
<td>Distance from historic urban centers</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td></td>
<td>0.2</td>
<td>0.2</td>
<td>Distance from archaeological areas</td>
</tr>
</tbody>
</table>

Once all the maps were converted to partial suitability, and standardized to the same value range, their corresponding relative importance weights were assigned. The partial suitability maps were then combined applying the weighted sum method to derive the overall suitability index. This was facilitated by combining the various attributes of each pixel to derive the suitability index map as shown in the following figure.
Figure 4-21 The composite suitability index map of the Serio-Oglio study area, obtained combining the attributes of each pixel using SMCE. The higher are the values of overall performance, the higher is the suitability.


B. Design of alternative sites for the park:

The suitability map was then used, together with the topographic base map, aerial photographs, and other related information, to manually design PPEs. In this process, considering the physical (natural and artificial) boundaries, the areas with the highest suitability were included in a PPE; as specifically dictated by law (L.R. 5 gennaio 2000, n. 1), existing physical (natural and artificial) boundaries were considered in delimiting the PPE. Afterwards, in a participatory process with the Park Officer of the Province, the 11 PPEs were combined into four alternative options for the park. The boundaries of the alternatives designed are presented in the following figure.

---

The boundaries of the four alternative options of the local park overlaid on the suitability index map of the Serio-Oglio
study area.


The boundaries can be briefly described as follows:

**Alternative 1** is located close to the Serio River Regional Park, as a protection buffer. It extends between three inhabited centres, limiting the urban sprawl and the risk of conurbation. The southern part of the park could also represent a mitigation band for the new highway and the new railway that will cross the area from the West to the East.
Alternative 2 is located in the southern part of the study area, characterized by extensive agricultural activities and small scattered settlements; in this area there still are a lot of active fountainheads.

Alternative 3 is located in the southern-central part of the study area. It represents a mainly agricultural area, with scattered small settlements and some active fountainheads. This is a bit smaller than the other alternatives but includes five municipalities. It is positioned in a strategi location.
Alternative 4 is located in the eastern part of the study area, very close to the Oglio River Regional Park, for which it could represent a protection buffer. It is mainly an agricultural area, with some active fountainheads and many rural and historic-architectural assets.

![Figure 4-26 The forth alternative.](https://example.com/figure.png)


4.5.5. Evaluation and Ranking of Alternative Sites:

A. Definition of a new criteria structure

The last phase of decision making is the evaluation and choice of alternative options. The four alternative sites for the urban green areas were evaluated using a different criteria structure. Besides the suitability index, resulting from the first urban green areas of the analysis, environmental-ecological, social and economic criteria were used for this part of the study. Differently from the indicators used to build the suitability map, the indicators selected for the evaluation phase are depending on the boundaries of the urban green areas. For this last phase the following aspects have been considered:

1. Degree of suitability.
2. Environmental-ecological effects.
3. Social effects.
4. Economic effects.

Figure 4-27 The criteria tree structure used for the evaluation and choice phase of alternative options in the Serio-Oglio study area.


1. Degree of suitability:
The area selected for the urban green areas might have a high suitability Index. The higher is the value of this Index, the higher is the performance of the potential urban green spaces\(^1\).

2. Environmental-ecological effects:
Considering the environmental-ecological function of the urban green spaces, the following criteria were used for the evaluation of the alternatives\(^2\):
- The fragmentation due to the presence of roads inside the green areas.
- The capabilities of the urban green spaces are to limit the urban sprawl, or the risk of conurbation between two or more municipalities.

---


The role of connection between the existing regional urban green spaces, and the protection role with respect to the existing regional green spaces.

To estimate the urban green spaces role on limiting the urban sprawl, a pair-wise comparison technique was used. Looking at their spatial location, pairs of alternatives were compared with respect to their capability to limit the urban growth. Next, verbal comparisons were converted to a numerical Saaty scale, as shown in the following table.\(^1\)

<table>
<thead>
<tr>
<th></th>
<th>ALT 1</th>
<th>ALT 3</th>
<th>ALT 2</th>
<th>ALT 4</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALT 1</td>
<td>1.00</td>
<td>5.00</td>
<td>7.00</td>
<td>9.00</td>
<td>4.21</td>
</tr>
<tr>
<td>ALT 3</td>
<td>0.20</td>
<td>1.00</td>
<td>6.00</td>
<td>7.00</td>
<td>1.70</td>
</tr>
<tr>
<td>ALT 2</td>
<td>0.14</td>
<td>0.17</td>
<td>1.00</td>
<td>6.00</td>
<td>0.61</td>
</tr>
<tr>
<td>ALT 4</td>
<td>0.11</td>
<td>0.14</td>
<td>0.17</td>
<td>1.00</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Concerning the functions of connection and protection with respect to the existing regional urban green spaces, two distance maps have been used with a different standardization. The result is shown in the following figure.

In practice, the standardized pixel scores decrease between 0 and 1500m of distance from the existing regional urban green spaces and they are nil between 1500 and 2500m (left diagram), or they increase again between 2500 and 4000m of distance (right diagram). The average distance is in fact 4000m.\(^2\)

1. Social effects:
The social function of the urban green spaces was assessed by two types of indicators: the educational and the recreational indicator. For the educational indicator, the same factors were used as considered in constructing the suitability map, such as the presence of cultural values, of historic-architectural values, of archaeological areas and of historic urban centers. For the recreational aspect, the presence of facilities such as cycling paths or agri-tourism activities, and other factors such as the dimension of the green spaces and the population served were considered for the evaluation.

2. Economic effects:
Many authors dealt with the problem, referred to the Italian situation, of the economic value of the protected areas, of the economic impacts on the local community of green areas establishment and of the development of economic activities in the national green spaces.

A set of generic criteria have been laid down, after some interviews with a number of technical personnel working in the existing urban green spaces. For costs, the financial costs were considered, split in fixed costs (personnel and office maintenance costs) and variable costs related to the activities carried on in the urban green spaces, and the losses caused by the regulation imposed on the land use after the establishment of the urban green spaces.

For benefits, the possible positive consequences were considered of the green spaces establishment on the neighboring areas on the areas inside the urban green spaces, and on the value of the agricultural and handicraft products coming from the area inside the green spaces.

In addition, the economic activities related to a given land use will be affected by the urban green spaces establishment. In some cases the effect will be positive, for instance for handicraft or specialized agriculture activities, in other cases it will be negative, as for manufacturing activities.

B. Weight assignment:
As previously discussed for the suitability map, the weights were assigned, using the rank order method, by the Park Officer supported by a group of experts. The result is the following figure.

---

### Table 4-6 Weights assigned to each factor and group of factors in the evaluation phase


<table>
<thead>
<tr>
<th>W</th>
<th>Group Factor</th>
<th>W</th>
<th>Group Factor</th>
<th>W</th>
<th>Group Factor</th>
<th>W</th>
<th>Group Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td><strong>Suitability</strong></td>
<td>0.15</td>
<td>Low Fragmentation</td>
<td>0.35</td>
<td>Limitation of urban growth</td>
<td>0.35</td>
<td>Connecting existing regional green spaces</td>
</tr>
<tr>
<td>0.25</td>
<td>Environmental and ecological effects.</td>
<td>0.5</td>
<td>Education site seeing.</td>
<td>0.35</td>
<td>Presence of cultural values</td>
<td>0.35</td>
<td>Presence of historic architectural assets</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.15</td>
<td>Distance from historic urban centers</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.35</td>
<td>Population Served</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.15</td>
<td>Presence of bicycle path</td>
<td>0.15</td>
</tr>
<tr>
<td>0.25</td>
<td>Social Effects</td>
<td>0.5</td>
<td>Recreation</td>
<td>0.67</td>
<td>Financial Costs</td>
<td>0.25</td>
<td>Fixed Costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.75</td>
<td>Costs from green areas activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.75</td>
<td>Decreasing land value (inside green areas)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.25</td>
<td>Income Loss for restriction in economic activities</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>Economic Effects</td>
<td>0.5</td>
<td>Losses</td>
<td>0.33</td>
<td>Loss of benefits</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
<td>Increasing land value (inside green areas)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.17</td>
<td>Increasing land value (outside green areas)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.33</td>
<td>Increasing value of products</td>
<td></td>
</tr>
</tbody>
</table>
Equal priority was given to the four main branches of the criteria tree: the suitability value, the environmental ecological effects, the social effects, and the economic effects related to the urban green spaces establishment. Regarding the environmental-ecological effects, a higher importance was attached to the role played by the potential green spaces in limiting the urban sprawl and in connecting the existing regional green spaces, rather than to the low fragmentation and to the protection function of the urban green areas.

It can be concluded that these preferences reflect the main concerns of the Park Office about the consequences on the study area of the increasing human pressures. As concerns the social effects, a higher preference was attributed to the presence of cultural and historic-architectural values, to the amount of population served and to the size of urban green spaces. In fact to the Park Office these criteria appeared more relevant than the other ones in selecting the best alternative for the green areas. As to the economic effects, the assigned weights reflect both the provincial Park Office view and the impressions collected by talking with the technical personnel working in the existing local green spaces. The financial costs of green spaces, and in particular the costs related to the green areas activities, seemed to be the higher economic charge in managing a local green spaces, while the loss of benefits is considered less important. The gains deriving from the urban green spaces establishment might be related mainly to increasing the land value inside it, secondarily to the higher value gained by the products of the economic activities carried out inside the green spaces and just in minimal part to the increasing land value around the urban green spaces.

4.5.6. Evaluation results:

Once all criteria maps were in a form representing the degree of suitability of each picture element or pixel of the park from different aspects and perspectives, the evaluation of alternatives could proceed. As shown in the following figure for every alternative the result was a map (utility map) in which the value of each pixel represented the overall suitability of that pixel for the park.
Figure 4-29 The comparison of the four alternative choices of the Serio-Oglio study area. The colours indicate utility values. (Source: Sharifi, (2004). Evaluating rail network options using multicriteria decision analysis. Case study Klang Valley Malaysia)

To compare the alternatives it was necessary to aggregate the pixel values. One of the simplest and often-used non-spatial aggregation methods is taking the average or the sum of pixel values. Combined with other descriptive statistical parameters, such as minimum and maximum values, the average and the sum were used to describe the overall performance of each alternative. The results are shown in the following table.

Table 4-7 A table shows the results of the evaluation phase

<table>
<thead>
<tr>
<th>Area</th>
<th>Perimeter</th>
<th>Number of Pixel</th>
<th>Average</th>
<th>Sum</th>
<th>Max Value</th>
<th>Min Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALT 1</td>
<td>11.64</td>
<td>37.49</td>
<td>29080</td>
<td>0.68</td>
<td>17036.09</td>
<td>0.78</td>
</tr>
<tr>
<td>ALT 2</td>
<td>12.68</td>
<td>31.84</td>
<td>31686</td>
<td>0.62</td>
<td>15836.63</td>
<td>0.71</td>
</tr>
<tr>
<td>ALT 3</td>
<td>8.99</td>
<td>19.94</td>
<td>21504</td>
<td>0.58</td>
<td>10457.41</td>
<td>0.73</td>
</tr>
<tr>
<td>ALT 4</td>
<td>10.05</td>
<td>25.01</td>
<td>25112</td>
<td>0.54</td>
<td>11379.98</td>
<td>0.64</td>
</tr>
</tbody>
</table>
As it is presented in the previous table, alternative 1 appears to be the most attractive site for the green areas. The methodology that was developed and applied in this study combined a value-focused approach with spatial multi-criteria evaluation techniques in supporting a land management problem: the selection of the most suitable site for the establishment of a new local urban green spaces. Moreover, spatial multi-criteria evaluation has been used either for design purposes or for the evaluation of different alternatives. The processing was supported by the ILWISs SMCE module, GIS software that demonstrated to be an effective tool for managing and combining a large amount of spatial and non spatial information. Further it facilitated processing ‘‘tables of maps’’, as well as ‘‘map of tables’’ (Sharifi et al., 2006). The main advantages of the methodology used in this study are the efficient structuring of geo-information, and processing large data sets to support management activities. This process proposed permits the efficient combination of multi-criteria evaluation with spatial data analysis tools that support a sustainable land management and provide a logical and scientific foundation into which the values of decision makers and stakeholders can be integrated1.

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4.6. Conclusion:

A. According to the importance of the urban green spaces, as they are considered the most important form of nature protection, so Geographic Information Systems based on spatial databases is considered with no doubt a necessary condition for the realization of statutory obligations of urban green spaces.

B. Urban green spaces are considered as outdoor places with significant amounts of vegetation, which exist mainly as semi-natural areas, or are viewed as last remnants of nature in urban areas.

C. The purposes of urban green spaces are to maintain the variety of the ecological systems and to protect the wild nature and the biological variety in the ecological systems, and to develop tourism and scientific, educational and recreational activities.

D. Previous studies have shown the positive impact of the urban green spaces on nearby residential property values, which consequently effect on people; desire to pay more for a home close to a nice green space. Economists called this phenomenon “hedonic value.”

E. Green areas are considered as urbanized environment which provide people with a feeling of place and identity. Green areas play an important part of urban ecosystems; play a pivotal role in preserving biodiversity in urban areas. Moreover, green spaces sequester CO2 and produce O2, they reduce air pollution and noise, regulate microclimates, and reduce the heat island effect in cities affect house prices maintain diversity; have recreational and social values and produce a vitamin ‘‘G’’ for health, well-being and social safety.

F. Reams of urban research have been carried out on the economics of housing, manufacturing, retail, and even the arts, there has been until now no comprehensive study of the worth of a city’s green space system, although city gains a big benefit from green spaces, these benefits can be compromised in the following main points, which are, increase income from tourists that target urban green areas, increase community cohesion between residents, removed air pollution from the city, and increase the level of resident physical activity.
G. The previous database model design (1) has introduced a useful, effective and efficient method for identifying suitable sites for developing green spaces in urban areas, as it is the first important step to ensure their roles and functions. Site information can be gained by using land suitability analysis based on GIS which is a strong, efficient and effective application within land-use planning, habitat analysis. Applying the ecological factor threshold method will help quantify how much green area is necessary to maintain an ecological balance in urban areas. Using an urban forest effects model will help quantify key values of urban green spaces such as carbon storage and sequestration. More importantly, the roles and functions of urban green spaces can be enhanced if they are organized by combining a variety of green space types for multiple purposes called a green network or urban green structure.

H. The previous database model design (2) has introduced three phases for identifying suitable sites for developing green spaces in urban areas, the first phase is considered as the problem formulation phase (intelligence) that led to the definition and specification of the green spaces, the second phase has led to the identification of few potential sites based on the specified characteristics, this was obtained in three steps: first, using a criteria structure, a suitability map was generated; then primary green spaces elements were identified using the suitability map, expert’s knowledge together with other relevant ancillary information such as topographic maps, land-ownership and land-use maps, aerial photographs, and satellite images, and the third phase has led to the final location for the urban green spaces. The costs and benefits of each site were analyzed and the potential green spaces were compared and ranked on the basis of their overall attractiveness (utilities).