

**DEMONSTRATION OF GEOGRAPHIC INFORMATION SYSTEM
BASED DESCRIPTION OF RESPONSIVE AND SENSORY QUALITIES OF
TWO CIVIC NODES OF CALCUTTA**

by

SUBHRENDU DAS

B.Arch., Birla Institute of Technology, 2001

A THESIS

submitted in partial fulfillment of the
requirements for the degree

MASTER OF ARCHITECTURE

Department of Architecture
College of Architecture, Planning and Design

KANSAS STATE UNIVERSITY
Manhattan, Kansas
2006

Approved by

Major Professor
Richard Hoag

ABSTRACT

Sensory qualities of a place are those that help people perceive a place through their senses (Lynch 1976). Responsiveness of a place is its ability to provide the user with a wide range of choices and opportunities (Bentley et al 1985). This thesis demonstrates a study of sensory and responsive qualities of urban spaces through the description of two civic nodes in the city of Calcutta, India – the Dalhousie Square and the Salt Lake City Center.

The demonstration technique adopted for the study uses Geographic Information System. This system, with the help of specialized computer software can manipulate, summarize, query, edit and visualize geographic information stored in a database. In this study site observations on the two civic nodes are presented as layers of information in Geographic Information System.

The civic nodes selected for this study were built at different times. The Dalhousie Square is the historic city center of the city of Calcutta, built during the British rule (1776-1947) over India. The Salt Lake City Center is a mixed-use retail development designed by the Indian architect Charles Correa.

TABLE OF CONTENTS

LIST OF FIGURES	v
LIST OF TABLES	x
ACKNOWLEDGEMENTS	xi
CHAPTER 1 - INTRODUCTION	1
CHAPTER 2 - BACKGROUND TO THE STUDY	4
Spatial Study of Urban Form	4
<i>Responsive Qualities</i>	7
<i>Sensory Qualities</i>	11
<i>Relation between Responsive and Sensory Qualities</i>	16
Capturing and Visualizing Responsive and Sensory Spatial-Temporal Characteristics.....	18
The City of Calcutta.....	24
The Study Sites	36
<i>Dalhousie Square</i>	36
<i>The Salt Lake City Center</i>	41
CHAPTER 3 - CASE STUDY METHODOLOGY	45
Creating the GIS Data for Calcutta.....	56
CHAPTER 4 - RESPONSIVE AND SENSORY QUALITIES OF THE TWO CIVIC NODES	65
Permeability Study of the Two Civic Nodes	65
Legibility Study of the Two Civic Nodes	77
Variety Study of the Two Civic Nodes.....	84
Robustness of the Two Civic Nodes.....	90
<i>Demonstration of Spatial Analysis to Compare Number of People Sitting in Open Spaces</i>	96

Sensory Qualities of the Two Civic Nodes.....	99
<i>Demonstration of Spatial Analysis of Pedestrian-Hawker Interaction</i>	<i>107</i>
CHAPTER 5 - DISCUSSION OF FINDINGS	112
Summary of the Responsive and Sensory Qualities of the two Civic Nodes .	112
Advantages of using a Geographic Information System	116
BIBLIOGRAPHY.....	119
APPENDIX A: Summary of Glossary of Techniques for Recording and Managing the Sense of a Region by Kevin Lynch	121
APPENDIX B: ABBREVIATIONS	125
APPENDIX C: ESRI DEFINITIONS.....	126

LIST OF FIGURES

Figure 1: Nolli's Building Coverage Map of Rome, 1748.....	4
Figure 2: Legible Sub-districts within Beacon Hill, Boston.....	5
Figure 3: Responsive Qualities in an Urban Setting.....	10
Figure 4: Outdoor Vendors at Salt Lake City Center, Calcutta – Sensory Qualities of Vision and Touch.....	12
Figure 5: Sequence of Sensory Qualities of Scollay Square, Boston, Recorded by Kevin Lynch	14
Figure 6: Colonial Buildings within Dalhousie Square, Calcutta act as Visual Elements	15
Figure 7: Landmarks in Streets of Calcutta supporting sensory quality of vision and responsive quality of legibility.....	17
Figure 8: Relational diagram between Sensory and Responsive Qualities – these qualities are linked and interrelated in a space-time setting within an urban environment	17
Figure 9: Abstract Forms Used to Communicate Spatial-Temporal Patterns.....	18
Figure 10.....	19
Figure 11.....	20
Figure 12.....	21
Figure 13.....	22
Figure 14: Geographic Location of Calcutta	24
Figure 15: Four Stages in the Growth of Calcutta	27
Figure 16: Calcutta during Colonial Period, a 19th Century Painting.....	28

Figure 17: Old Calcutta based on Upjohn's Survey 1792-93, showing location of Dalhousie Square	31
Figure 18: District of Central Calcutta and Salt Lake and the locations of Dalhousie Square and Salt Lake City Center.....	32
Figure 19: District of Central Calcutta showing location of Dalhousie Square	34
Figure 20: Salt Lake showing location of City Center	35
Figure 21: Dalhousie Square in the year 1910.....	36
Figure 22: Identified Zones within Dalhousie Square	38
Figure 23: Lal Dighi.....	39
Figure 24: Pedestrian Trail Surrounding.....	39
Figure 25: Car Park.....	39
Figure 26: Hawker Zones.....	39
Figure 27: Bus Terminus	39
Figure 28: HSBC Garden.....	39
Figure 29: Buildings Surrounding Dalhousie Square	40
Figure 30: Distinct Zones within Salt Lake City Center.....	43
Figure 31: Residency	44
Figure 32: Mall Blocks	44
Figure 33: Shopping Spine.....	44
Figure 34: Cineplex.....	44
Figure 35: Main Plaza.....	44
Figure 36: Entrance Plaza	44
Figure 37: Diagrammatic representation of the study process.....	46

Figure 38: Hawker-Pedestrian Interaction within the Civic Nodes	52
Figure 39: Hawker-Pedestrian interaction at Dalhousie Square	53
Figure 40: Hawker-Pedestrian Interaction at Salt Lake City Center	53
Figure 41: Creating the GIS Shapefile for Calcutta and defining its geographic location	57
Figure 42: Digitized Street Map of Calcutta.....	58
Figure 43: Diagrammatic representation of feature class and storage of feature class data	61
Figure 44: Combination and overlay of feature classes.....	61
Figure 45: Attribute table associated with feature classes	62
Figure 46: Hooghly River	66
Figure 47: Local Train	66
Figure 48: Tram	66
Figure 49: Subway	66
Figure 50: Roads connecting the Civic Nodes.....	67
Figure 51: Mass Transit Network in Calcutta.....	68
Figure 52: Transportation Nodes in Central Calcutta.....	69
Figure 53: Pedestrian routes in Dalhousie Square	70
Figure 54: Strand Road	71
Figure 55: Chowringhee Road	71
Figure 56: Intersection of Hare Street and Government Place West	71
Figure 57: Pedestrian street surrounding Lal Dighi	71
Figure 58: Eastern Metropolitan Bypass.....	72
Figure 59: : Major Road, Salt Lake	73

Figure 60: Transpotation nodes and road network - Salt Lake.....	74
Figure 61: Pedestrian routes within Salt Lake City Center.....	75
Figure 62: Block distribution within Central Calcutta and Salt Lake.....	76
Figure 63: East Side of Dalhousie Square (1945).....	78
Figure 64: Esplanade (Indian Museum).....	79
Figure 65: Park Street	79
Figure 66: View from Maidan with the Park Street sub-district buildings in the background.....	79
Figure 67: Dalhousie Square (HSBC Building).....	79
Figure 68: Legible sub-districts within Central Calcutta.....	80
Figure 69: Important Landmarks within Central Calcutta.....	81
Figure 70: Water tanks act as landmarks in Salt Lake City blocks	82
Figure 71: Corporate building, Sector 5, Salt Lake	82
Figure 72: Important landmarks within Salt Lake	83
Figure 73: Commercial nodes and districts within Central Calcutta	85
Figure 74: Important anchor buildings surrounding Dalhousie Square.....	86
Figure 75: Land Use Plan, Salt Lake	87
Figure 76: Major destinations near Salt Lake City Center	88
Figure 77: Anchor shops within Salt Lake City Center.....	89
Figure 78: Different activities within Dalhousie Square	91
Figure 79: Different activities within Salt Lake City Center.....	92
Figure 80: Perimeter shops	92
Figure 81: Buildings with perimeter shops, Dalhousie Square.....	94

Figure 82: Ground floor shops, Salt Lake City Center	95
Figure 83: Number of people sitting inside pedestrian trail zones, Dalhousie Square	97
Figure 84: Number of people sitting in Salt Lake City Center plazas and open spaces ...	98
Figure 85: Landmarks within Dalhousie Square	101
Figure 86: Images of identified visual landmarks, Dalhousie Square	102
Figure 87: Landmarks in Salt Lake City Center	104
Figure 88: Visual elements within Salt Lake City Center	105
Figure 89: Images of visual elements and landmarks, Salt Lake City Center	106
Figure 90: Hawker-pedestrian interaction, Dalhousie Square	109
Figure 91: Outdoor vendor-pedestrian interaction, Salt Lake City Center	110
Figure 92: Hawker-Pedestrian Interaction, Dalhousie Square.....	111
Figure 93: Outdoor vendor, Salt Lake City Center.....	111

LIST OF TABLES

Table 1: Population Statistics of Calcutta.....	25
Table 2	49
Table 3: Observation chart to compare number of people sitting within a site zone.....	50
Table 4: Observation chart to compare pedestrian-hawker interaction at Dalhousie Square	54
Table 5: Observation chart to compare pedestrian-hawker interaction at Salt Lake City Center.....	54
Table 6: List of Feature Classes Created for the Study	59
Table 7: Attribute table of Dalhousie Square buildings showing number of ground floor shops	93
Table 8:Attribute table of City Center buildings showing number of ground floor shops	93
Table 9: Comparison of number of people sitting in pedestrian trail zone, Dalhousie Square	96
Table 10: Comparison of number of people sitting in open spaces, Salt Lake City Center	96
Table 11: Attribute table of Dalhousie Square buildings showing building use and history	100
Table 12: Comparison of hawker-pedestrian interaction, Dalhousie Square	108
Table 13: Comparison of outdoor vendor-pedestrian interaction, Salt Lake City Center	108
Table 14: Comparison of the two Civic Nodes.....	115

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my major professors, Professor Richard Hoag and Professor Eric Bernard in guiding me throughout the period of study. Professor Bernard's critical comments and guidance during the concluding period of the study has helped me eventually realize my goals.

Then there has been friends – Nibedita, Diptansu and Pragnya and was lucky to have them beside me when it was most needed.

Lastly thanks to Ma and Baba for letting me come this far.

CHAPTER 1 - INTRODUCTION

“A City Center must be a very special place . . . a microcosm of the whole metropolis, catering to multiple land-uses and diverse income profiles . . . a kaleidoscope of contrast and color and energy.” Charles Correa.¹

Urban centers are extremely dynamic places. In many cities throughout the world, urban centers support the majority of human activity. These activity centers are reflective of the culture from which they have grown. As cities expand, new urban centers are created and old centers renovated and revitalized revealing changes in demography, economy, societal needs, and shifts in political control. At present, globalization has also become important to both cities' growth processes and the function and culture of urban centers. The effects of a global marketplace are especially great in developing south-east Asia. Amongst the twenty world's megacities of more than ten million people, eight of them exist in south-east Asia. These include Mumbai, Delhi, Calcutta, Shanghai, Jakarta, Dhaka, Karachi and Beijing.²

In cities like Shanghai and Mumbai, the need for horizontal expansion has given rise to suburban growth and thus the development of multiple urban centers. There has been a change in the way of living in these new urban additions due to globalization. The

¹ <http://www.bengalambuja.com/retail/CITYCENTRE.shtm> (Retrieved on March 15, 2005)

² United Nations (2003) *World Urbanization Prospects: The 2003 Revision*. New York: Author.

design of housing, shopping centers, theaters and entertainment facilities has metamorphosed to cater to cultural changes. The challenge of design disciplines given global changes lies in how to integrate the design of civic facilities into the historical fabric of an entire city, both in terms of the function and culture of place. Failing to embrace the historic evolution and vocabulary of a city runs the risk of creating disconnected and foreign spaces to people based on prior sensual and responsive understanding.

In order to meet the challenge of the demand for new urban growth centers those involved in the design process such as architects, planners, traffic engineers, developers etc. should first understand the human needs from a holistic point of view and then from the regional view. This means understanding the entire city structure and then the more site-specific aspects. Thus, there is a requirement of studying the spatial structure of the city such as transportation facilities, demography, land use etc., in conjunction with specific needs such as places for socializing. Before making new additions it is important to study how existing urban places respond to human needs and how users sense them.

Two civic nodes in the southeast Asia megacity of Calcutta, India, were examined via case study to determine the potential for using a Geographic Information System (GIS) to facilitate characterizing sensory and responsive qualities of urban centers as an aid to design decision making. The Dalhousie Square, located at the heart of the historic central business district, and the newly planned and developed Salt Lake City Center, a

mixed-use retail development located outside the historic city in a planned suburban district connected to Calcutta were selected for this study.

The characterization of the centers or nodes, focuses on both sensory qualities described by Kevin Lynch, and responsive qualities described by five British authors: Ian Bentley, Alan Alcock, Sue MCGlynn, Paul Murrain and Graham Smith. Bentley et al. described responsive qualities as essential for design approaches for urban districts. The description of the sensory qualities of a place was first stated by Kevin Lynch (1976) in his book "*Managing the Sense of a Region*". The sensory qualities describe those elements that affect the human senses and hence the perception of a place. These are vision, sound, touch and smell.

Given Calcutta's population over fourteen million, projected rapid growth into the future, and the author's passion for the place having grown up in the city, led to the selection of the study site. The author's interest in Geographic Information Science (GIScience) coupled with formal training and practice experience in architecture led to the following thesis. Can a GIS be used to characterize and communicate sensory and responsive qualities of urban centers critical to design decision making?

CHAPTER 2 - BACKGROUND TO THE STUDY

Spatial Study of Urban Form

Today we have an increasingly urbanizing world marked with economic change, population growth and constant addition to the built environment, all of which can be manifested spatially. Spatial analyses of cities are performed by urban geographers, planners and designers to analyze social phenomenon in order to reach practical solutions. Many researchers have performed extensive work in the field of spatial analysis of urban spaces. One of the earliest works of spatial studies can be found in Nolli's map (Figure 1) of the building coverage of Rome, 1748. In this study Nolli treats space as an object to enhance the intricate relationship between the open and closed spaces of historic Rome.



Figure 1: Nolli's Building Coverage Map of Rome, 1748

(Source: Lynch, Kevin., *The Image of the City*, Cambridge: The MIT Press, 1959.)

The mode of spatial representation of urban forms and their analysis become more advanced with the incorporation of additional observed phenomenon. Since humans are the main users of urban spaces, observations of human activity in conjunction with physical city form, add both richness to the understanding urban environments and complexity to urban studies.

Kevin Lynch, for instance, studied the characteristics of urban spaces according to the perception of those spaces by their inhabitants. He developed a methodology to spatially represent these studies in the form of maps and symbols in order to complete his analysis of urban spaces. For example, in his study of the legibility of Beacon Hill in Boston, Lynch distinguishes important landmarks by interviewing the residents of Beacon Hill. He then represented these landmarks according to their use on the map of Beacon Hill. In another study of the same place Lynch described Beacon Hill according to the sensed environments within it by dividing the area into various legible sub-districts.

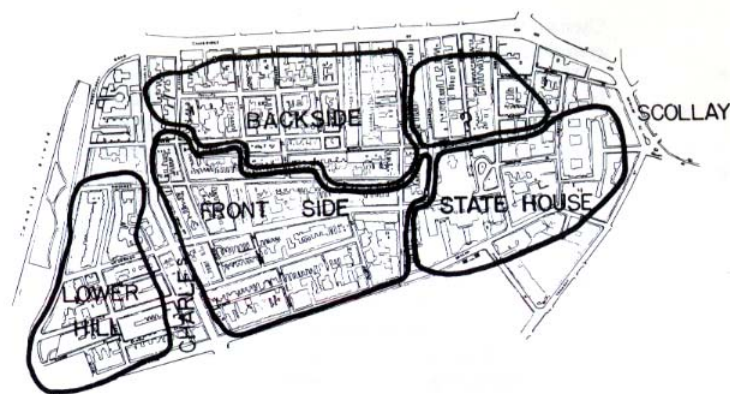


Figure 2: Legible Sub-districts within Beacon Hill, Boston

(Source: Lynch, Kevin., *The Image of the City*, Cambridge: The MIT Press, 1959.)

Another proponent of urban study was William Whyte (1980), who studied the viability of existing settings in New York's plazas. Whyte's studies (1980) focused more on the behavior and analysis of people within small scale open spaces, while Lynch focused on larger regional contexts. However, both Lynch and Whyte focused on how people perceive urban space, or the sensory qualities of space.

Ian Bentley et al (1985) studies take into account the physical as well as the perceptual characteristics of urban spaces defining both as responsive qualities of place. Responsive Qualities are those qualities of an urban space that provide a democratic setting to its users by maximizing the degree of choices and opportunities (Bentley et al 1985).

Urban designers are challenged to incorporate elements in design that make a public space function while appealing to the perception and sensual experience of humans. Case studies of existing settings help to identify these elements and understand how they work in relation to each other. A study of large regions before designing smaller urban spaces allows the smaller design to integrate with the macro environment.

However, in many cases designs are completed considering only the immediate surroundings and fail to derive a deeper context for users. Failure to do so is the result of many factors including but not limited to: lack of available data, and limited project time and dollar budgets. Thus, before designers and planners start altering small urban settings it is desirable to study the responsive and sensory quality of the surrounding

region as part of the experiential framework of the design and ultimately the perception and sensual experiences of people.

In order to conduct such a study one needs to identify elements within an urban space that contribute to both responsive and sensory qualities, first at the regional level and then at the more site specific level. These elements can be treated as guiding parameters while introducing new built environments.

Responsive Qualities

Bentley et al has identified seven principle elements to understand the quality of responsiveness of urban regions. These include permeability, legibility, variety, robustness, visual appropriateness, richness and personalization. Following are brief descriptions of each of the seven responsive qualities.

1. Permeability

This quality refers to the physical access and movement within and through an urban district. High accessibility means the place can offer more choices to its users. Permeability can be evaluated by studying the alternate routes leading to a place and the available mass transit systems (See Figure 3).

2. Variety

This quality refers to the range of uses available within a place. The key elements of an area that has high variety include (a) mix of land use; (b) existence of affordable spaces which could be used by small commercial establishments; (c) careful location of anchor spaces such as large shopping malls, housing and office blocks and easy pedestrian movement within the region (See Figure 3).

3. Legibility

Legible spaces are those, which form a strong impression on people's minds allowing them to grasp the physical form, layout and character of the space (Bentley et al. 1985). The most important character of legible spaces is identifiable features that stand out from rest of the built environment and guide people through the space (See Figure 3).

4. Robustness

Robustness is a quality that increases the use of a place or a building by supporting diverse forms of human activity. In any urban region the edge of the buildings is an important area to evaluate the robustness of a place (Bentley et. al. 1985). The presence of ground floor shops adjacent to streets, outdoor restaurants and places to sit in front of buildings increase robustness (See Figure 3).

5. Visual Appropriateness

Visually appropriate places allow users of the space to interpret the available uses. To achieve this quality the design of the space should allow publicly visible surfaces,

which communicate with the users. Building facades that portray a sense of particular building usage contribute to the visual appropriateness of the place.

6. Richness

Richness is a quality that increases the sensual experience of the users. These qualities are the same as the sensory qualities of a place. They affect the experience of the sense of vision, touch, sound and smell.

7. Personalization

This quality allows users to personalize an urban space to establish their own identity. Architectural elements such as steps, window sills, canopies create opportunities for users to personalize certain spaces. For example pedestrians can personalize steps in front of buildings and use them for sitting.

While the seven responsive qualities of urban spaces defined by Bentley et al (1985) add additional layers of understanding to civic space, they cannot be studied in isolation. The designer also needs to identify elements prompting environmental behavior in existing settings. Most factors contributing to behavioral pattern have some form of physical existence. For example mass transit systems are purely physical factors that relate to the responsive quality of permeability. Similarly different forms of human activities that contribute to the robustness of a place are not purely physical, but they too have spatial existence. To study such qualities one needs to associate responsive qualities with spatial locations or objects which influence environmental behavior.

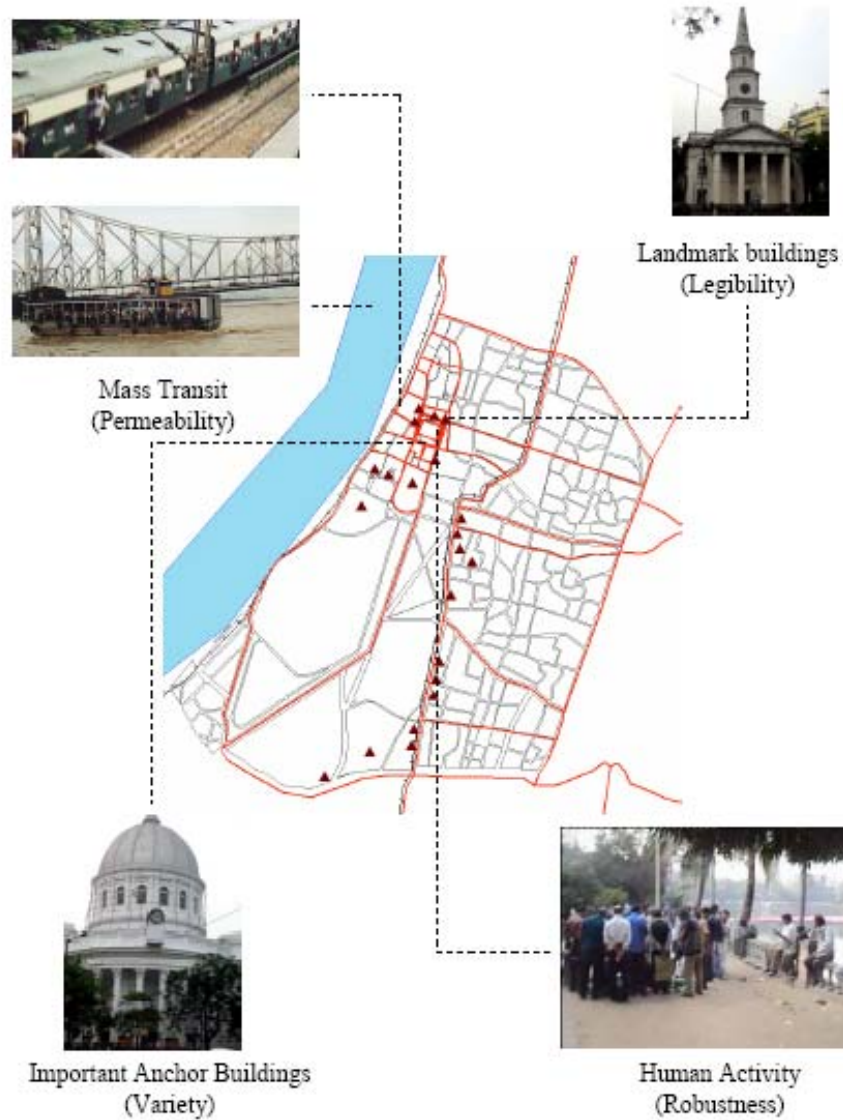


Figure 3: Responsive Qualities in an Urban Setting

As illustrated in Figure 3, responsive qualities can be associated spatially within an urban setting allowing the degree of responsiveness of a space to be evaluated.

Additionally, the seven responsive qualities identified by Bentley et al (1985) include aspects of sensual experience of a place. For example, richness of space is

associated with its sensory qualities. In his text, *Managing the Sense of a Region*, Lynch gives a glossary of techniques to describe, record, and analyze the sensed form of a large environment (Appendix A). Lynch's studies on sensory qualities are extensive and he suggests that recording of such qualities of a region should be developed as a strategy. In this thesis sensory qualities of place are studied as a separate section though both responsive and sensory qualities are interrelated (See Figures 7 and 8).

Sensory Qualities

In analyzing urban spaces, a record of the sensory qualities is highly desirable. Sensory in this case refers to those qualities required by humans to perceive an object or space and generally includes: vision, touch, smell and sound. How users perceive a space through their senses is directly manifested in their environment behavior within the space. An interaction between street vendors and pedestrians in urban settings is an example of the existence of the sensory qualities of vision and touch as illustrated in Figure 4.



Figure 4: Outdoor Vendors at Salt Lake City Center, Calcutta – Sensory Qualities of Vision and Touch

Lynch also discovered a great challenge lies in how to comprehend these techniques in terms of tangible data and use an analytical model to interpret them. In his personal studies of various regions he emphasizes mostly graphic techniques, and in most cases the results are maps with incorporated data in the form of some recognizable patterns. From the eleven techniques Lynch identifies, the combination of a few can lead to an elementary understanding of the sensed environment of a region. For instance, spatial form and temporal pattern in combination could lead to certain interpretations.

In addition, Lynch describes activity cycles or apparent tempos of study settings can portray how certain regions are sensed and perceived. Certain urban spaces are found to be more active during the day than night or vice versa. In both these cases the spatial and temporal aspect serves as the basis for data acquisition. Spatial forms are best

explained in the form of diagrammatic models or map diagrams divided into sub-landscapes. Temporal forms such as a cycle of activities, which could be diurnal variation in pedestrian usage could then be superimposed on the original spatial form to reveal potential correlation.

Since most of the sensory qualities of a region correspond to vision and touch, a methodology for recording these experiences is necessary. Lynch called these experiences sequences in vision (See figure 5 & 6). This can be represented as a series of animated images and can lead to an understanding about clarity of various pathways within the site. Data in this category could be signage, visible entry points and dominant features. Visibility itself could be a category where areas can be described by counting landmarks or recording visual absorption quality. For visual absorption the data might become descriptive notes but properly structured to make a visible interpretation on a map. Visual absorption could be some form of external element such as plant cover which allows change in building facades without much impact (Lynch, 1976).

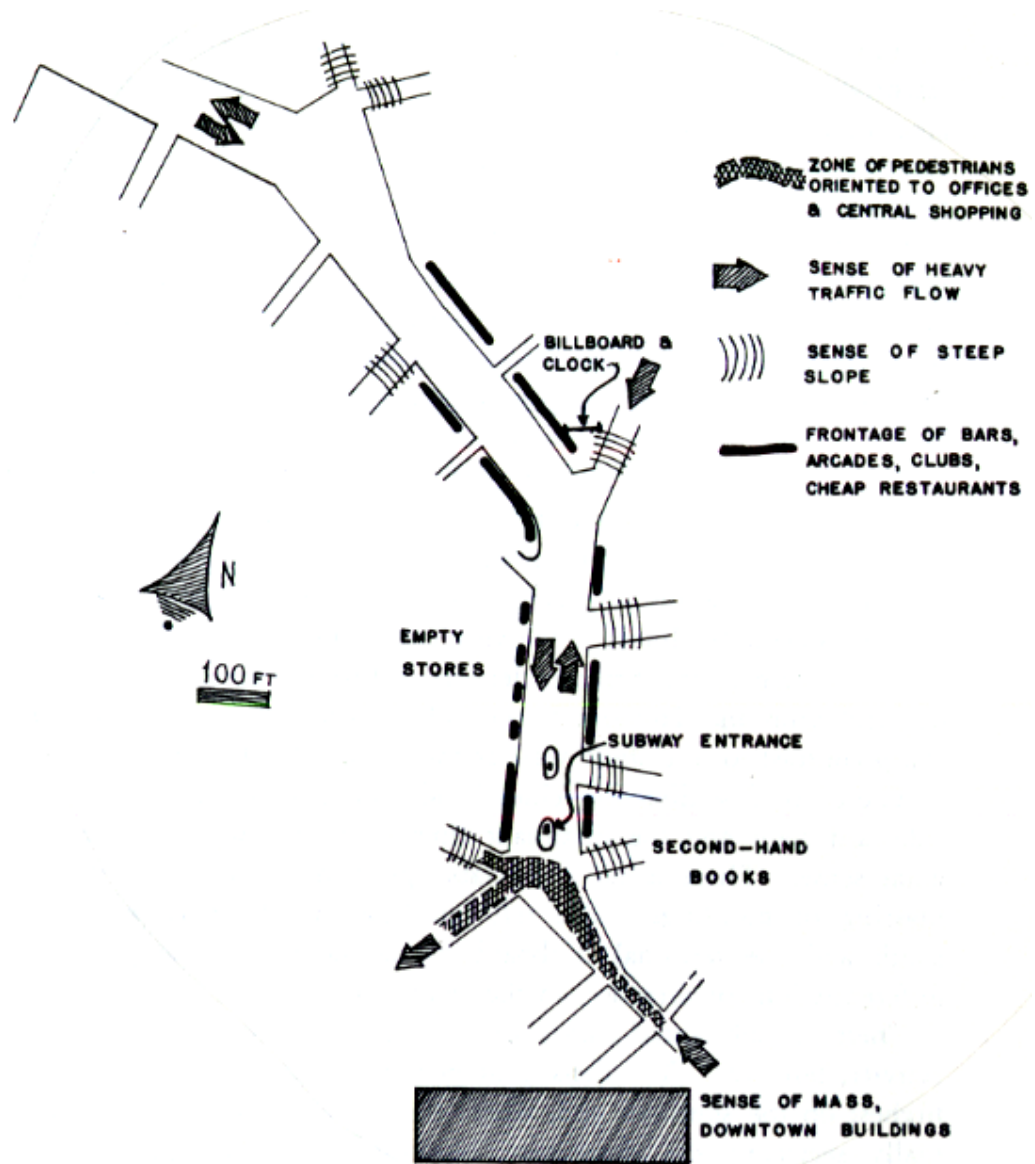


Figure 5: Sequence of Sensory Qualities of Scollay Square, Boston, Recorded by Kevin Lynch

(Source: Lynch, Kevin., *The Image of the City*, Cambridge: The MIT Press, 1959.)



Figure 6: Colonial Buildings within Dalhousie Square, Calcutta act as Visual Elements

Figure 6 illustrates how sequence of vision is enhanced within Calcutta's historic districts by the strategic location and design of key colonial buildings.

The ambient quality of a region is another recordable attribute to determine sensory qualities. This might refer to the feel of various sub-landscapes in terms of their micro-environments. These include sunlight glare, wind reflectors, public shelters, noise, and quality of artificial lighting.

Surface details of buildings also apply to certain sensory qualities. While surface texture affects the sensation of touch, color affects the visual sense. Apart from these basics, other broader forms of data are those that affect the spatial behavior which in turn affect the senses. These include steps for sitting, waste receptacles, newsstands, etc. Natural features and visible activity within a region also affect the senses. Detailed descriptions of these and further description of Lynch's sensory qualities and techniques can be found in Appendix A.

Relation between Responsive and Sensory Qualities

Responsive and sensory qualities of an urban space are not independent of each other. These qualities are interrelated in a space-time setting within an urban environment (figure 8). As discussed, the responsive qualities of richness are actually the qualities that increase the sensual experience of a place. However the presence of both these qualities within an urban environment increases both its experiential quality and the degree of choices and opportunities. For instance, street features such as monuments and sculptures (figure 7) act as landmarks contributing to the sensory quality of vision as well as to the responsive quality of legibility.



Figure 7: Landmarks in Streets of Calcutta supporting sensory quality of vision and responsive quality of legibility

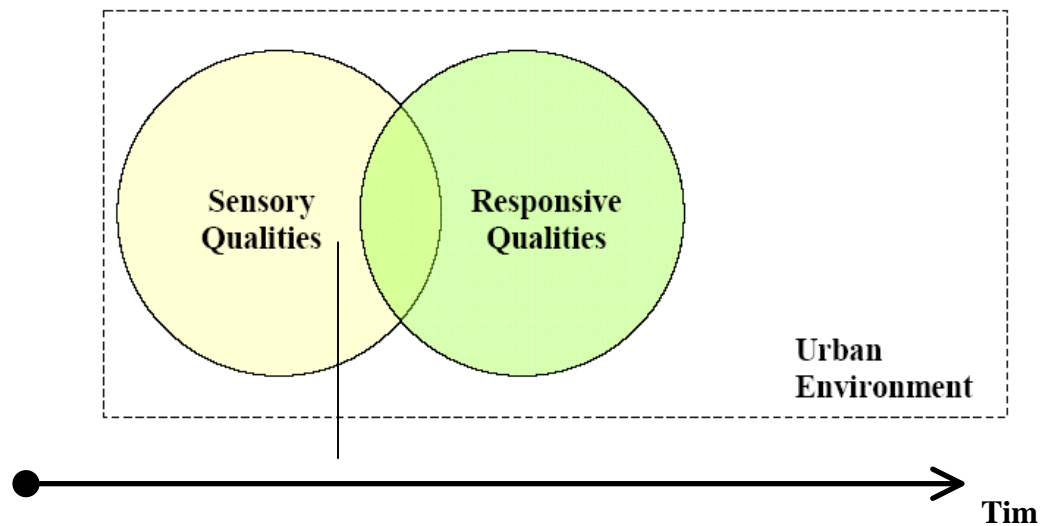


Figure 8: Relational diagram between Sensory and Responsive Qualities – these qualities are linked and interrelated in a space-time setting within an urban environment

Figure 8 illustrates the interrelationship between sensory and responsive qualities in a space-time setting. While Bentley and Lynch have provided a framework by which one can measure degrees of sensory and responsive qualities in a spatial-temporal setting,

documenting and communicating or creating a virtual representation to communicate these interrelationships is incredibly challenging.

Capturing and Visualizing Responsive and Sensory Spatial-Temporal Characteristics

Underpinning the study of sensory and responsive qualities is a map of the urban fabric much like Nolli's Building Coverage Map of Rome, 1748, which captured the spatial patterns of structures and spaces for people. Lynch used maps to document the spatial pattern of observed sensory qualities. Maps and diagrams, and all other forms of communication are abstractions of a three-dimensional world at a moment in time. Figure 9 illustrates the common abstract forms of explaining spatial temporal patterns.

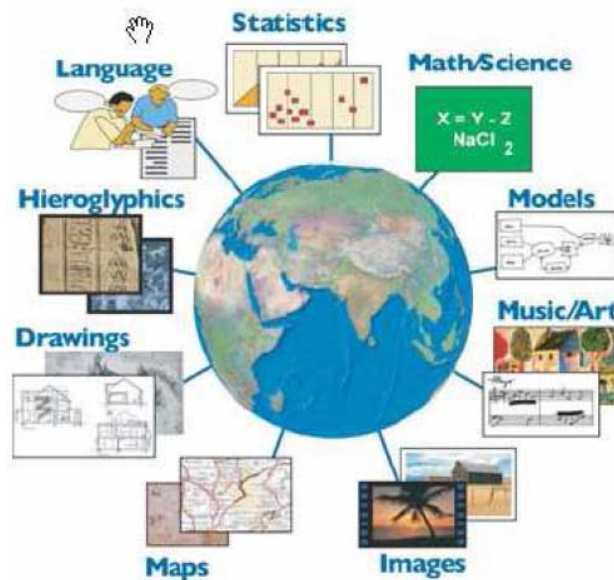


Figure 9: Abstract Forms Used to Communicate Spatial-Temporal Patterns

To capture and visualize information from urban spaces both Lynch and Bentley used a combination of paper maps, images and statistical data. In addition Lynch interviewed local people and noted their perceptions of places. These perceptions were either presented as descriptions or as cognitive maps and drawings.

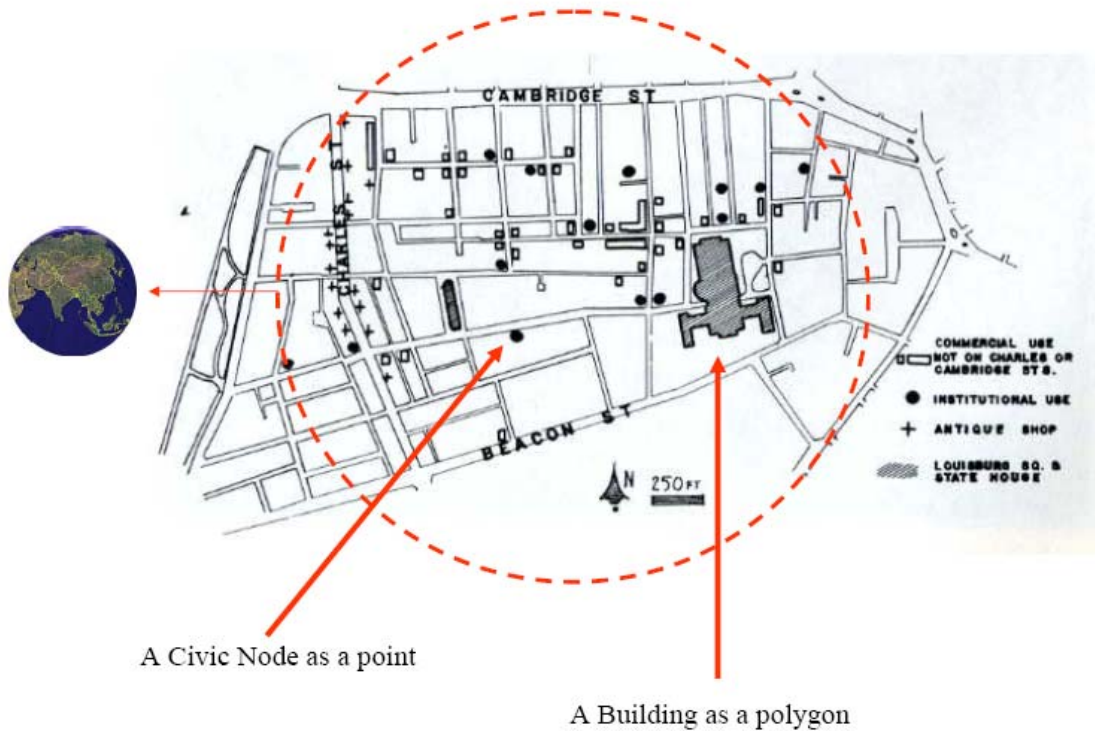


Figure 10

Figure 10 illustrates Lynch's representation of commercial nodes and landmarks in Beacon Hill, Boston. Lynch used abstract symbols to represent civic nodes and buildings in this study and then used a legend to describe the symbols. Observations on these elements were then given in descriptive forms. The visualization thus had several elements but the mode of representation was paper based and therefore static.

Geographic Information Science (GIScience) is a science dedicated to understanding and modeling spatial-temporal patterns and communicating them. A Geographic Information System (GIS) is a tool comprised of data and their spatial relationship, computer hardware and software and people trained in geographic information science and specialized computer software. A GIS can be used to store, manipulate, summarize, query, edit and visualize geographic information stored in a computer database. Figure 11 illustrates a common GIS framework and abstract forms typically used to represent spatial-temporal patterns.



Figure 11

The various forms of spatial information including those suggested by Lynch and Bentley can thus be stored, analyzed and visualized using GIS. Additionally, GIS is capable of creating a virtual model of 3D space and animating that model through time creating a dynamic view of urban space and sensory and responsive qualities.

The elements from urban spaces such as landmark buildings, legible paths, civic nodes or a high sensory zone such as overcrowded plazas can be used to describe responsive and sensory characteristics. These need to be converted to some form of spatial representation, and the characteristics of these elements which could be descriptive or tabular need to be associated with the element they describe. The advent of GIS has made the task of converting such large amounts of observed data into meaningful patterns much easier. This is because of the use of computer database to store the data and the use of specialized software to represent the data spatially. The various data formats in GIS are:

1. Geometric data such as points, lines and polygons
2. Rasters such as satellite images and photographs
3. Surfaces (terrain or continuous spatial phenomena)
4. Tabular data

Points, lines and polygons can be used as abstract representation of various elements of urban spaces. Figure 12 illustrates how a point can represent a building at a regional scale; a line can represent a path and a polygon can represent an urban zone.

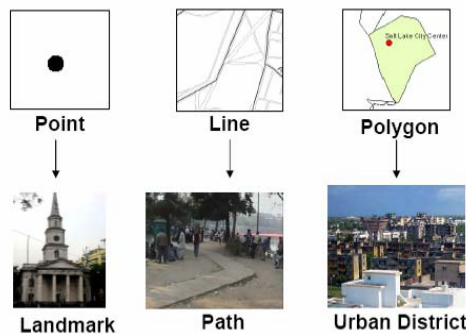


Figure 12

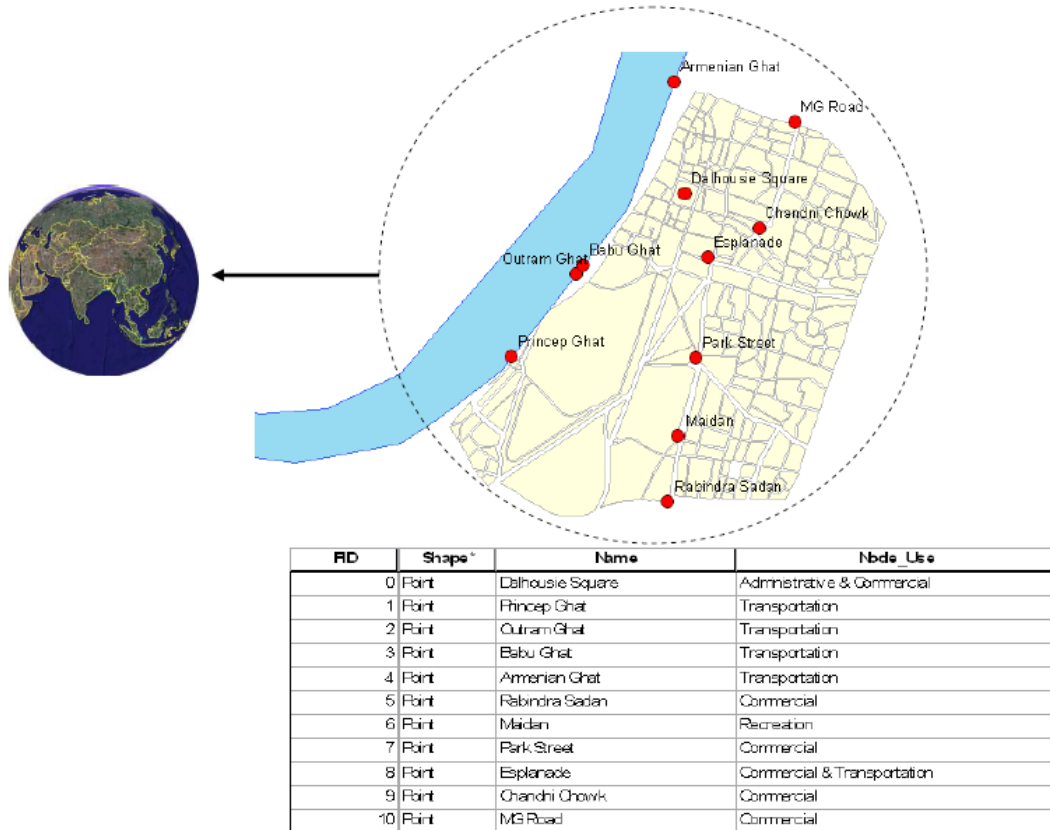


Figure 13

Compared to Lynch's representations (See Figure 10), a GIS map as illustrated in figure 13 can have tabular data associated with geometric data. In this map civic nodes in central Calcutta are represented as points and the tabular data associated describes each nodes primary use. The visualization of the points on the map can be symbolized to represent the characteristics stored as attributes in the geodatabase.

While mapping and visualizing spatial objects is important to urban studies, the ability to analyze the spatial phenomenon and temporal patterns of users is the critical task for designers. The most important aspect of GIS is not only representation of spatial data but the use of correlation or overlay techniques to communicate and develop

understanding of spatial-temporal phenomenon. For instance, the commuter mass transit system and population density of a city when overlaid can show a relationship (Greene, Pick 2006). This relationship can be used to determine whether the city's transit system is accessible to majority of its population. The information can then be utilized in successive planning.

Many urban and civic planning studies use GIS to develop land use maps and model potential development scenarios. Local governments in the United States use GIS technology to support open space planning, identifying key parcels that need to be purchased for parkland or otherwise protected from development (Looney 2000). Likewise studies regarding sensed and responsive environment could be used by architects, landscape architects and urban designers to develop a pre-design analysis.

Revitalization of a downtown could be modeled and analyzed using GIS to understand how proposed design solutions respond to existing civic patterns and sensory and responsive qualities inherent in future users. Although invisible psychological traits are just beginning to be analyzed in GIS, it can be a powerful tool to assess such factors. In a recent paper submitted to Map Asia (2003), Kana Takada wrote about GIS based analysis of sense of place for Fujisawa City in Japan. In her research she first presents a questionnaire survey in which she obtained sense of place data by free-writings and map drawings from people of Fujisawa City. She then performs a spatial analysis of this data using GIS, which allowed her to determine those areas in the city that has strong values of sense of place. Works such as this illustrate the potential power of GIS and GIScience

tools and methods for understanding spatial and temporal sensory and responsive qualities of urban spaces.

The City of Calcutta

Two civic nodes in Calcutta, India (see Figure 14), are used to explore the efficacy of GIS as a tool to assemble, store and analyze spatial-temporal responsive and sensory qualities of urban civic centers. Calcutta is located in West Bengal, India, at latitude $22^{\circ} 82'$ North and longitude: $88^{\circ} 20'$ East. The city lies just 17 feet above sea level and has a temperate climate with temperatures ranging from $12-27^{\circ}\text{C}$ in winter and hot and humid summer with temperature range of $24-38^{\circ}\text{C}$ and an average rainfall of 160cm. A recent estimate of the metropolitan area totaled 1380sq. km with a population density of 24760 people per square kilometer (Source: <http://www.calcuttaweb.com/geography.shtml>).

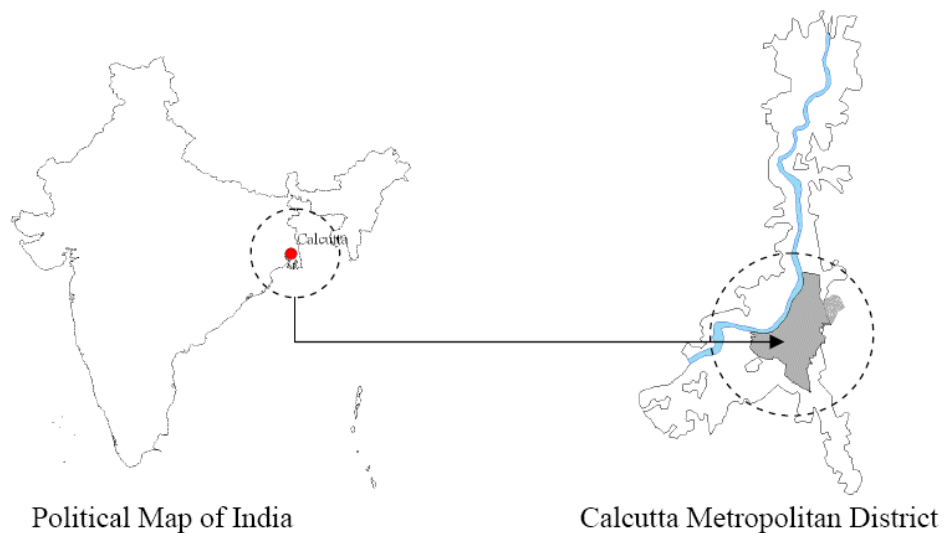


Figure 14: Geographic Location of Calcutta

A little more than three hundred years old, Calcutta is a very recent city if we compare it with the time-span of human civilization in the Indian subcontinent. Yet in these three centuries no other Indian city apart from Bombay has seen such rapid growth, the statistics of which can cause nightmares for urban planners as evidenced in Table 1.

Table 1: Population Statistics of Calcutta

Year	1950 - 2015	Urban population (%) 1950 - 2015	Total population (%) 1950 - 2015
1950	4 446 000	7.2	1.2
1955	4 945 000	7.1	1.3
1960	5 500 000	6.9	1.2
1965	6 162 000	6.6	1.2
1970	6 912 000	6.3	1.2
1975	7 888 000	6.0	1.3
1980	9 030 000	5.7	1.3
1985	9 946 000	5.3	1.3
1990	10 890 000	5.0	1.3
1995	11 925 000	4.8	1.3
2000	13 058 000	4.7	1.3
2005	14 299 000	4.6	1.3
2010	15 452 000	4.4	1.3
2015	16 747 000	4.2	1.3

Indian cities like Calcutta, which developed as mega-cities were established during the British rule. Bombay, Calcutta and Madras were the three trading grounds for England, all established as port cities. The East India Company, and later the British Government connected India with railroads allowing the cities to be easily accessed by other urban and rural populations.

In 1690, Job Charnok, a British trader leased three villages from the local landlords to establish a trading post. Together these three villages, Kolikata, Gobindapur and Sutanuti formed Calcutta (figure 15). Other colonial establishments in the region were those of Chinsurah, Hooghly and Chandannagore, which were outposts of Portugese, Dutch and French traders (Chakravorty 2000). The entire region was brought under control of the British rule after the decisive battle of Plassey, which took place in 1757 between the British and the local landlords. When the Queen of England took direct control of India from the East India Company, Calcutta served as the capital of British-India, finally loosing its status to Delhi in 1911. The three phase history of the city is categorized as – its colonial past, industrial decline, and hope for resurgence in the present and near future (Chakravorty 2000). Figure 15 illustrates the stages of growth of Calcutta.

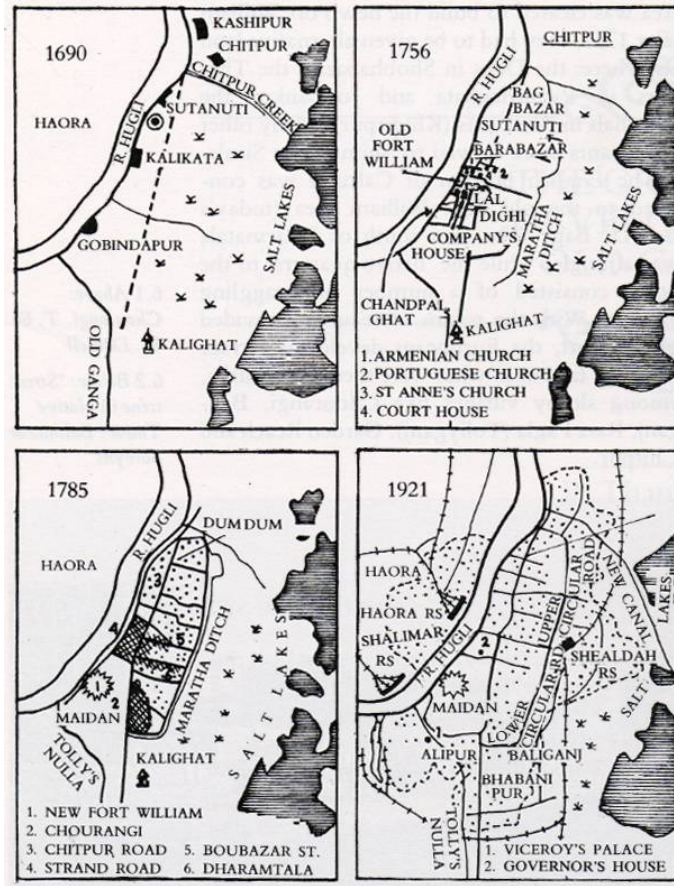


Figure 15: Four Stages in the Growth of Calcutta

(Source: P 12, Chaudhuri, Sukanta. ed., Calcutta: The Living City, Calcutta: Oxford University Press, 1990.)

During the early colonial days West Bengal and the present country of Bangladesh together were the undivided state of Bengal. The region was famous for the production of jute, the golden fiber used to produce gunny sacks. Figure 17 provides an image of Calcutta during the colonial period.



Figure 16: Calcutta during Colonial Period, a 19th Century Painting

(Source: <http://www.kolkataweb.com/picture/picdisplay.php?id=195>)

Calcutta has been strongly influenced by globalization, though there is not been much physical manifestation to date. However its expansion and population growth have been remarkable. After several economic setbacks, the city had lost control over this rapid growth, which left large portions of it in chaos and almost unattended. Being the capital of British-India for a longtime, Calcutta had some beautiful colonial buildings and urban places, and numerous palaces in the Indo-European style.

Today most of these structures lie in shambles except a few which serve as important public buildings. The riverfront particularly is studded with warehouses that have immense potential of being revitalized. Urban renewal as a concept has not been explored in this city, and thus it is important for the government to do a comprehensive study of the city structure and its growth pattern.

Even with the urban degradation, the socio-cultural life in the city has remained very rich. It has been hailed many times as the cultural capital of India. There is a great relationship between the social life of the city and the city form. The people have specific behavioral patterns. Some of these are typical for South-East Asian cities while some are unique to Calcutta.

Immediately after India's independence there was an era when people migrated to current Indian mega-cities. Today we call this distress migration since most of the peasant families made choices to explore the cities looking for jobs (Correa, 1980). Local authorities didn't keep up with the growth and cities like Bombay and Calcutta grew almost organically. There were no planned civic centers, but the European parts of these cities comprised of public buildings such as high courts and general post offices became the central business districts. Bombay for example, developed Nariman Point, which is not the geographical center of the city but for long a time was the place where people traveled for jobs from the perimeter. In Calcutta it was the Dalhousie Square.

For a long time, Calcutta's geography has been verbally divided by its inhabitants into a north, central and southern district. Central Calcutta has a predominant European influence in its architecture surrounded by chaotic development. The north is also the older part of the city settled during the British rule by many educated Bengali families. The south except certain regions was later additions and is presently settled by the rich and upper middle class. There are marked cultural differences between these districts.

As illustrated in Figure 15, the Hooghly River forms the most prominent edge on the western side of Calcutta. Along the east, the city is bounded by wetlands which act as a physical barrier for expansion forming a definite edge. However, with time development on these wetlands became inevitable. With the expansion on the eastern side, Salt Lake, or Bidhannagar Township, was developed as a planned suburban settlement. Today this forms the most coherent district within Calcutta since there is a striking difference between the organized plan of Salt Lake and the rest of the city.

With the development of suburban settlement as Salt Lake there was a demand for more urban centers, such that jobs could be relocated from the historic city center and opportunities of entertainment, shopping and similar facilities could be created. The Salt Lake City Center is one such urban growth center established recently in 2004.



Figure 17: Old Calcutta based on Upjohn's Survey 1792-93, showing location of Dalhousie Square

(Source: P 22, Chaudhuri, Sukanta. ed., Calcutta: The Living City, Calcutta: Oxford University Press, 1990.)

The Dalhousie Square was built during the British rule over India; hence it is located in the region of the city originally settled by the Europeans (see Figure 17).

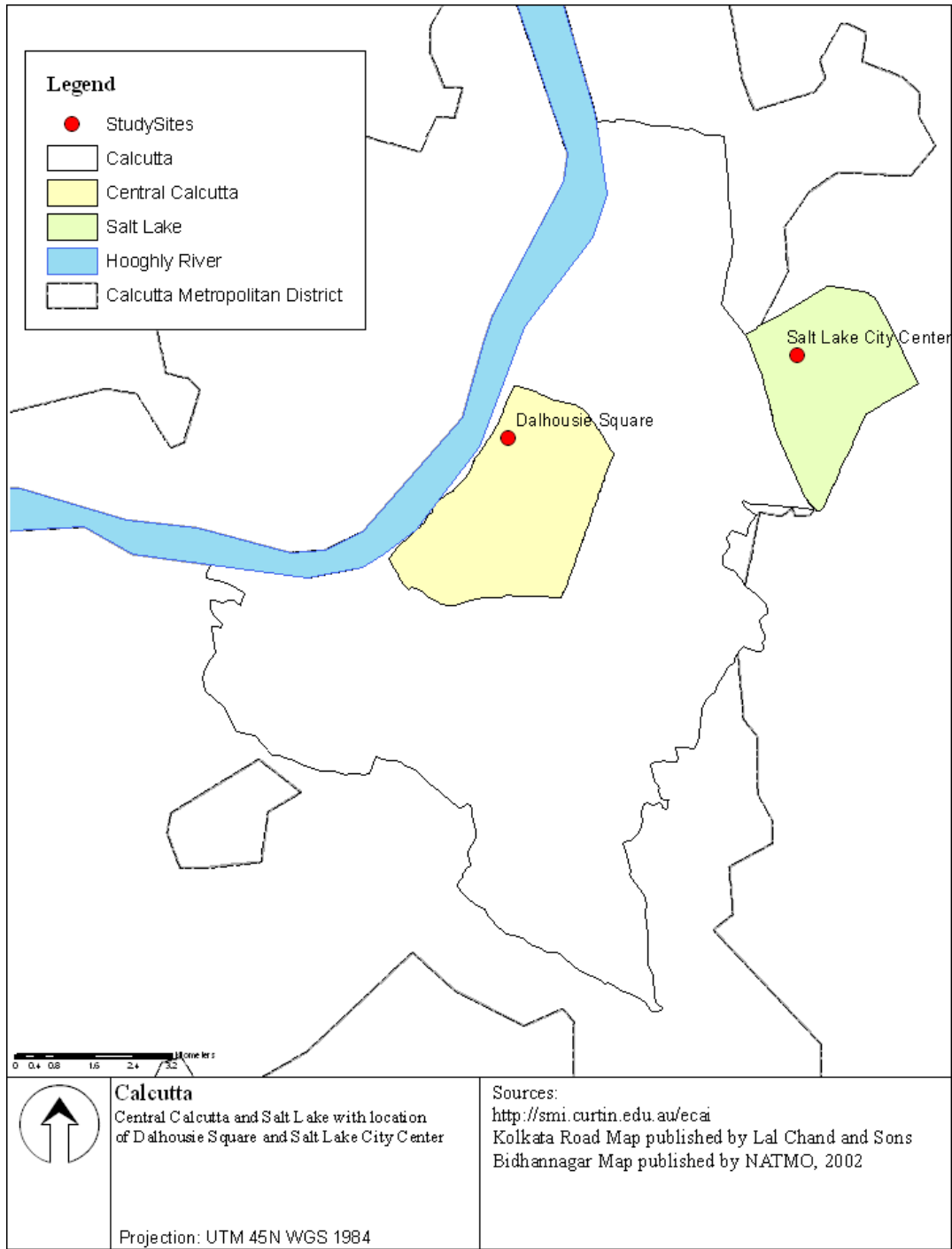


Figure 18: District of Central Calcutta and Salt Lake and the locations of Dalhousie Square and Salt Lake City Center

The civic nodes of Dalhousie Square and Salt Lake City Center, belong to distinct urban districts (See Figure 18). The blocks immediately surrounding the Dalhousie Square have a unifying character because of the existence of similar kinds of historic buildings and land use. For this study, blocks are considered together as an urban district and have been described as the Dalhousie District. The entire region of Central Calcutta has distinguishing characteristics mainly because of the phased growth that took place in the expansion of Calcutta and are represented in the urban districts denoted. Salt Lake being the most recent addition to the city is a district by itself.

The Central Calcutta region is clearly distinct from the rest of the city because this was the region originally settled by the British. This settlement took place on the bank of the river Hooghly with Fort William as a military base. The British planned this region to include an administrative district surrounding the Dalhousie Square and a residential district along Park Street. They left vast open parks surrounding the fort. These parks are known as maidans in the local language. Even today these are the only major open green spaces within Calcutta and are hailed as the lungs of the city. On the west, the Hooghly River forms a natural edge for this district. In the south the boundary of the park forms an edge. The north is bounded by the present Mahatma Gandhi Road and the east is bounded by the AJC Bose Road (See Figure 19).

The marked difference of the urban character of Salt Lake from the rest of the city of Calcutta is because it is a planned township. The planning of Salt Lake has been based on sectors and blocks (See Figure 20). Presently Salt Lake has five sectors out of which

the first three sectors are planned as mixed use. Sector 5 has been planned as an industrial sector and Sector 3 as an amusement park.

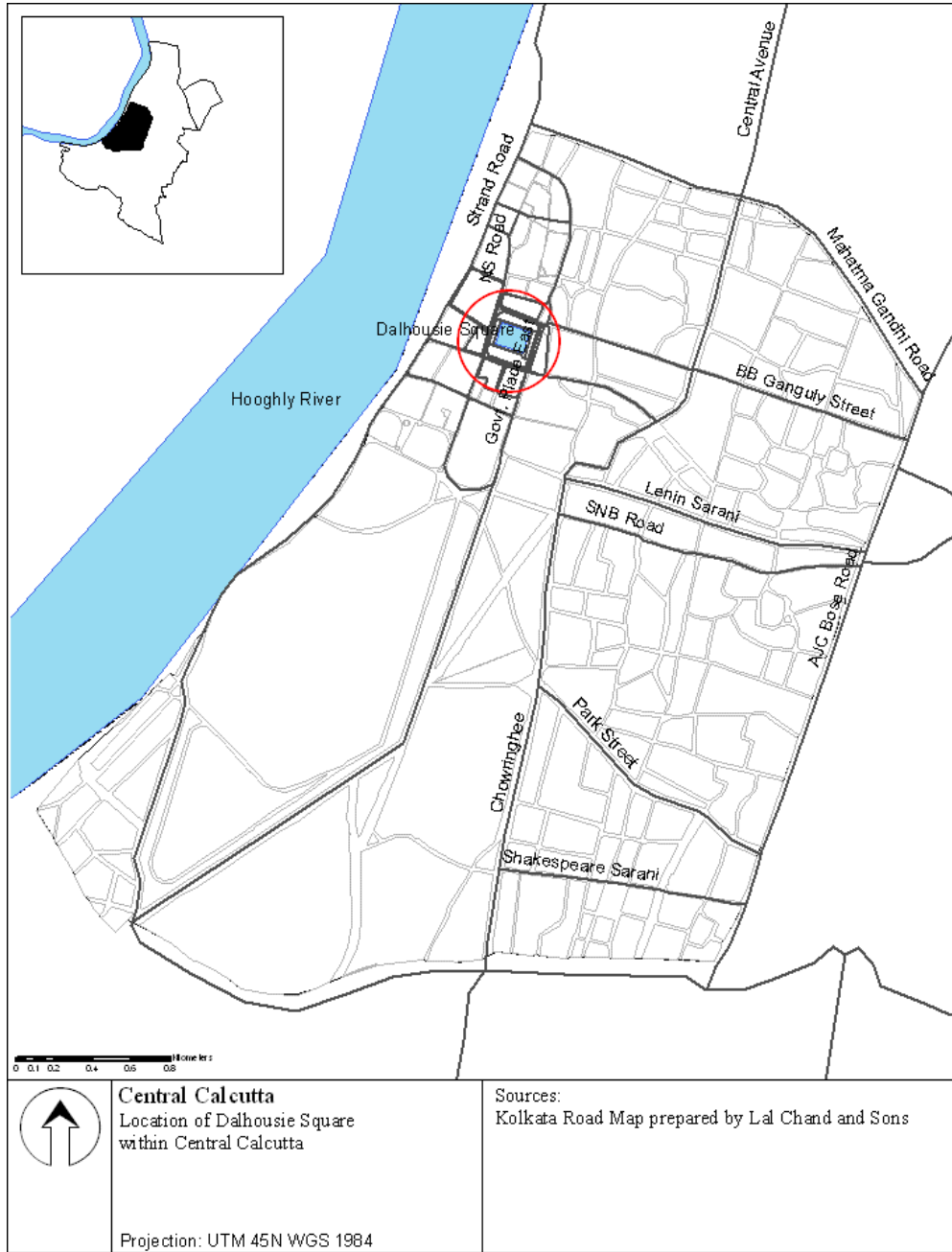


Figure 19: District of Central Calcutta showing location of Dalhousie Square

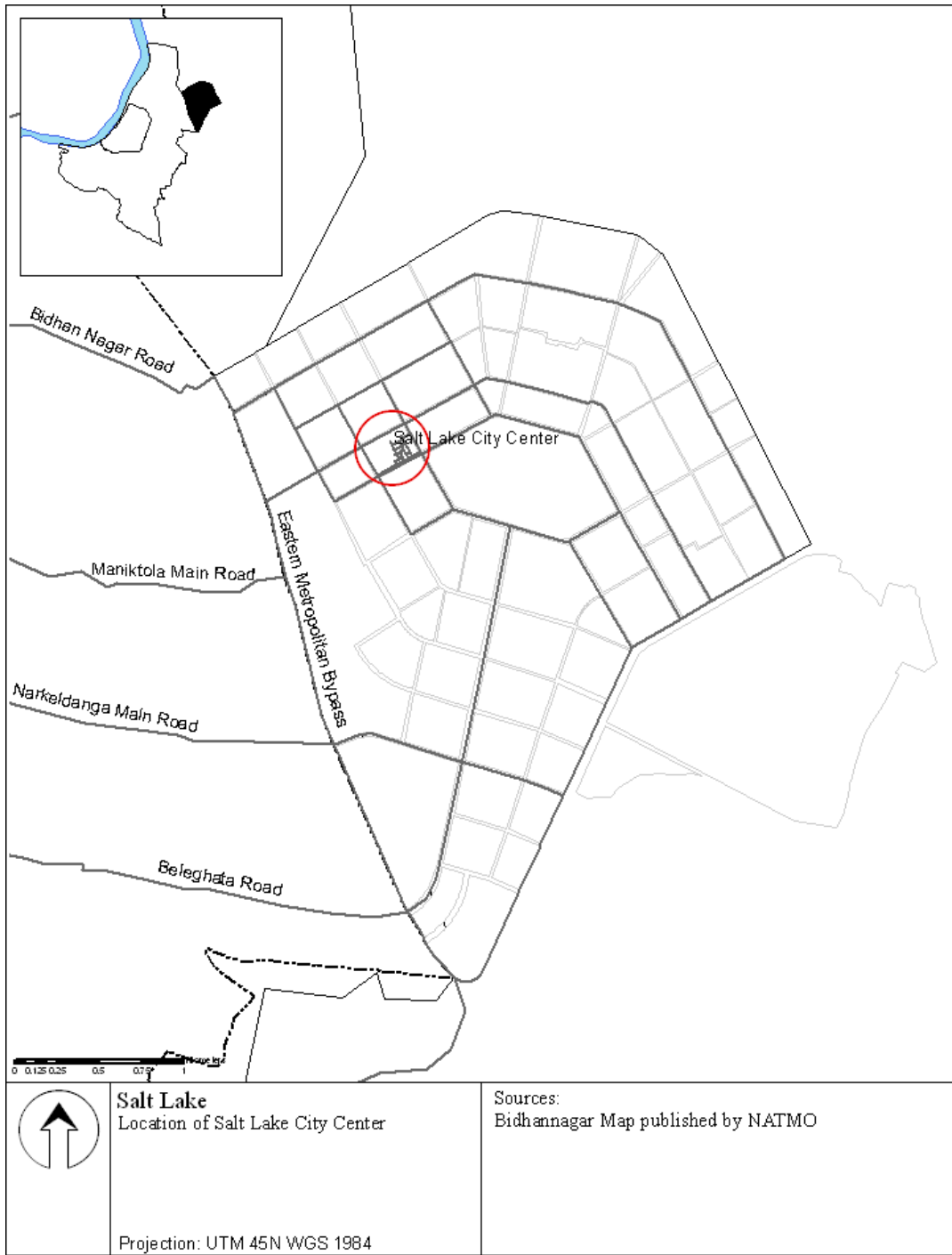


Figure 20: Salt Lake showing location of City Center

The Study Sites

Dalhousie Square

Dalhousie Square was the seat of British administrative power until 1911. The Square was named after James, Marquise of Dalhousie, Governor General of India from 1847 to 1856. Today it is considered as the historic city center of Calcutta and is situated right in heart of the city occupying an approximate area of two square kilometers. It has a number of historic colonial structures serving as important administrative buildings. At the center of the Square is the Lal Dighi, a large water tank. The space around this tank is used extensively by pedestrians and hawkers. In India, road-side vendors are known as hawkers. The street life of Calcutta is very active in the city's commercial districts, and this is largely evident within and around Dalhousie Square. The colonnaded facades of the colonial buildings serve as a backdrop for numerous small shops and independent hawkers which makes the place very vibrant during the day.



Figure 21: Dalhousie Square in the year 1910

(Source: <http://www.kolkataweb.com/picture/picdisplay>)

Zones within the Dalhousie Square

The Square comprises a large body of water within a public park. This body of water is square in shape and is known as the Lal Dighi (See Figure 23). The park is further surrounded by a number of important administrative and commercial buildings, all of which face inwards toward Lal Dighi (See Figure 29). Between the buildings and the park the vehicular and pedestrian routes are extremely busy during the day. The roads surrounding the park are Dalhousie Place North, South, East and West depending on their cardinal position. The Lal Dighi is enclosed within the park and is separated from the roads by metal railings. Surrounding the park is a large parking lot (See Figure 25).

A tram track runs right through the parking lot, forming a loop surrounding the park. Apart from the Lal Dighi, the park is actually a pedestrian trail used by pedestrians to cut across the square (See Figure 24). A concrete railing surrounding the Lal Dighi is utilized by people as a seating area. A large number of people use this plaza during the day. People, who use this park, include employees of the government and commercial offices that surround the square, visitors to nearby offices and daily workers.

There is a huge influx of pedestrians during the day. Though this area historically was an administrative center, today many hawkers occupy the pedestrian routes selling goods to the pedestrians. The activity of the hawkers makes the place vibrant, noisy and sometimes chaotic. For this study the square has been divided into distinct zones depending on the purpose and activity that go on within it (Figure 22).

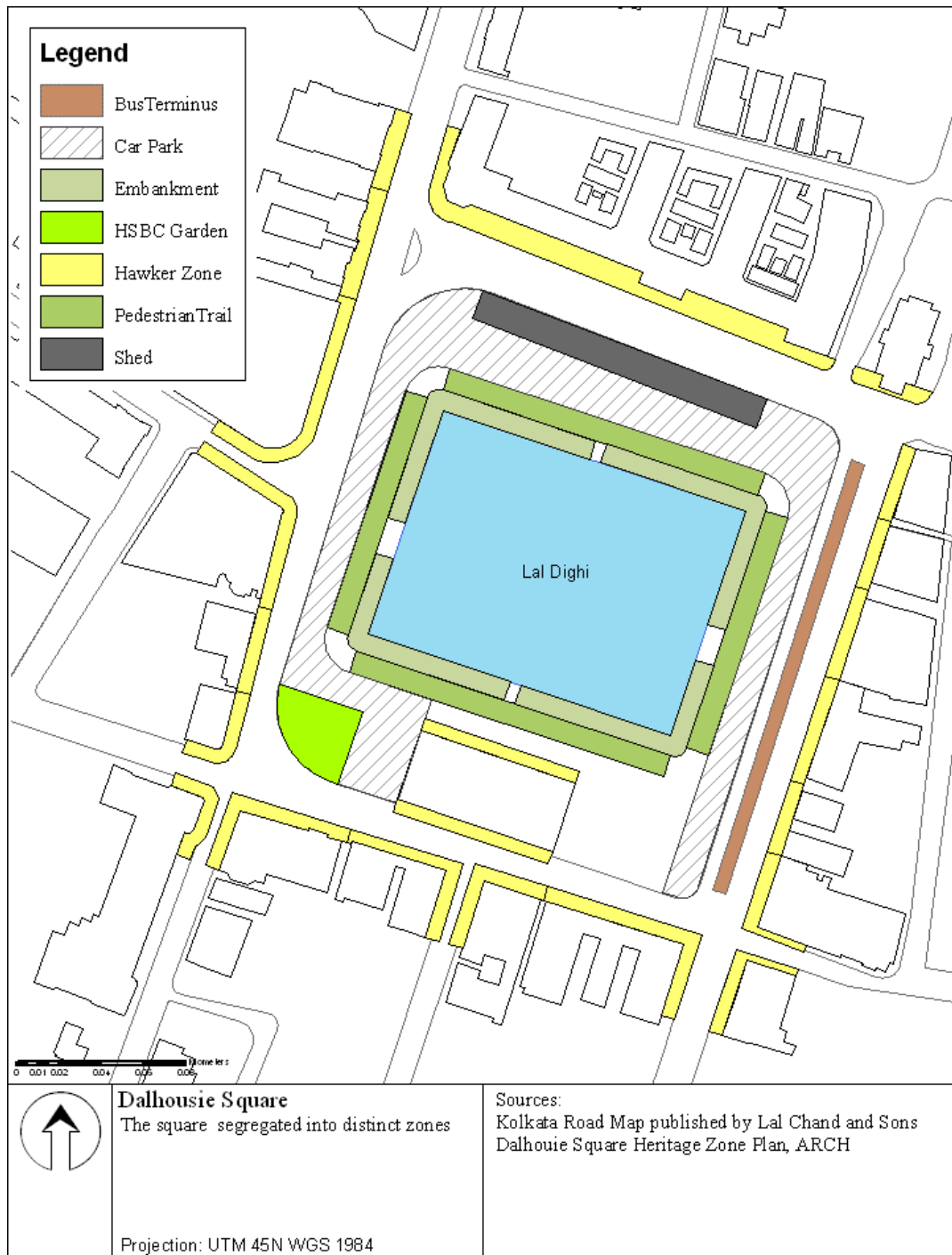


Figure 22: Identified Zones within Dalhousie Square

Identified Zones within Dalhousie Square



Figure 23: Lal Dighi



Figure 24: Pedestrian Trail Surrounding Lal Dighi



Figure 25: Car Park



Figure 26: Hawker Zones



Figure 27: Bus Terminus



Figure 28: HSBC Garden

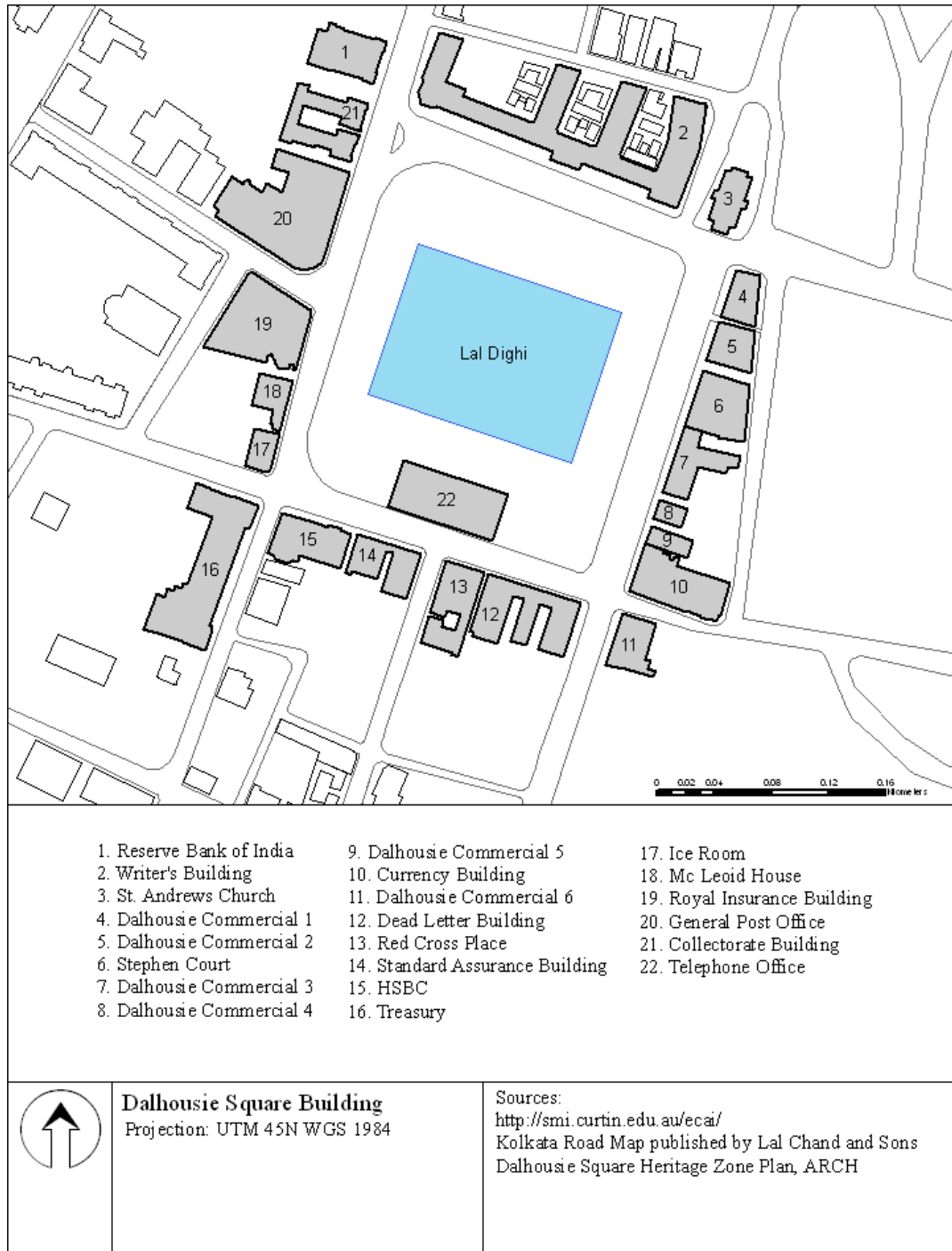


Figure 29: Buildings Surrounding Dalhousie Square

The Salt Lake City Center

“We have here in the Salt Lake City Centre a wide range of different sized residences, entertainment centers, offices, and shops - varying from the smallest dukaans to the most glamorous air-conditioned boutiques and large department stores.

These multifarious activities, all arranged in a fine-grained mix, are generated by a complex system of spaces . . . from broad colonnaded public arcades to narrow bazaar gullies to large terraced plazas . . . culminating in the kund in the centre of the complex. Coffee shops and restaurants, strategically placed at pivotal locations, provide opportunities to rest under wide spreading trees and observe the world around you . . . a marvelous tradition, which has always been essential to life in the great city of Calcutta.”

Charles Correa³

The Salt Lake City Center was developed by Bengal Ambuja Housing Development Limited and designed by the Indian architect Charles Correa. Bengal Ambuja is a joint enterprise of two organizations: West Bengal Housing Board which is a Government of West Bengal organization engaged in mass housing, and Gujarat Ambuja Cements, a cement manufacturing company.

While the Dalhousie Square is a public space in the midst of Calcutta’s old central business district, the Salt Lake City Center represents Calcutta’s new and changing face. The entertainment and shopping facilities attract a large number of young people. It also

³ <http://www.bengalambuja.com/retail/CITYCENTRE.shtm> (Retrieved on March 15, 2005)

attracts a large crowd from Salt Lake's Sector 5 which has a number of information technology and telecommunication offices.

Correa design incorporates elements found in the older civic nodes of Calcutta into this new City Center. The design elements have been simplified, but the elements drawn from the cityscape make the place a part of the whole region and not just a mere decorative addition. For example the colonnaded facades of the old colonial buildings are repeated in the mall facade. The street and the courtyard are design features that form an integral part of Correa's design. This is manifested in the Salt Lake City Center in the form of a shopping spine and several plazas.

Zones within the Salt Lake City Center

The site comprises of a mall, a cineplex and a residency. The mall is subdivided into 5 blocks of shops and offices. The open spaces consist of four entrance plazas, a main plaza and a shopping spine (See Figure 30).

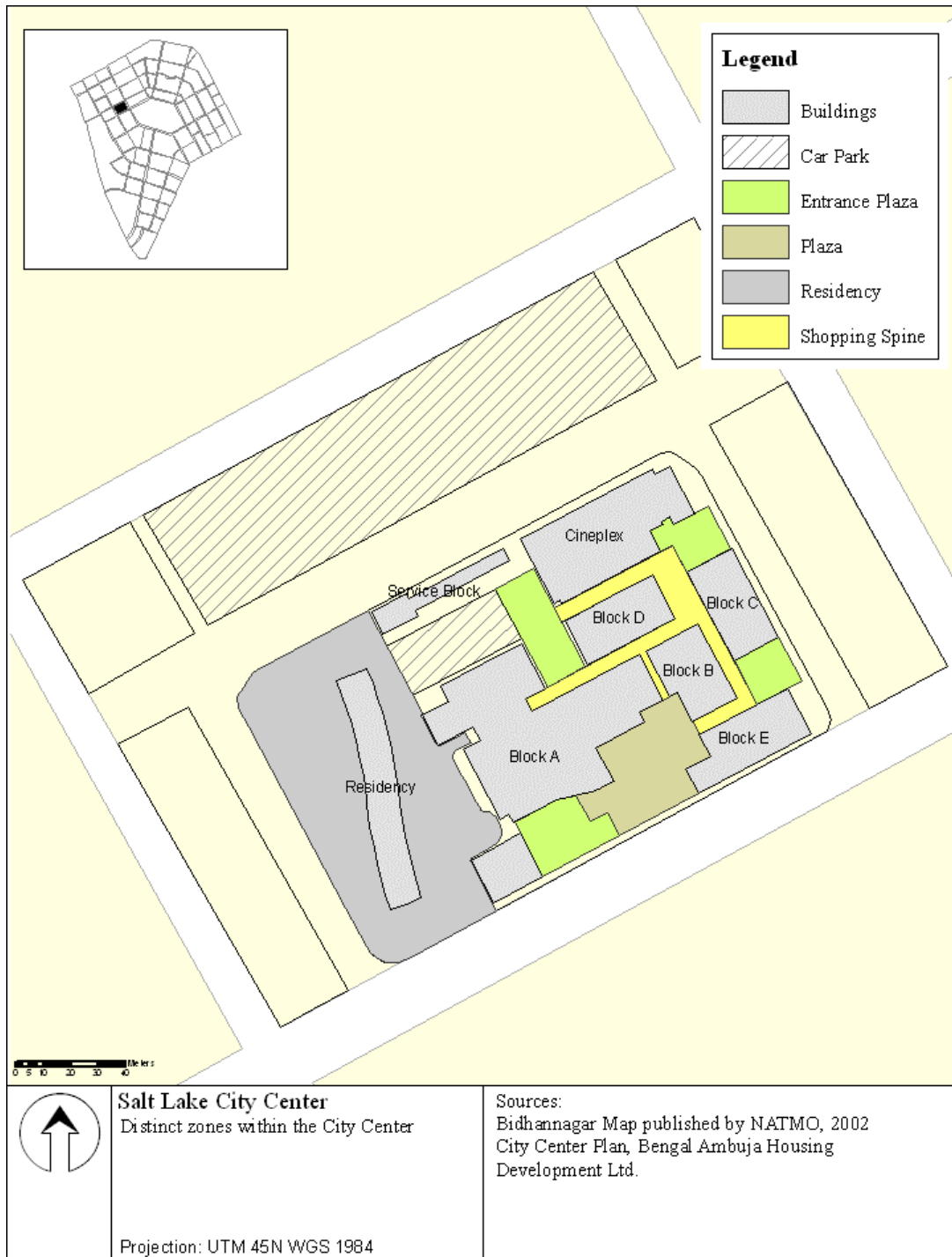


Figure 30: Distinct Zones within Salt Lake City Center

Identified Zones within Salt Lake City Center



Figure 31: Residency



Figure 32: Mall Blocks



Figure 33: Shopping Spine



Figure 34: Cineplex



Figure 35: Main Plaza



Figure 36: Entrance Plaza

CHAPTER 3 - CASE STUDY METHODOLOGY

Responsive and sensory qualities of urban places are characteristics, which co-exist in a spatial-temporal environment and when designed critically and intentionally offer great benefit to the users of a place. Given the spatial-temporal aspect of these qualities and the capability of GIS as a tool capable of capturing and visualizing spatial-temporal information, there is a logical connection. However it is important in this study to illustrate whether design and planning decision-making can be aided by coupling responsive and sensory qualities in an integrated spatial-temporal geodatabase. For this reason it was necessary to carry out tests on real urban settings. Thus a case study methodology was adopted to describe these qualities within the two civic nodes of Calcutta. Please note that the study is not meant to be a complete description of each of the responsive and sensory qualities, but rather illustrate a methodology for conducting such studies to improve decision making by designers and planners using GIS and GIScience. Figure 37 represents diagrammatically the steps undertaken during the study.

During the case study the elements, which contribute to the sensory and responsive qualities were noted by direct on-site observations. The on-site study was performed January 1st through 23rd, 2006, in Calcutta, India. January in Calcutta is considered winter and weather conditions are mild and very conducive to outdoor activities such as: strolling and sitting in the park for pleasure as well as hawkers. The temperate mild climate enables discovery of sensory and responsive qualities of place.

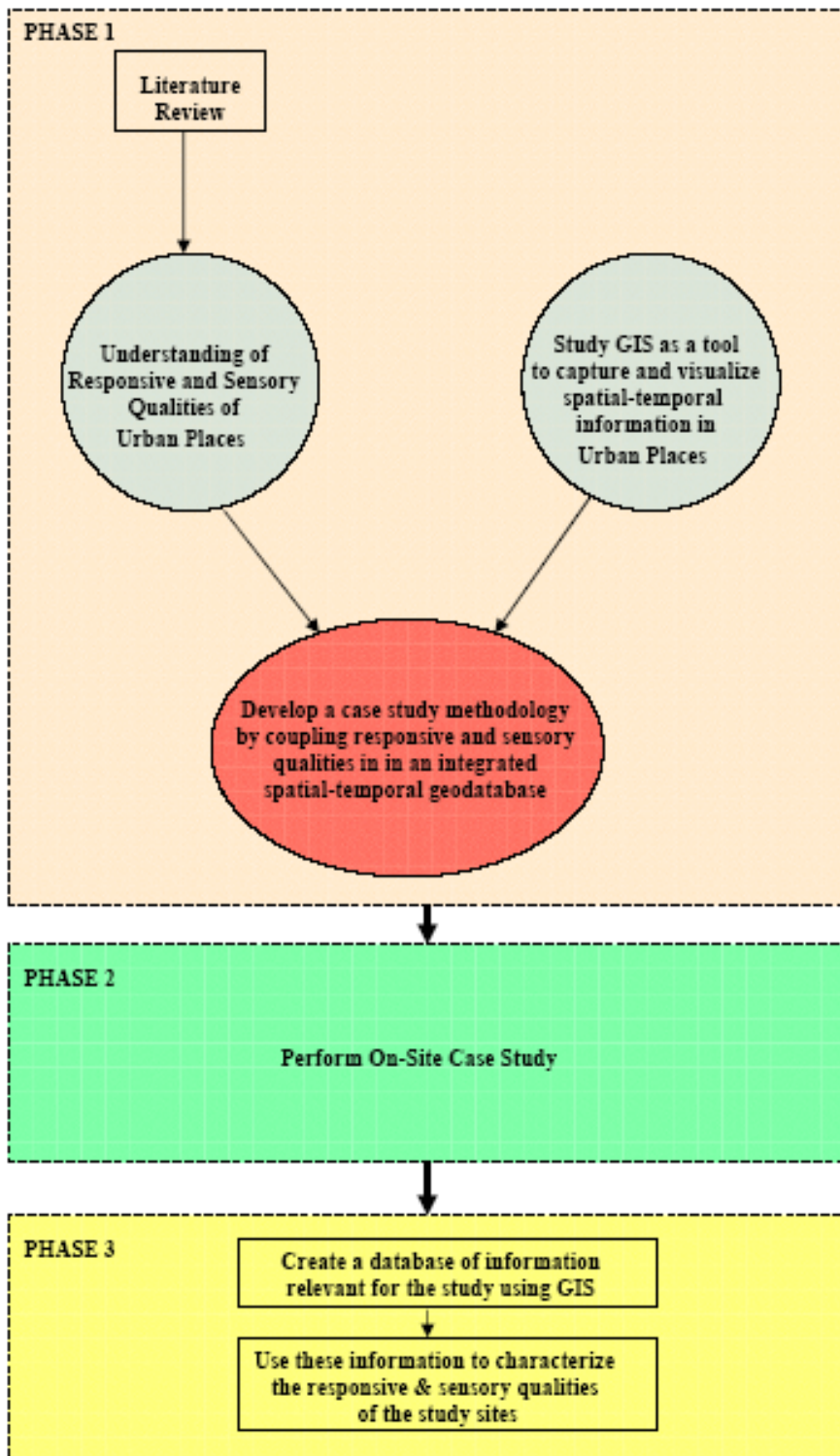


Figure 37: Diagrammatic representation of the study process

The topics mentioned in phase one in figure 37 were discussed in Chapter 2 of this thesis as background information. The case study methodology was developed such that the information obtained about the two civic nodes could be used to create a geodatabase in a GIS, and subsequently virtually represent responsive and sensory qualities of the two civic nodes.

The second phase of the study involved detailed observations and on-site studies carried out at three levels.

1. The city level with respect to the two civic nodes.
2. The surrounding urban district levels for both the nodes, i.e. the Central Calcutta district for Dalhousie Square and Salt Lake for the Salt Lake City Center (See Figure 18).
3. The site level, which involved observations on the various zones within the civic nodes (See Figure 22 & 30).

While in Calcutta from December 24, 2005 to January 24, 2006, the author made several trips to the two civic nodes to study their physical connectivity to the city, surrounding urban land use, and presence of important landmarks. The author also relied on past experience living and growing up in Calcutta while making observations and interpretations.

To perform the study at the city level observations were noted on paper maps. For this, the street map of Calcutta, published by Lal Chand and Sons and the map of Salt

Lake published by NATMO was utilized as a base. These maps were utilized to note the physical qualities, which contributed to the responsiveness of the two civic nodes. The responsive qualities of permeability, legibility and variety were studied in this manner. The next section discusses information that was noted on the paper maps for the assessments.

Permeability

1. The hierarchy of street system in Calcutta and Salt Lake (See Table 2) and the level of connectivity of the two civic nodes with the rest of the city.
2. The mass transit system of the City.
3. Presence of transportation nodes.

Legibility

1. Presence of landmarks within the district level
2. Presence of legible streets

Variety

1. Land-use within the district levels
2. Presence of anchors which serves as attractants for people

The street system in Calcutta can be divided into several categories to show the hierarchy of connectivity that exists for the two civic nodes. Table 2 gives a description of the identified street hierarchy system.

Table 2

Category	Description
Calcutta Main Roads	These roads are the main roads within the boundary of Calcutta that connect various parts of the city and act as important thoroughfares.
Central Calcutta Roads	These are the important roads within the Central Calcutta District. These form a network of connecting linkages for Dalhousie Square.
Connecting Roads	These roads connect the main city of Calcutta to the Salt Lake region.
Salt Lake Major Roads	These include all the major roads within the Salt Lake area that connect with the Eastern Metropolitan Bypass to increase the physical permeability of the district.
Dalhousie Roads	Internal roads within Dalhousie district.
Salt Lake Internal Roads	Internal roads within Salt Lake.
Pedestrian Routes	Internal pedestrian routes within the civic nodes.

To study robustness and sensory qualities site-specific observations were made. The following section discusses the site observations performed. Robustness has been studied in the following way.

1. Numerical counts of perimeter shops were taken at both civic nodes to indicate the activities at the interface of the buildings and the streets.
2. The human activities were noted at both civic nodes.
3. Numerical count of people sitting in the pedestrian trails at Dalhousie Square and at the plazas within the city center was taken (See Table 3). Number of people sitting within each zone was counted at three specific time periods. The first count was taken between 9AM and 11AM, the second count was taken between 11AM and 1PM and the third count was taken between 4PM and 6PM. The observations were taken on Sunday, January 15, 2006 at the Salt Lake City Center zones. The Dalhousie Square observations were recorded on Monday, January 16, 2006. The observations were taken on a Sunday for the Salt Lake City Center because this node is more active on the weekend. This is because of the presence of the mall and the Cineplex.

Table 3: Observation chart to compare number of people sitting within a site zone

Site Zone	Number of pedestrians sitting within the zone		
	9AM – 11AM	11AM-1PM	4PM-6PM
Example: Pedestrian Trail			

The sensory qualities within the two civic nodes have been studied according to the following categories:

1. Visual quality to study the sensory quality of vision.
2. Visible activities to study the sensory qualities of sound and touch.

Lynch proposed these methods in his glossary of techniques in '*Managing the Sense of a Region*' (See Appendix A).

One of the ways visual quality of a place can be assessed is by identifying the presence of landmark structures. In order to distinguish landmarks within the two civic nodes, an inventory of the existing structures was made. During the site visits photographs and video films were taken to review the place at a later date for further assessment to identify buildings with a dominating visual character. Each building within the two nodes was assessed according to the following factors.

1. Singularity
2. Identity
3. Spatial prominence
4. Contrast

Singularity and identity has been studied by distinguishing the buildings according to the historic context and use. Spatial prominence and contrast has been studied by identifying buildings with a dominating presence.

Visible activity of a place denotes human activities. During the site visits it was observed that a key element which contributing to the sensory qualities within the two civic nodes is the interaction between street hawkers and pedestrians. This is a visible activity that mostly affects the sensory qualities of sound and touch. The address of the street hawkers to passing pedestrians affects mostly the sense of hearing, or sound. During the interaction when a pedestrian stops at a hawker stall to appraise a particular item, the sensory quality of touch is affected.

To illustrate the extent of the hawker-pedestrian interaction number of hawkers in front of each building or site zone was noted. For Dalhousie Square, the space on the side walk is considered a hawker zone. It was also observed that within Dalhousie Square the buildings played a major role in the hawker-pedestrian interaction process. This is because the availability of space on the sidewalk for each building varies. Thus during observation each building within the Square is associated with a hawker zone.

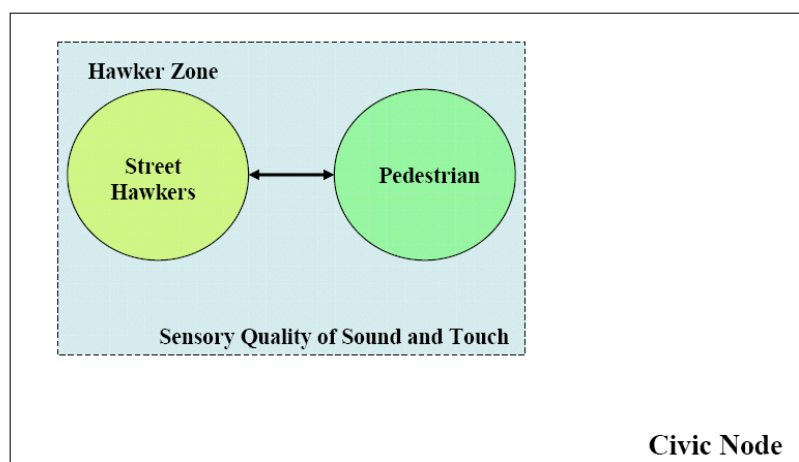


Figure 38: Hawker-Pedestrian Interaction within the Civic Nodes

Within the controlled environment of the Salt Lake City Center the number of hawkers is greatly reduced and they form stalls at open plazas and the shopping spine. The number of hawker stalls for the City Center was also noted.

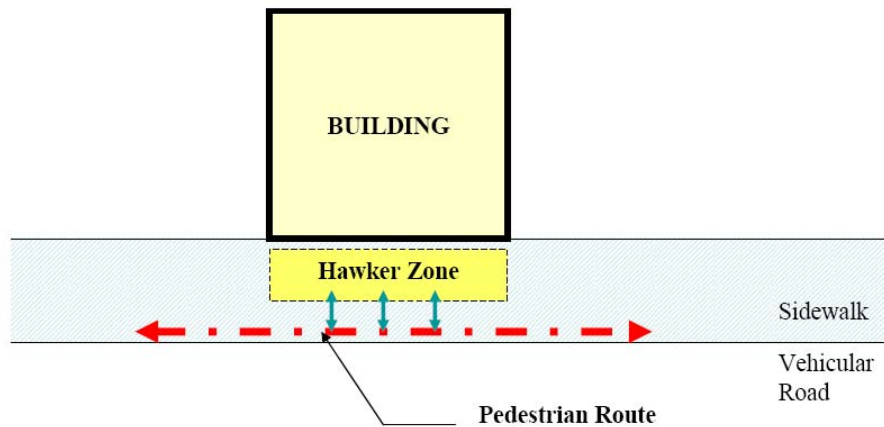


Figure 39: Hawker-Pedestrian interaction at Dalhousie Square

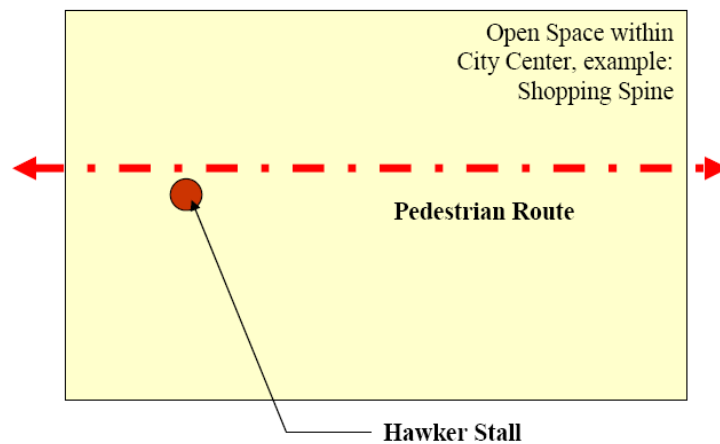


Figure 40: Hawker-Pedestrian Interaction at Salt Lake City Center

Next the number of pedestrians interacting with hawkers was noted at three specific time intervals. For Dalhousie Square the number of pedestrians interacting at each hawker zone was counted (See Figure 39). At Salt Lake City Center number of pedestrians at each hawker stall was counted (See Figure 40). The first count was taken between 9AM and 11AM in the morning to note the interaction in the early part of the day. Offices in Calcutta start functioning between 9AM and 10AM. The next count was taken between 11AM and 1PM, which coincided with the lunch hours. The last count was taken between 4PM and 6PM. The Dalhousie Square observations were performed on Tuesday, January 17, 2006, which was a weekday. The Salt Lake City Center observations were performed on Monday, January 23, 2006. January 23 was a state holiday. Since malls are more frequently visited during holidays, the observation would indicate approximate peak usage.

Table 4: Observation chart to compare pedestrian-hawker interaction at Dalhousie Square

			Number of pedestrians interacting with hawkers		
Site Zone	Adjacent Building	Number of Hawkers	9AM-10AM	11AM-1PM	4PM-6PM

Table 5: Observation chart to compare pedestrian-hawker interaction at Salt Lake City Center

			Number of pedestrians interacting with hawkers		
Hawker Stall	Location	Product	9AM-10AM	11AM-1PM	4PM-6PM

Once the on-site study and site observations were completed, the next step was to create a geodatabase populated with the acquired data. The process begins by obtaining and creating digital spatial information for the city for objects such as buildings, roads, open space, etc. The spatial objects are then used to attach observed qualities as attributes. The result of creating a geodatabase in a GIS in this study is a series of maps illustrating patterns such as connectivity, surrounding features, space usage and spatial behavior for both civic nodes. The next section discusses how the GIS data has been created and the way the observations are integrated with spatial entities of the study sites to generate the required layers of information.

Creating the GIS Data for Calcutta

The GIS software ArcGIS 9.1 by ESRI, Inc. (www.esri.com) was used to build the data for Calcutta and the two civic nodes. Appendix B explains the various components of ArcGIS and includes the standard definitions of terms pertaining to the software and relevant for this study. Figure 46 at the conclusion of this chapter summarizes the process of creating and visualizing the geodatabase for this study.

The first step in this process was to create a GIS shapefile of Calcutta. This was necessary to define the locations of the two civic nodes with respect to the city. This was also important to describe the surrounding area of the site at a regional scale to understand the approach routes and proximity levels to various infrastructures.

The Internationalizing South Asian Scholarly Data website, which is an Electronic Cultural Atlas Initiative, has made available some downloadable data for the South Asia region. This website contains GIS shapefiles for most of the Indian cities along with the metadata. ESRI also provides some data for political boundaries worldwide, and for this study the world countries geodatabase was used as the polygonal feature for India, which all other data is referenced spatially in the UTM 45 North Zone WGS 1984 projection as illustrated in Figure 41.

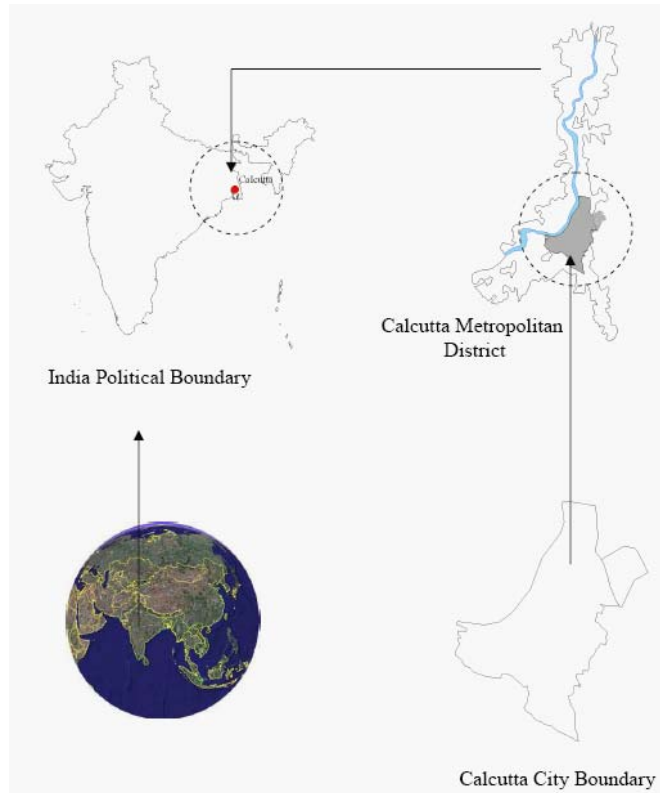


Figure 41: Creating the GIS Shapefile for Calcutta and defining its geographic location

The next step was to create the street map of the region around the two civic nodes. The street maps were digitized from paper maps using the Raster Design application by Autodesk, Inc. (www.autodesk.com). The digitized street maps were then imported to ArcGIS 9.1 as shapefiles (See Figure 42). Similarly shapefiles of the features within the Dalhousie Square area and the Salt Lake City Center were created from CAD files. The CAD map of the Dalhousie region was made available from the society of Action Research Conservation of Heritage, which is an active non-profit organization involved in conservation of Dalhousie Square. The CAD layout of the Salt Lake City Center was made available by its developer, the Bengal Ambuja Group.

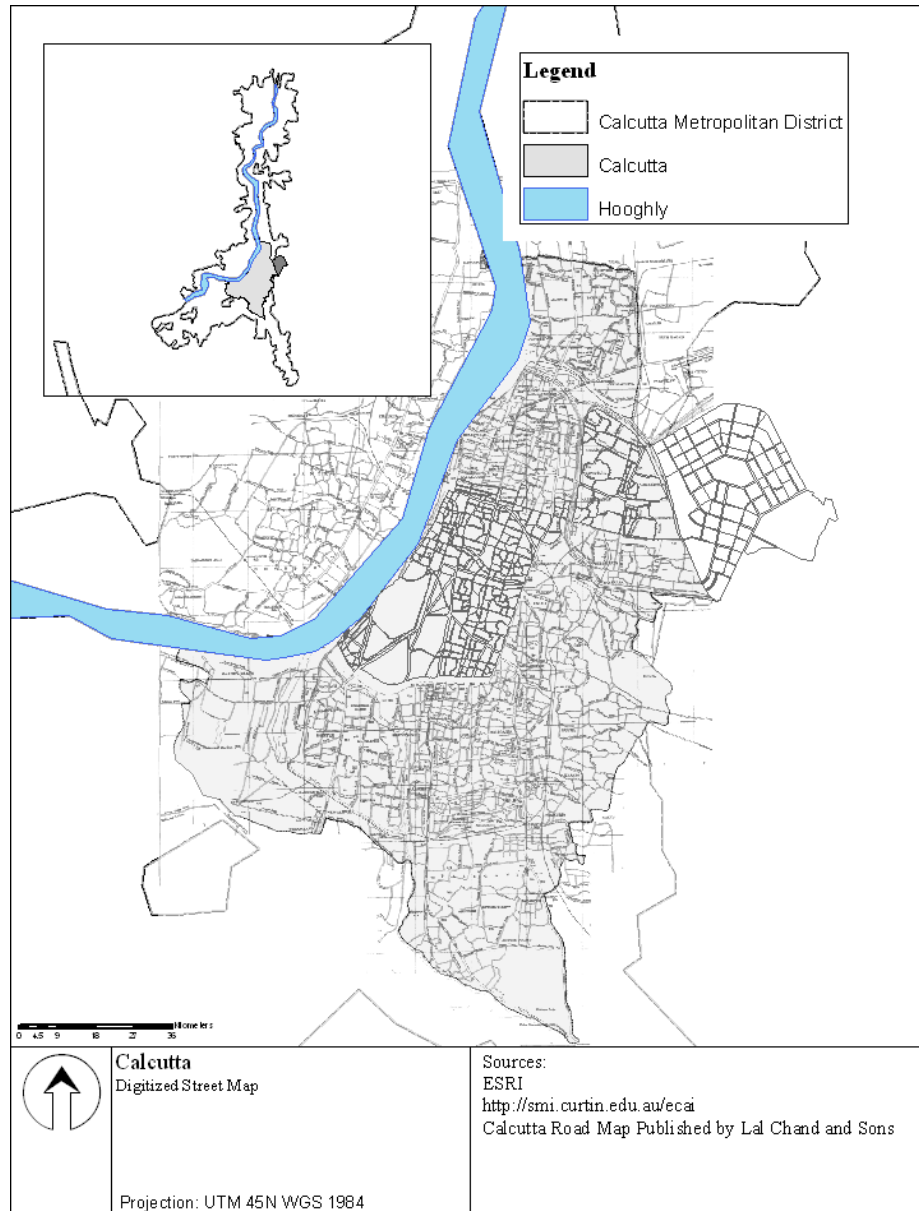


Figure 42: Digitized Street Map of Calcutta

To incorporate the data acquired during site observations into Geographic Information System, layers of information have been generated using feature classes in a personal geodatabase. In ArcGIS, a collection of geographic features with the same geometry type (such as point, line, or polygon) and the same spatial reference is known

as a feature class. Each feature class can represent a particular object or place in space (See Figure 43). For example a landmark can be represented as a point feature class, a street as a line feature class and a particular urban zone as a polygonal feature class. The complete list of feature classes has been given in Table 6.

Table 6: List of Feature Classes Created for the Study

Feature Class	Feature Geometry	Description	Source
India	Polygon	Political Boundary of India	ESRI
Cal_MetDistrict	Polygon	Calcutta Metropolitan District Boundary	http://smi.curdin.edu.au/ec/ai/
Cal_Boundary	Polygon	Calcutta City Boundary excluding Salt Lake	Calcutta Road Map
Hooghly	Polygon	The Hooghly River	http://smi.curdin.edu.au/ec/ai/
Cal_Central District	Polygon	Central Calcutta region originally developed by the British	Calcutta Road Map
Salt Lake	Polygon	The Salt Lake suburban region	Salt Lake Map
Calcutta_Roads	Line	The road network surrounding and connecting the two study sites	Calcutta Road Map Salt Lake Map
Calcutta_Masstransit	Line	Transit network including the train and subway routes	Calcutta Road Map Salt Lake Map
Calcutta_Nodes	Point	Important civic nodes	Calcutta Road Map
Calcutta_Landmarks	Point	Important landmarks within the central Calcutta and Salt Lake	Created as new feature class
Buildings	Polygon	Buildings within Dalhousie and Salt Lake City Center	Dalhousie Survey Plan, ARCH; City Center Layout, Bengal Ambuja Group
DalSquare_Zones	Polygon	Zone within the Dalhousie Square	Created as new feature class
CityCenter_Zones	Polygon	The Zones inside City Center	Created as new feature class

A number of feature classes have been used in combination to convey the extent of the responsiveness of the two civic nodes (See Figure 44). Also site observations related to the responsive and sensory qualities of the two civic nodes have been attributed to the feature classes (See Figure 45).

The feature classes are stored in a geodatabase. Geodatabase is short for geographic information database. The geodatabase is a model in ArcGIS that provides a management framework for data. ArcGIS geodatabases can recognize and represent various kinds of data such as features, rasters and tables and manage the relationship between spatial data and associated attributes or characteristics. It is important to organize data housed in geodatabase to enable management of complex relationships and allow for easy retrieval. A geodatabase also allows defining the relationship between different kinds of data. It also allows creation of new feature classes within the database. Figures 43 and 44 illustrate a framework geodatabase structure for urban studies and examples of visualization capabilities.

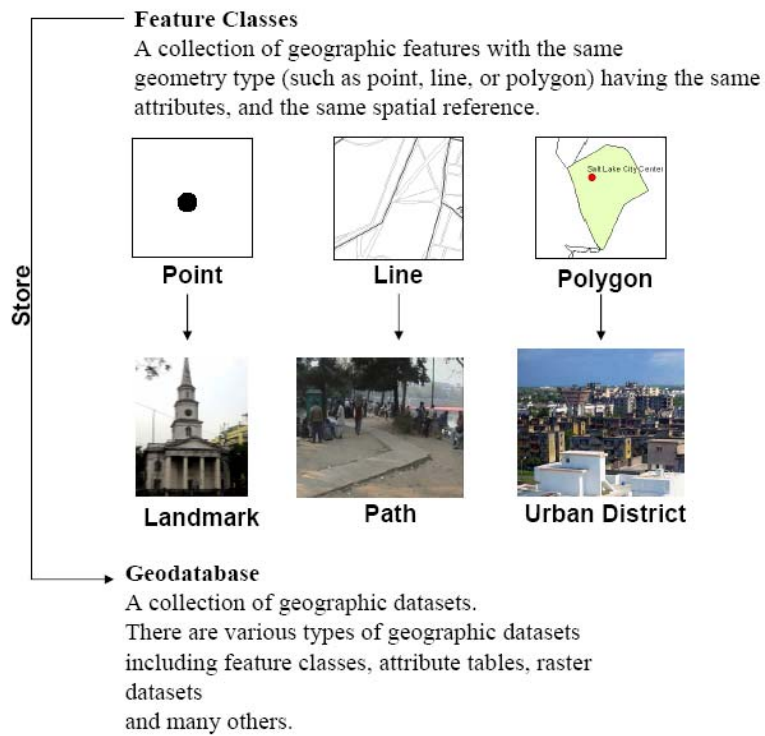


Figure 43: Diagrammatic representation of feature class and storage of feature class data

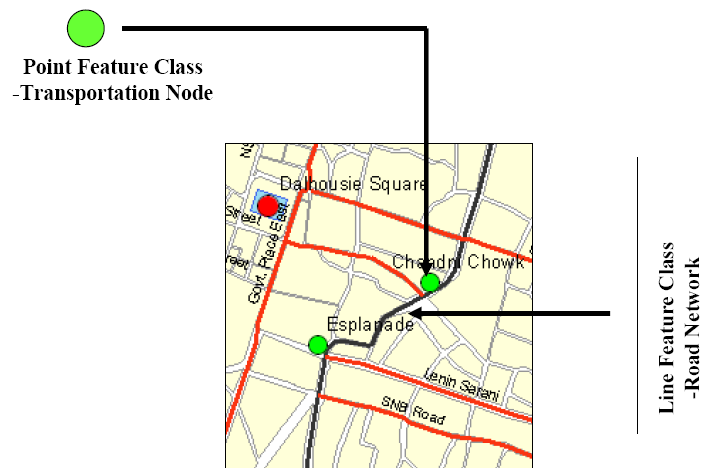
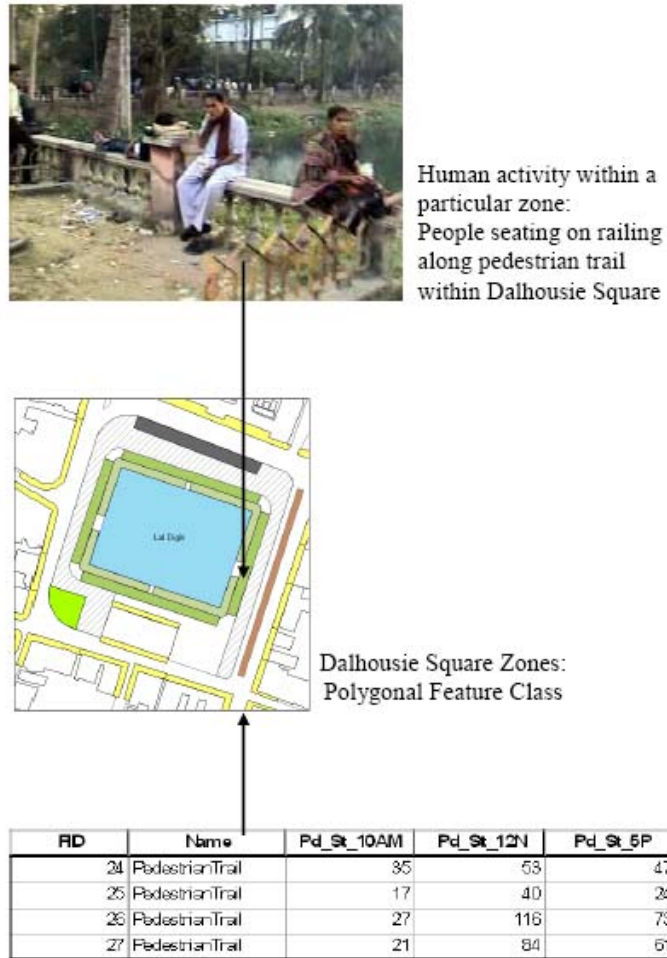


Figure 44: Combination and overlay of feature classes

Figure 44 shows an example of how one feature class is overlaid on another to show a responsive quality of the civic nodes. In this case the figure illustrates the

responsive quality of permeability of Dalhousie Square by showing proximity of transportation nodes to major road networks connecting the site.



Attribute table associated with the feature class of site zones in which site observations has been incorporated

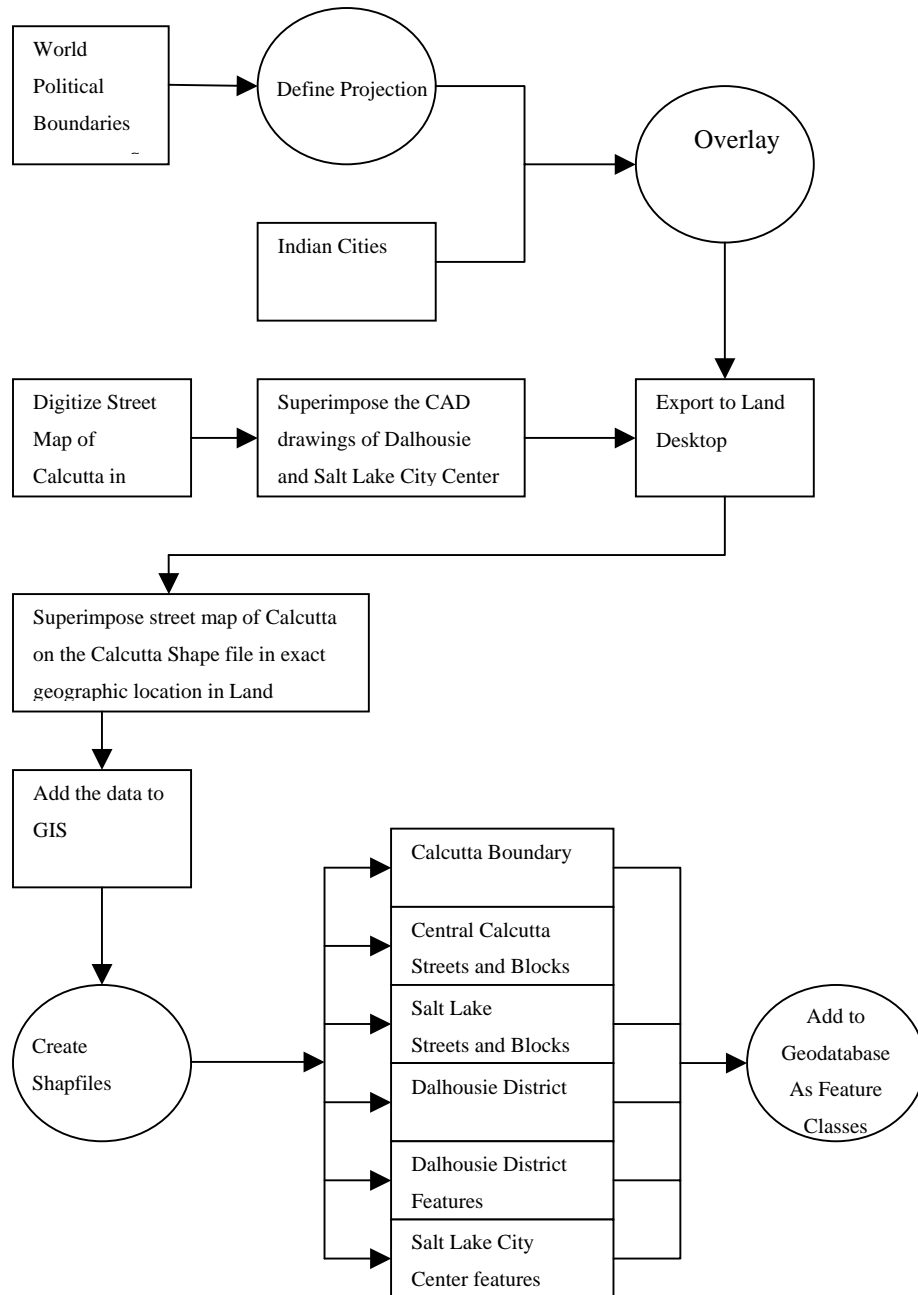
Figure 45: Attribute table associated with feature classes

Figure 45 illustrates how site observation data has been attributed to feature classes. The observations from the chart shown in Table 3 have been incorporated in the attribute table associated with the Dalhousie Square and Salt Lake City Center site zones.

In this case it illustrates the responsive quality of robustness by showing an extent of human activity within the site (pedestrians sitting in open spaces with the civic node).

Chapter 4 gives the descriptions of the civic nodes in terms of spatial information by using the above mentioned techniques of feature class overlay and incorporation of observed data as feature class attributes.

Flowchart explaining the creation of GIS data



CHAPTER 4 - RESPONSIVE AND SENSORY QUALITIES OF THE TWO CIVIC NODES

Once the geodatabase of base map features is constructed, site observations of responsive and sensory qualities can be added or connected to features in the geodatabase representing spatial objects in the city and two civic nodes. All maps explaining responsive and sensory qualities are the result of joining tabular site observations with spatial features stored as points, lines, or polygons in the geodatabase. Legend information and map symbology is automatically generated for spatial features and represents qualities based on attributes connected to the spatial features.

Permeability Study of the Two Civic Nodes

One of the factors contributing to the permeability of the civic nodes is Calcutta's road network system. The other factors include presence of mass transit system and transportation nodes. The pedestrian routes contribute to permeability of the nodes at a site level.

The major roads in Calcutta run along a north – south axis. Both the civic nodes are connected to major roads via connector roads running on east-west axis (See Figure 50). The subway system also follows a north – south axis (See Figure 51). This north-

south linear structure of the city is because the river in the west and the wetlands in the east restrict growth. The Eastern Metropolitan Bypass, which runs along the eastern fringe of Calcutta is the only major connecting route between Salt Lake and Calcutta (See Figure 50 & 51).

The region of Dalhousie Square is in close proximity to several modes of mass transit (See Figures 46-49). Central Calcutta is bounded on the western side by the Hooghly River and on the eastern side by the subway, both of which are corridors of transit. The arrangement of the city blocks permits several entry points to the district. The blocks surrounding Dalhousie Square do not follow strict geometry and is a mix of a variety of block sizes. The maze of streets increases permeability. However the streets are congested with vehicular traffic, pedestrians and hawkers. Visual permeability to Dalhousie Square occurs through the streets.



Figure 46: Hooghly River



Figure 47: Local Train



Figure 48: Tram



Figure 49: Subway

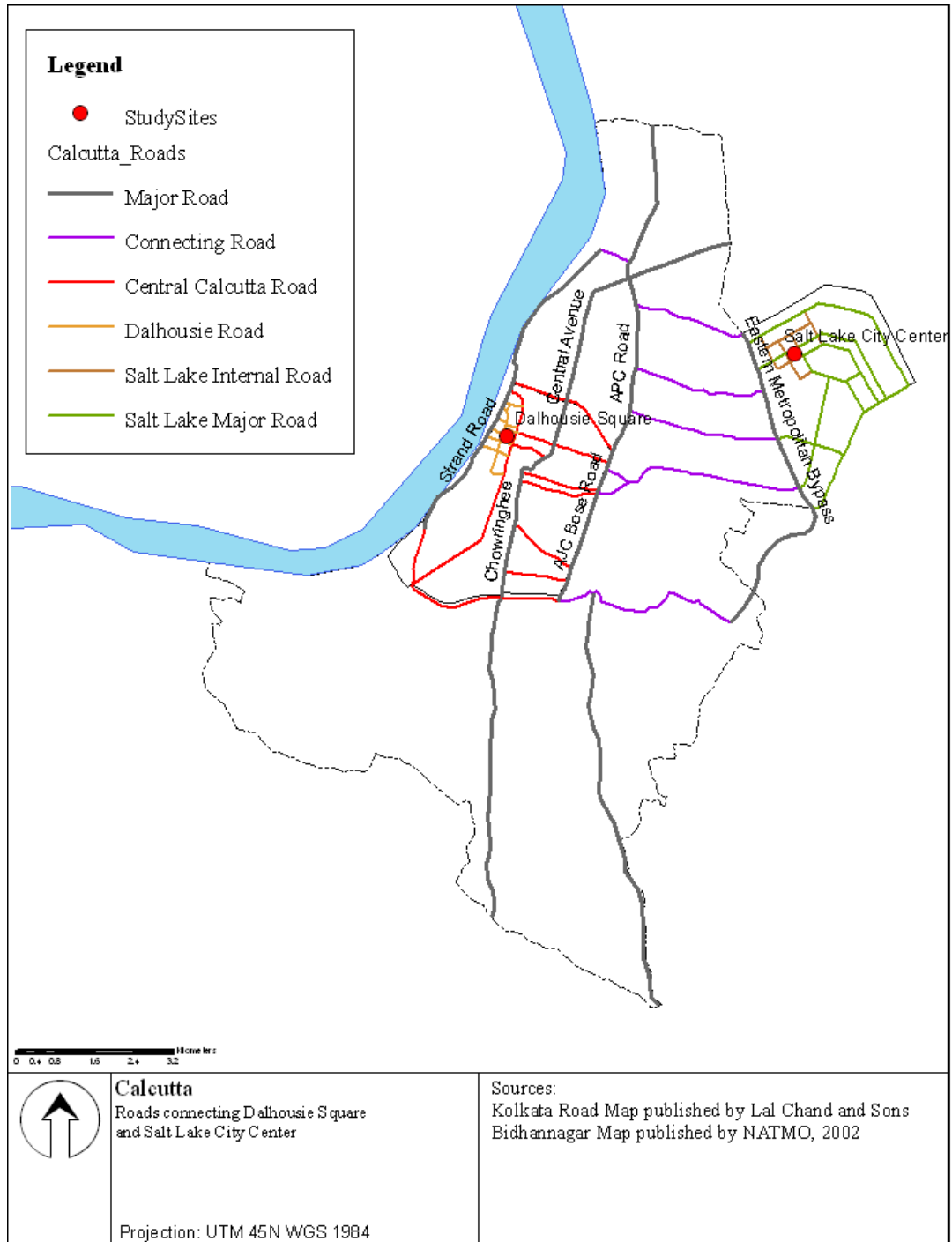


Figure 50: Roads connecting the Civic Nodes

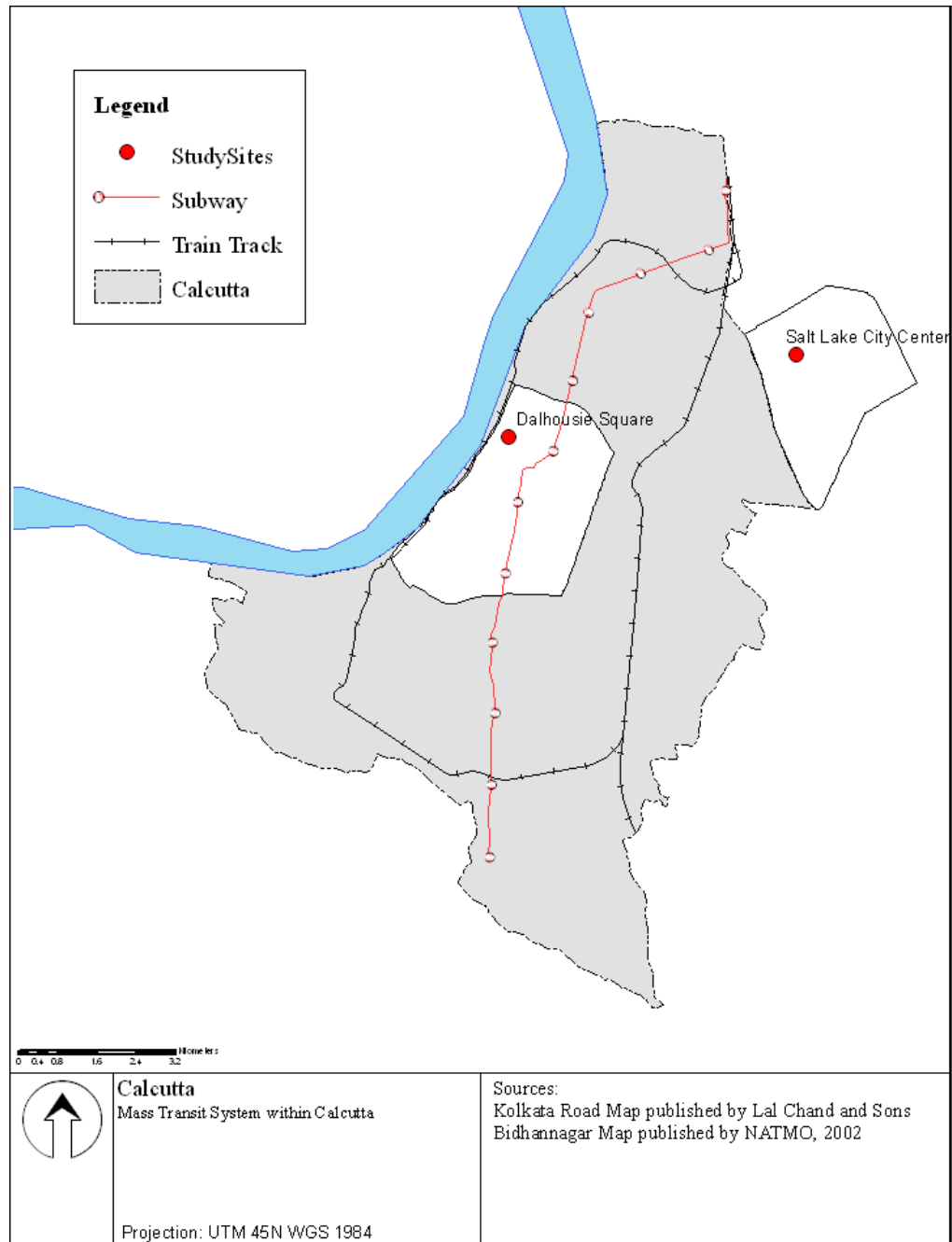


Figure 51: Mass Transit Network in Calcutta

Figure 51 shows the existing mass transit system in Calcutta in relation to the two civic nodes.



Figure 52: Transportation Nodes in Central Calcutta

Figure 52 illustrates the major transportation nodes overlaid on the road network system of Central Calcutta. The river and the subway are the transit routes. The major roads within Central Calcutta are indicated in red.

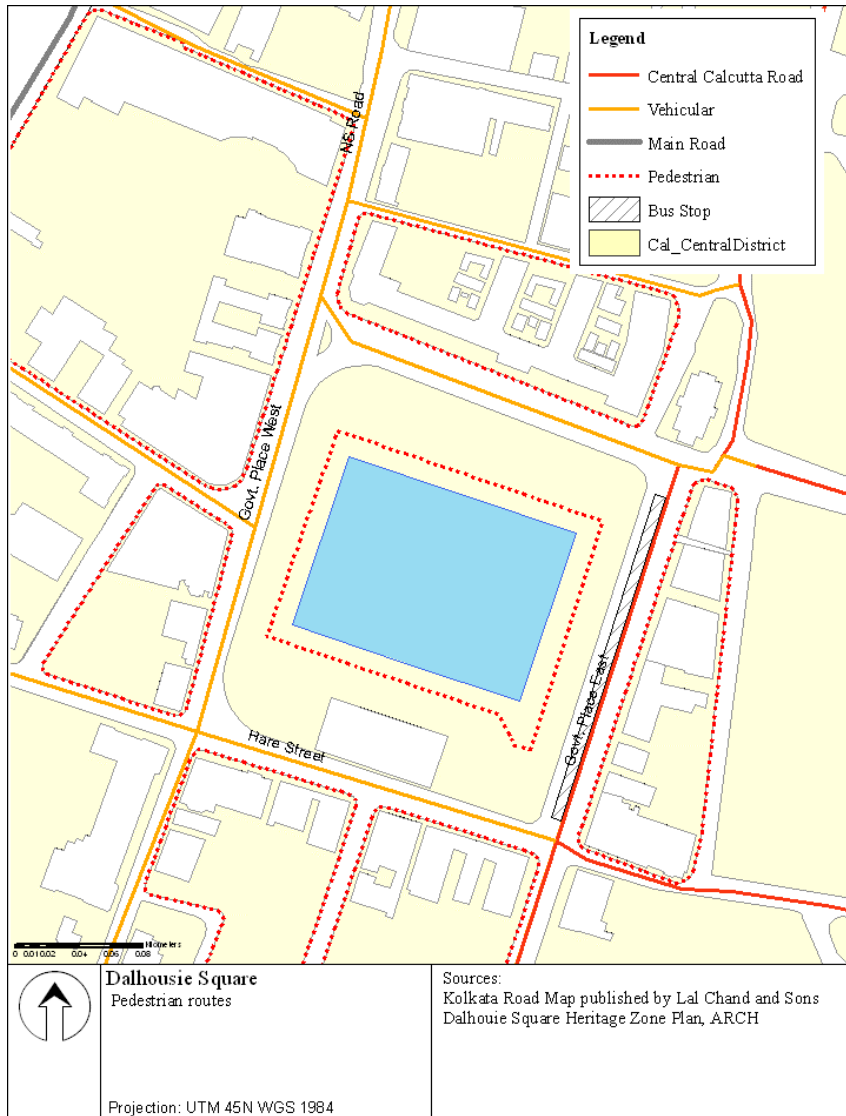


Figure 53: Pedestrian routes in Dalhousie Square

The Dalhousie Square bus terminus is the main transportation hub for the Central Calcutta region (See Figure 53). Major bus routes from the perimeter of the city terminate here. From the terminus people use the pedestrian routes to reach to their offices. Major roads such as Strand Road (See Figure 54) and Chowringhee Road (See Figure 55) are the primary bus transit routes. The roads within Central Calcutta such as Hare Street and

Government Place East and West (See Figure 53) connect to the Dalhousie Square. Pedestrians heavily use the Square during the office hours (See Figure 57).



Figure 54: Strand Road



Figure 55: Chowringhee Road



Figure 56: Intersection of Hare Street and Government Place West



Figure 57: Pedestrian street surrounding Lal Dighi

The permeability of Salt Lake City Center depends on the permeability of Salt Lake. At present the major entry points to Salt Lake from Calcutta are through the Eastern Metropolitan Bypass. People heading toward the City Center or the Sector 5 industrial district can only enter Salt Lake through five entry points on the Eastern Metropolitan Bypass (Figure 60).



Figure 58: Eastern Metropolitan Bypass

The people of south Calcutta do not have the option of train or subway. The only mode of transit is through the Bypass, which is a bus route. The city blocks of Salt Lake do not vary greatly, and the streets are linear running parallel or perpendicular to each other. Thus the choice of alternative routes has been reduced considerably within this planned district. The Salt Lake City Center is strategically located along a major route that connects the Bypass. This increases both physical and visual permeability of the place. Figure 65 shows the hierarchy of road network in Salt Lake and the connectivity of the Salt Lake City Center. The roads lack a nomenclature system. Major roads connect to the Eastern Metropolitan Bypass. Internal roads then connect to city blocks.



Figure 59: Major Road, Salt Lake

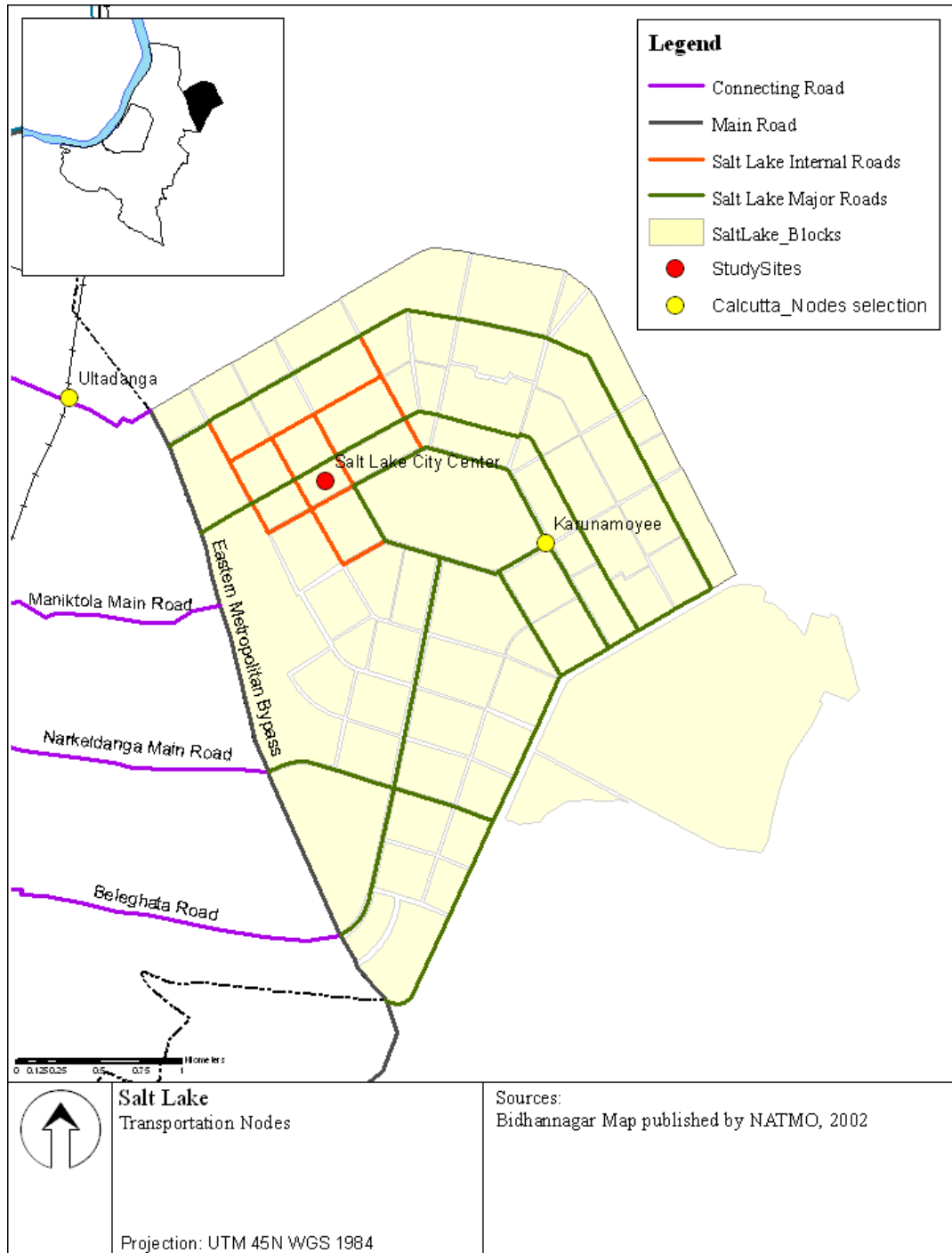


Figure 60: Transportation nodes and road network - Salt Lake

The Salt Lake City Center is connected to the Bypass by a major road. The Bypass then links with the rest of the city. However the only near-by mass transit nodes are the Ultadanga and Karunamoyee (See Figure 60).

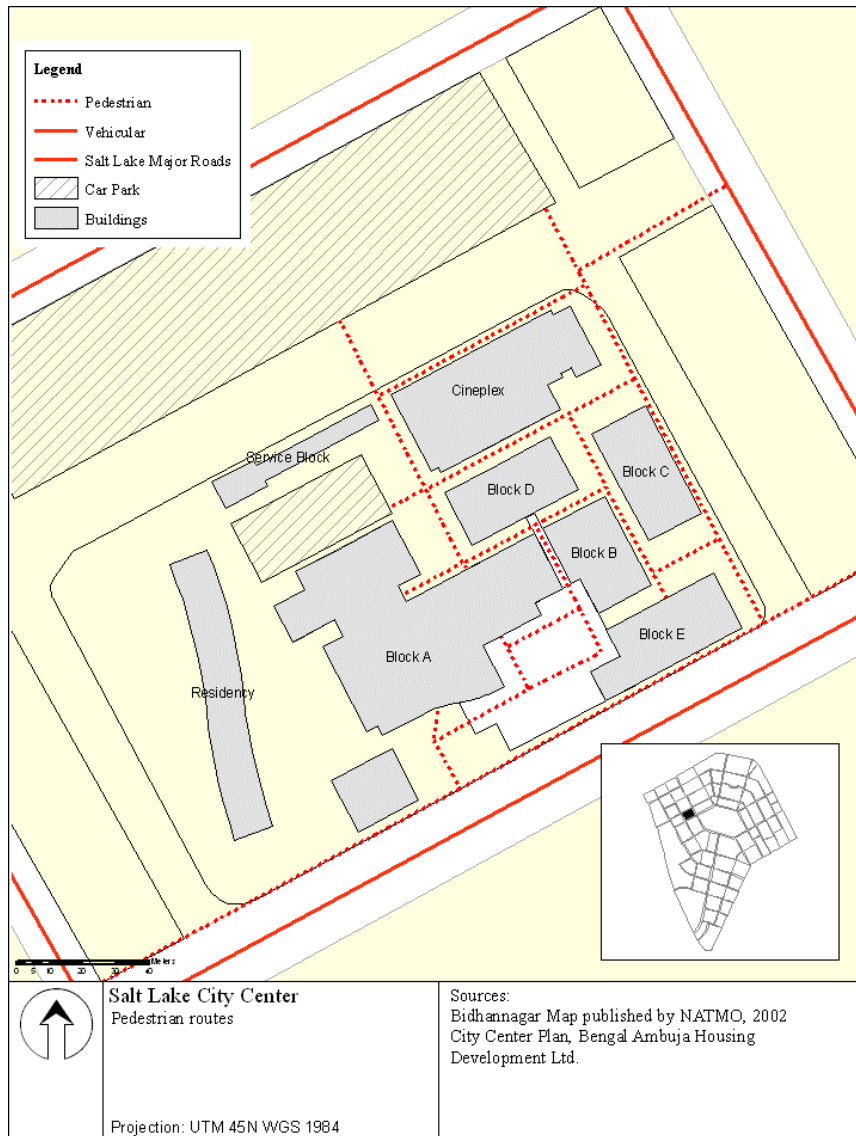


Figure 61: Pedestrian routes within Salt Lake City Center

The Salt Lake City Center site is designed as a system of pedestrian streets and building blocks. The streets form a shopping spine.

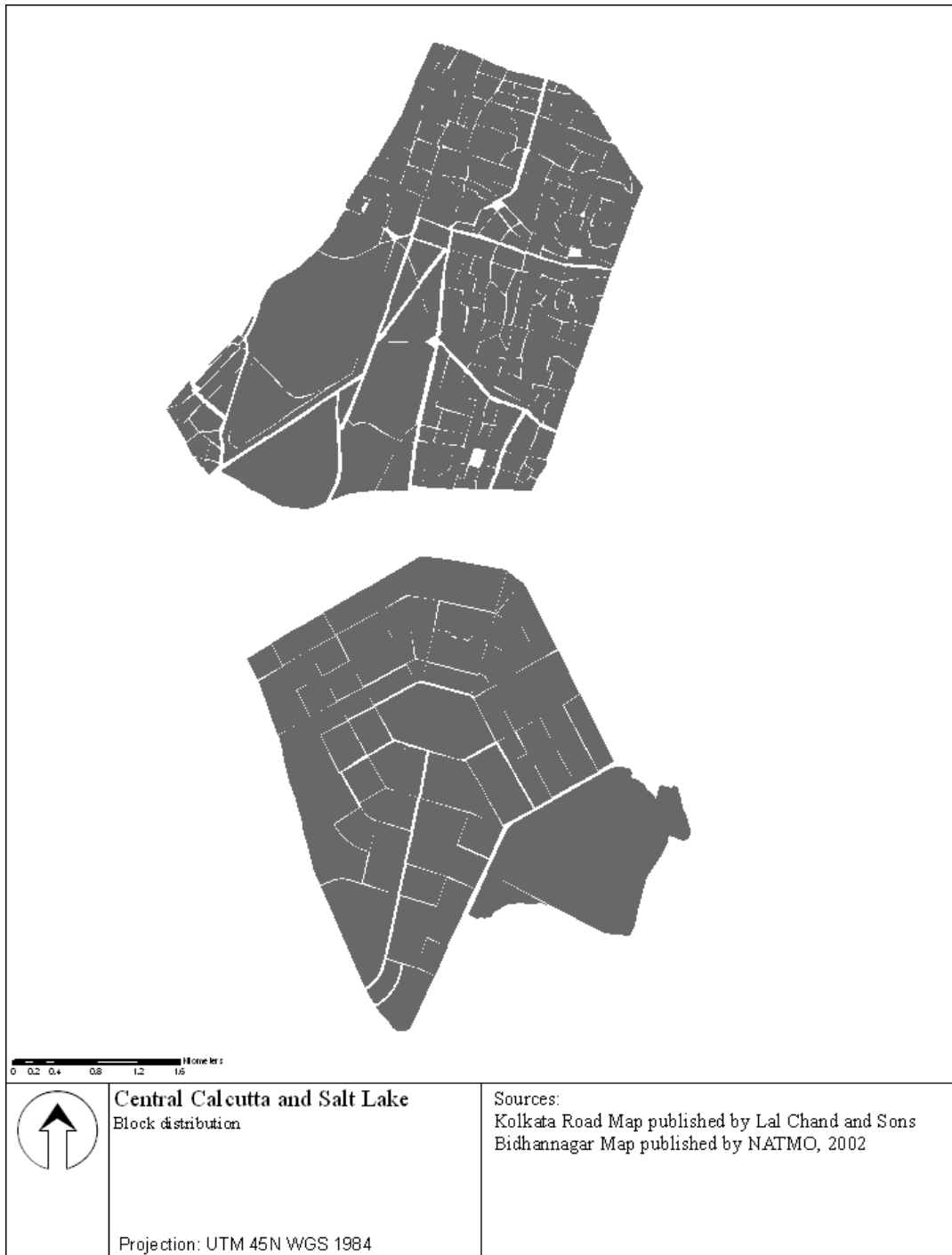


Figure 62: Block distribution within Central Calcutta and Salt Lake

Permeability also depends on the size of blocks within a district. Smaller blocks increase the choice of routes (Bentley et al. 1985). Figure 62 compares the block size and distribution of Central Calcutta and Salt Lake. The irregular block sizes and street system increase the choice of access and provides visual permeability within Central Calcutta. This factor has been greatly reduced in the planned district of Salt Lake as illustrated in Nolli-like GIS maps shown in Figure 62.

Legibility Study of the Two Civic Nodes

The area around the Dalhousie Square has a number of historic colonial buildings. These form landmarks increasing legibility (Figure 69). Many streets within Central Calcutta and the Dalhousie region form important paths. These act as connecting routes to jobs and commercial spaces. Historic buildings, shops, restaurants and even names of the streets have qualities that increase the legibility of these areas.

The blocks surrounding the legible paths of Central Calcutta can be considered as legible sub-districts. Such legible sub-districts are Esplanade, Park Street, Maidan and Dalhousie Square. All of which contribute to the legibility of the whole region, and hence Dalhousie Square (See Figure 68). Esplanade and Park Street are the main commercial hubs of Central Calcutta. Esplanade is highly legible due to the presence of numerous colonial structures such as the Indian Museum (Figure 64). The Park Street sub-district is formed by the blocks surrounding Park Street. The Maidan sub-district is comprised of open parks, planned originally by British planners as part of the European

settlement. Even today these are the only major green spaces within old Calcutta (the region excluding Salt Lake).

British planners wanted the buildings of Dalhousie Square to be viewed from the Maidan, which generated powerful vistas and images. Figure 63 shows a view of east side of Dalhousie Square during the colonial days. This is the view from the Maidan. St. Andrew's Church acts as a focal point. The Park Street sub-district has many contemporary buildings, including high-rise office towers, which act as legible landmarks (See Figure 66).



Figure 63: East Side of Dalhousie Square (1945)

(Source: <http://www.kolkataweb.com/picture/picdisplay.php?id=288>)



Figure 64: Esplanade (Indian Museum)



Figure 65: Park Street



Figure 66: View from Maidan with the Park Street sub-district buildings in the background



Figure 67: Dalhousie Square (HSBC Building)

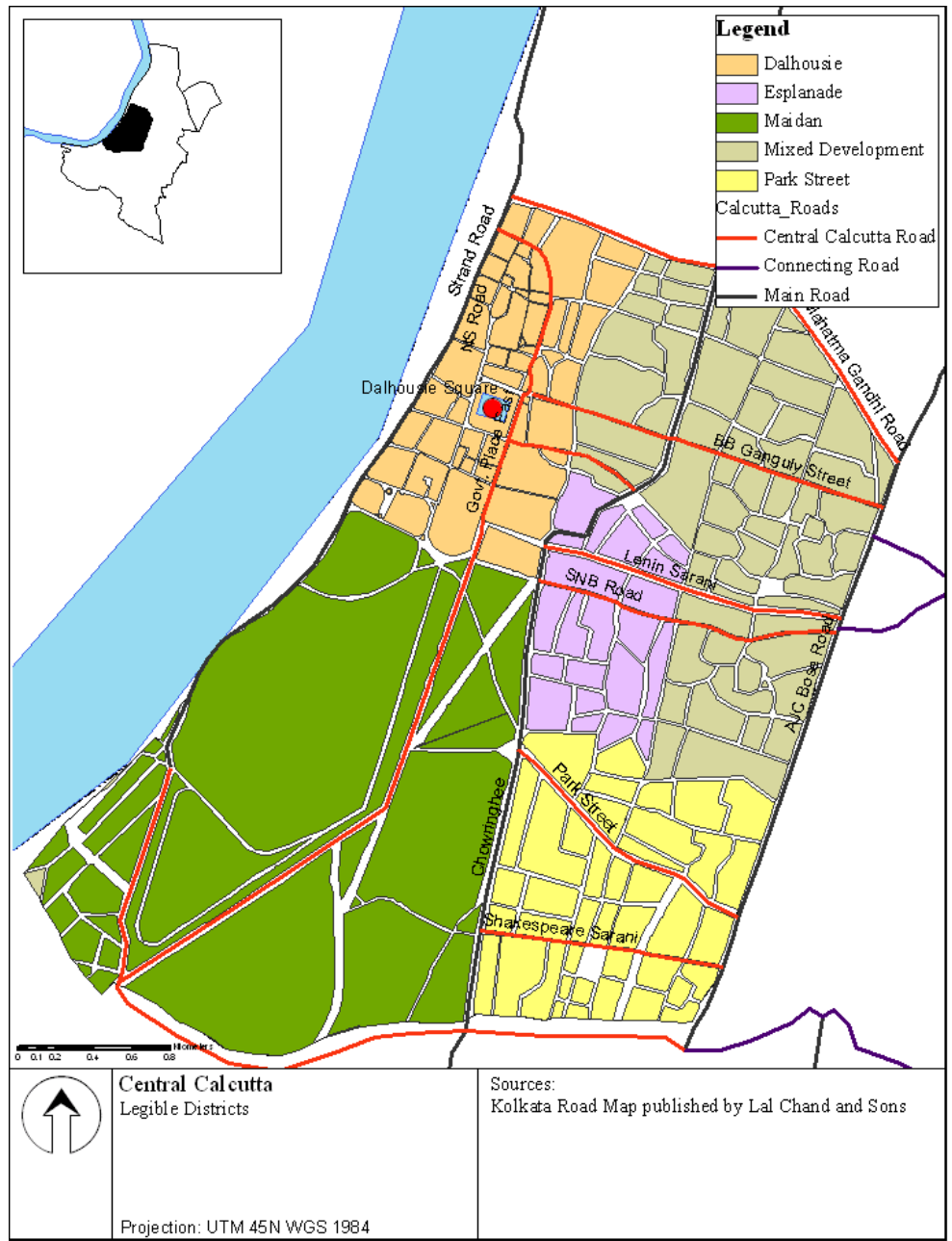


Figure 68: Legible sub-districts within Central Calcutta

Because of the legible character of the sub-districts within Central Calcutta, people traveling to Dalhousie Square through these urban areas are easily guided to their destinations.

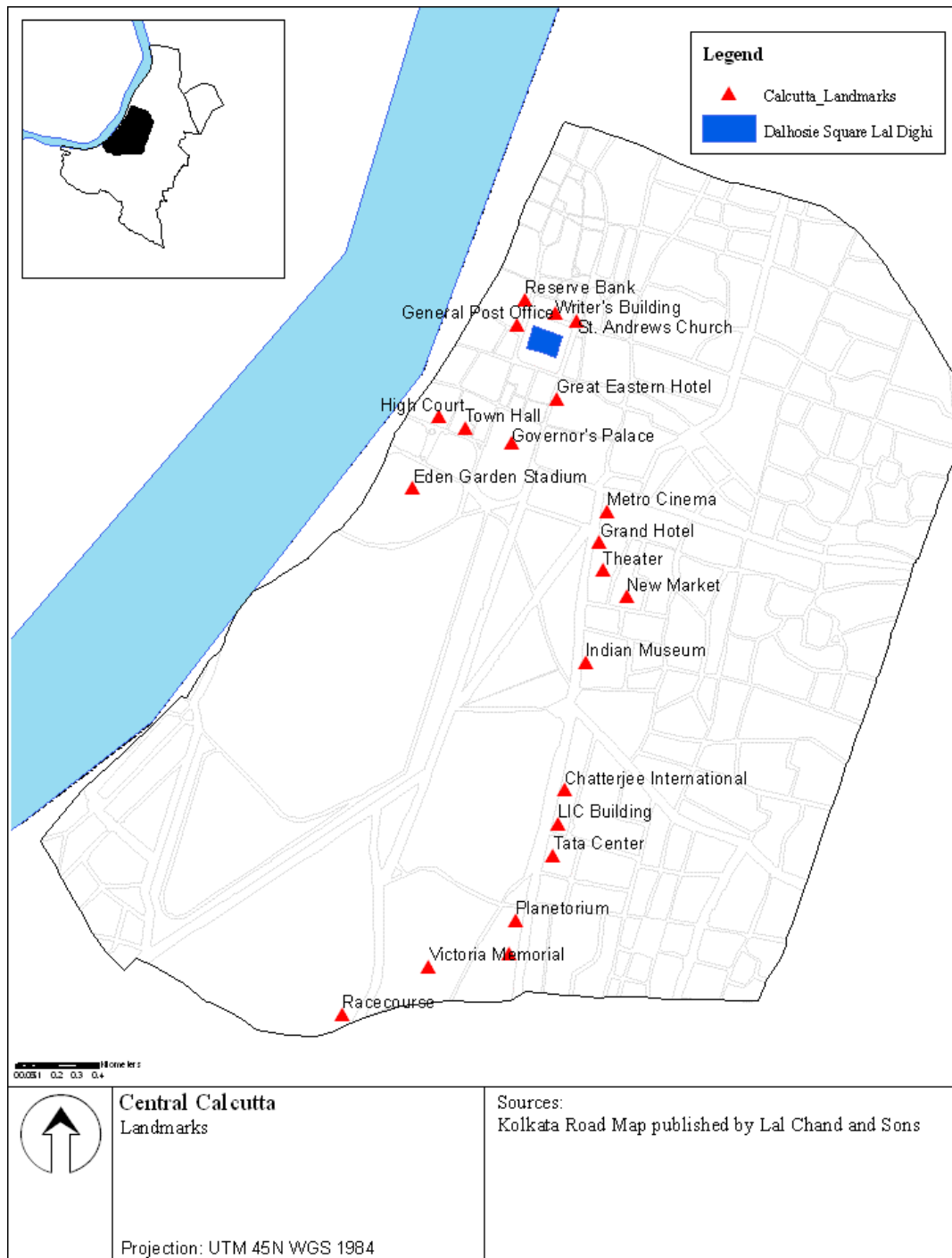


Figure 69: Important Landmarks within Central Calcutta

Lack of variety in transit systems makes the roads in Salt Lake less legible. Variety in mass transit can increase the importance of particular paths within the city. For example, the Chowringhee in Central Calcutta supports the subway as well as bus transit making it an important legible path. However, the lack of mass transit options and the streets in Salt Lake, unlike Central Calcutta, do not have any nomenclature and people identify places by blocks. A study of landmark places within Salt Lake shows that most of the blocks do not have major features, which could be easily identified and remembered (See Figure 72). People identify places by associating their location with the water tanks.

The major commercial regions, which could be considered as legible sub-districts within the Salt Lake district are the blocks surrounding Central Park and the blocks in Sector 5 (Figure 75). There are a number of important government buildings within the blocks that surround Central Park (Figure 76). The corporate buildings in Salt Lake's Sector 5 contribute as landmarks.



Figure 70: Water tanks act as landmarks in Salt Lake City blocks



Figure 71: Corporate building, Sector 5, Salt Lake

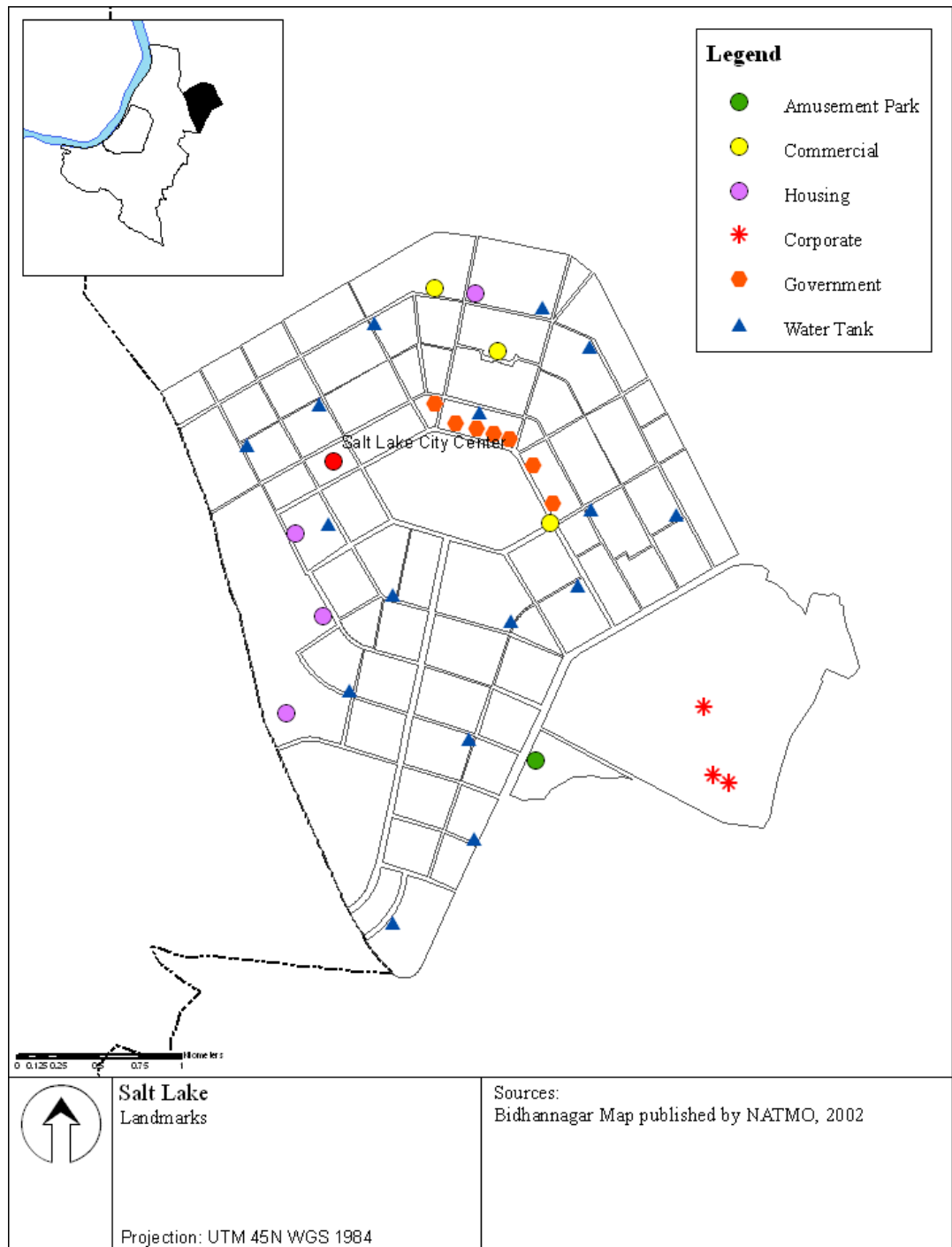


Figure 72: Important landmarks within Salt Lake

Variety Study of the Two Civic Nodes

The study of the characteristic of Variety for both the civic nodes was done at the district level. The Central Calcutta region has a wide variety of use with the numerous commercial spaces juxtaposed with residential development. There is no separation of land use because the development took place prior to the establishment of strict city zoning code. However the existence of a number of old buildings and lack of urban renewal projects from the government has limited the establishment of new uses, thus reducing variety.

Anchors, or important destinations, and the existence of pedestrian routes leading to these anchors produce variety and attract pedestrians. Independent hawkers, restaurants and small shops thrive along these pedestrian routes. This provides various opportunities for pedestrians. Within Dalhousie Square the important administrative and commercial buildings such as the Writer's Building, Governor's Palace and the General Post Office act as important destinations (Figure 74). Figure 73 shows the four major urban nodes contributing as anchors in the Central Calcutta region.

Variety within Salt Lake has been determined by the land use. Salt Lake was established as a self-sustaining community. In Salt Lake, apart from a few city blocks which are totally residential, most of development maintains a mix of commercial and residential use (See Figure 75). This mode of mixed-use planning has introduced variety within the region. The state government has also moved a number of important administrative offices from the Central Calcutta region to Salt Lake's central area. These

government offices contribute as anchors. The Salt Lake City Center being located near these anchors benefits from these anchors.

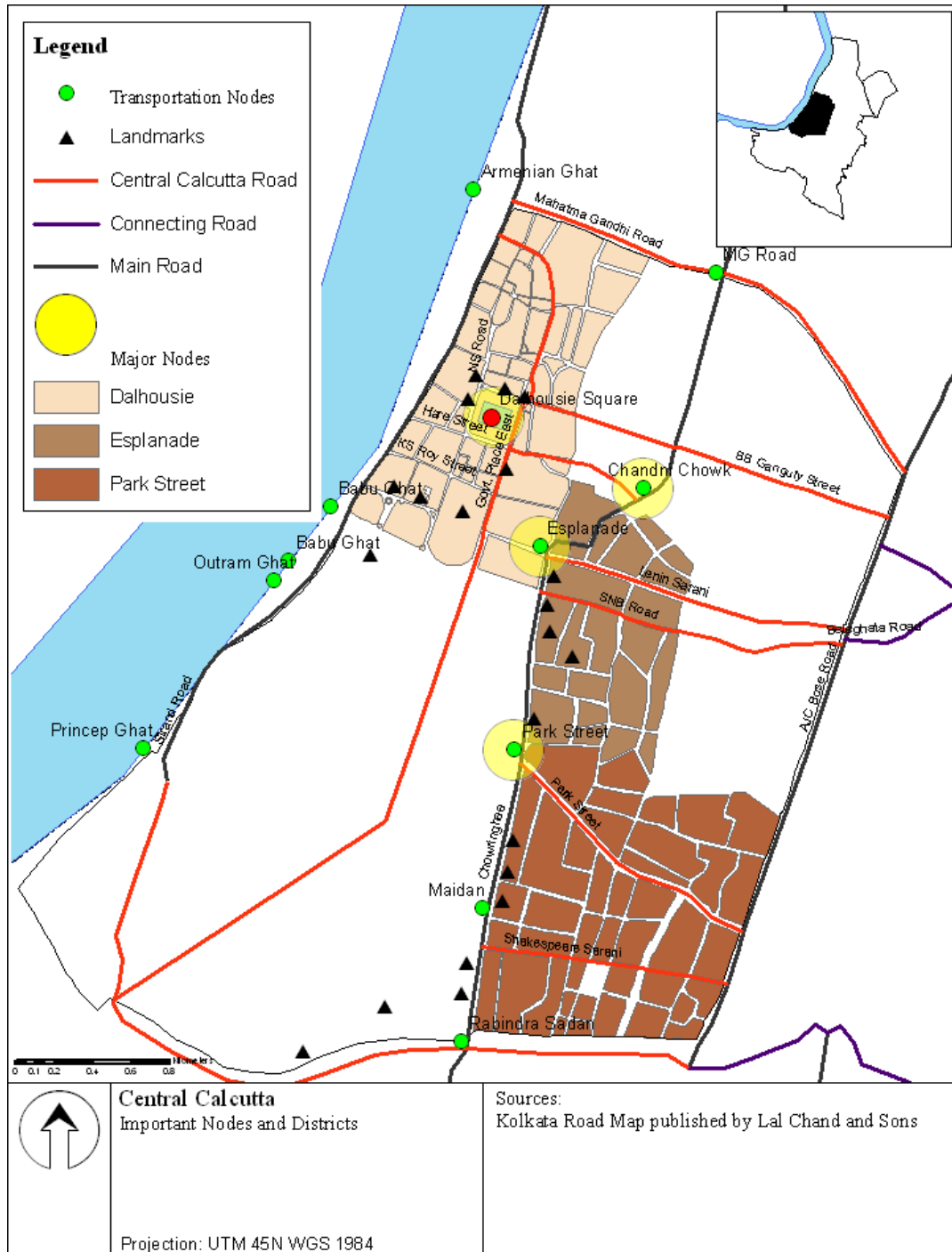


Figure 73: Commercial nodes and districts within Central Calcutta

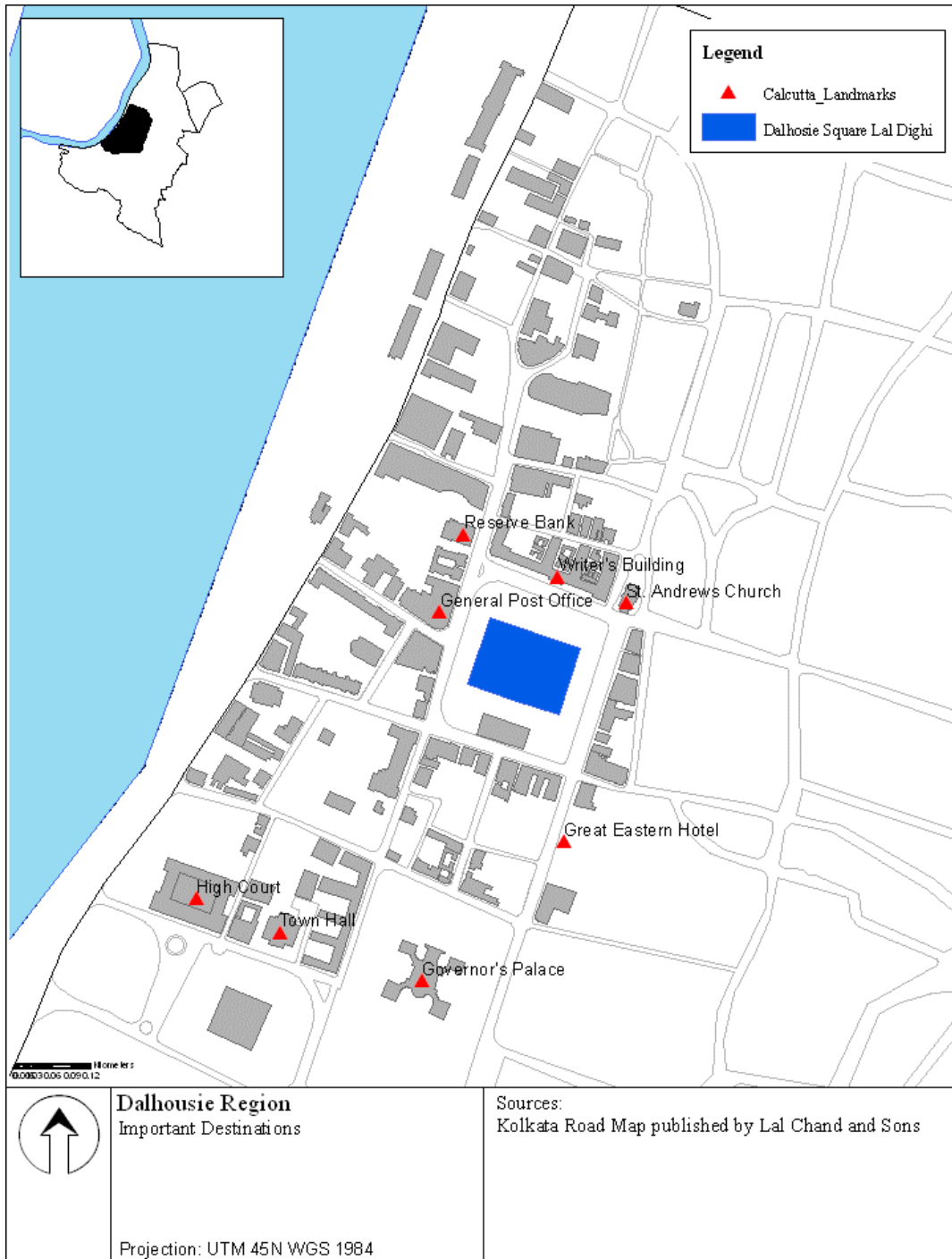


Figure 74: Important anchor buildings surrounding Dalhousie Square

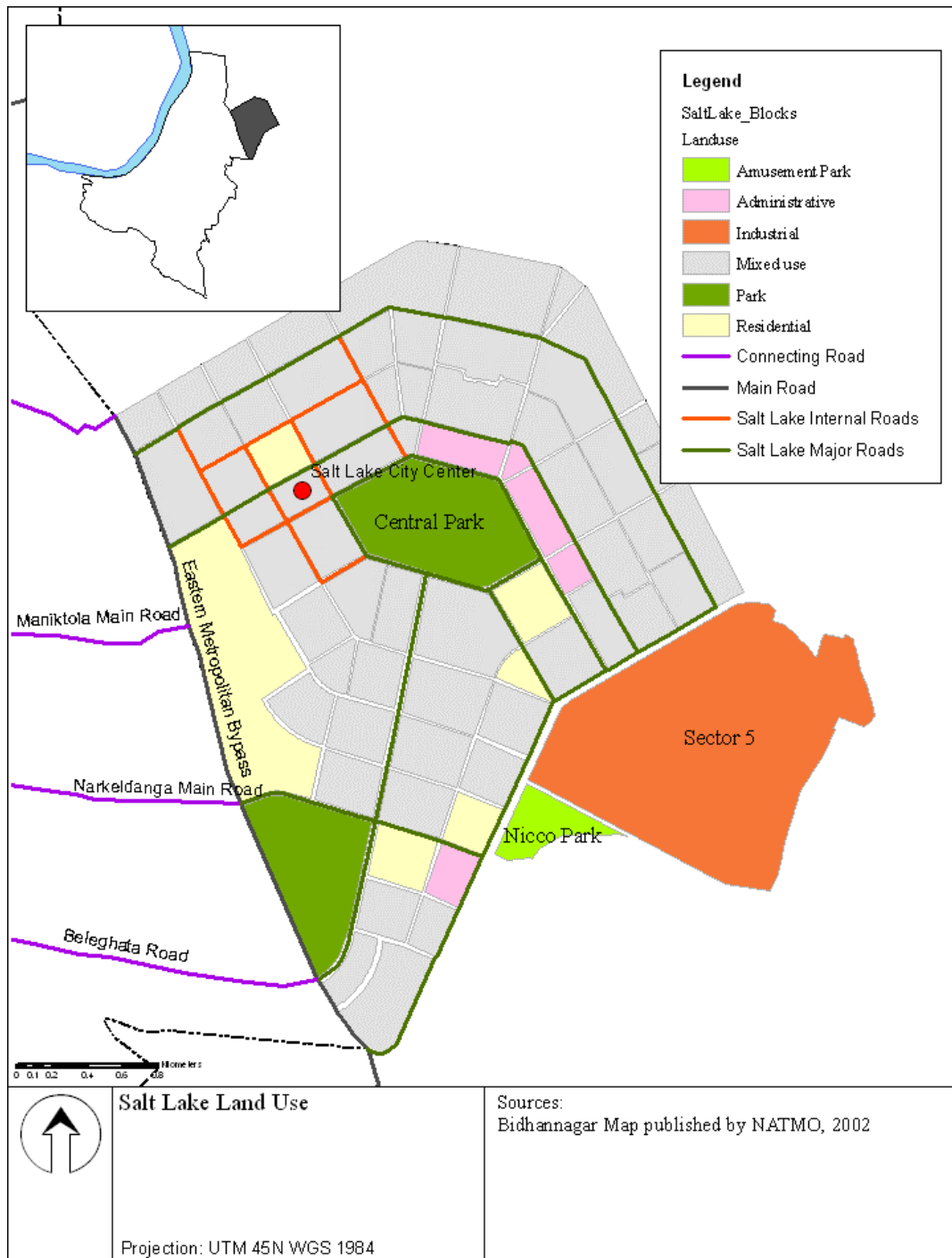


Figure 75: Land Use Plan, Salt Lake

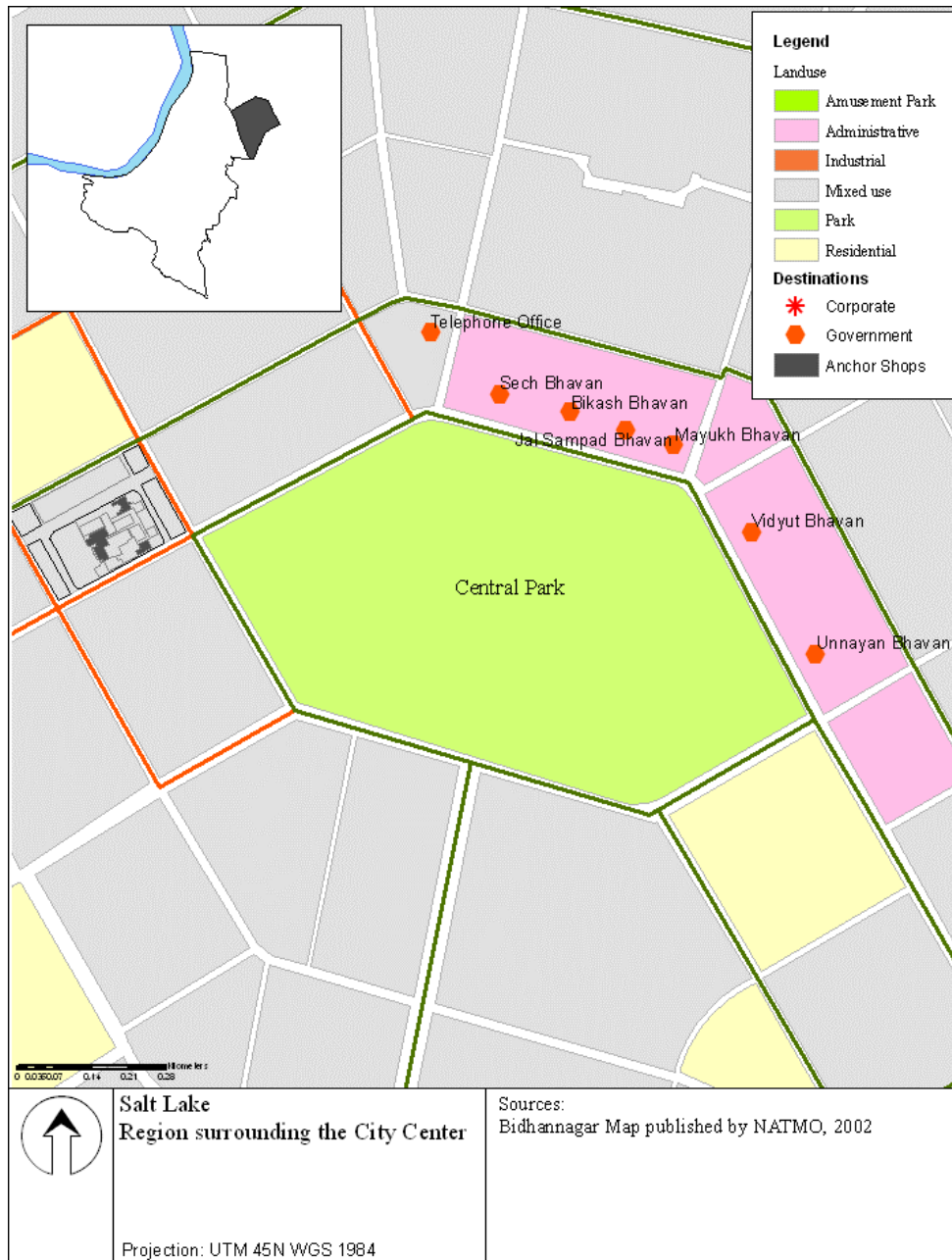


Figure 76: Major destinations near Salt Lake City Center

The administrative blocks adjacent to the City Center are in close proximity for people visiting government buildings to connect to the center. These buildings together with the existence of the City Center act as anchor for the region.

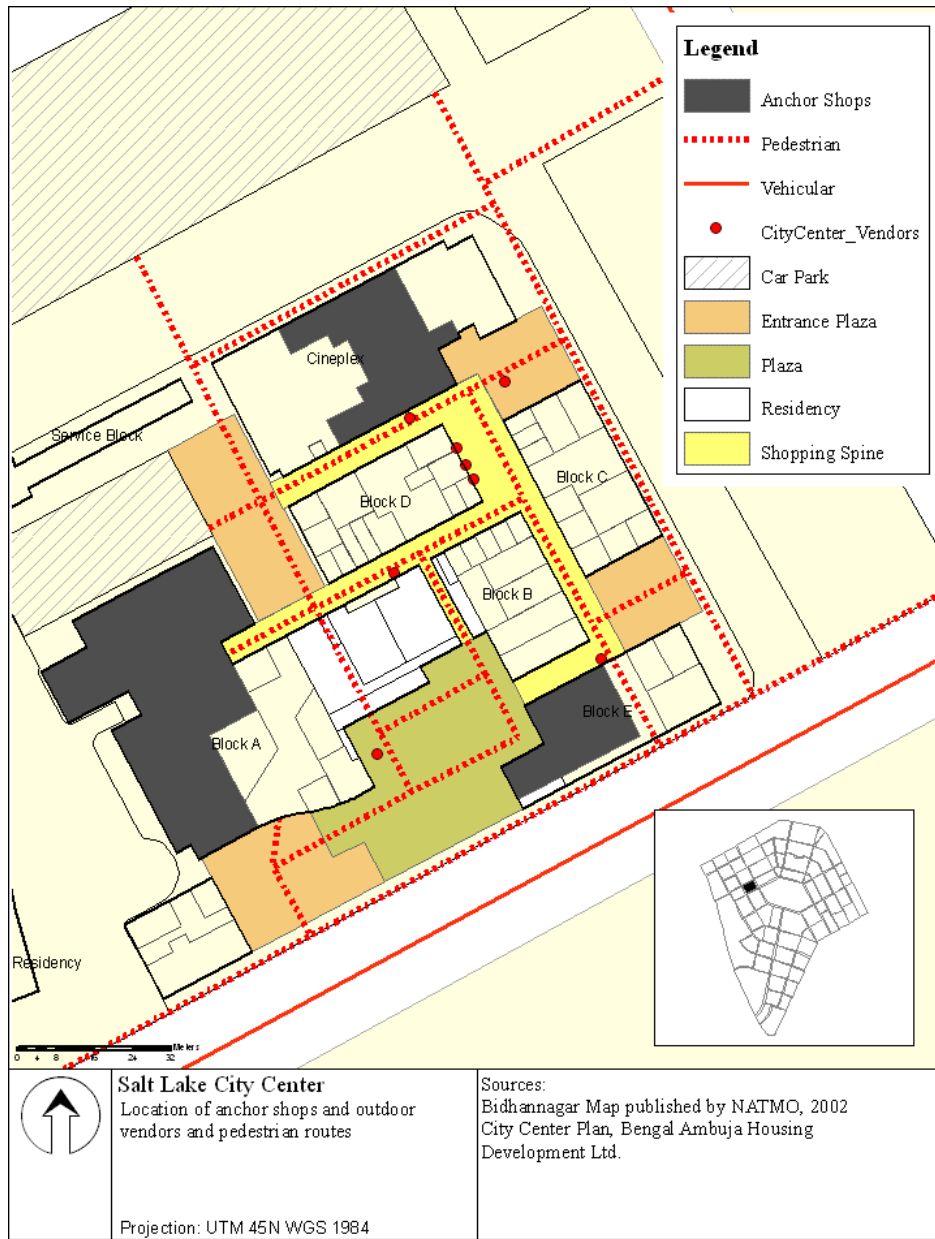


Figure 77: Anchor shops within Salt Lake City Center

The concept of anchors increasing the variety of an urban space was applied to the design of the Salt Lake City Center. Anchor shops have been strategically located to increase pedestrian movement and benefit small businesses (Figure 77).

Robustness of the Two Civic Nodes

Robust places support diverse forms of human activities, a condition, which should be true for most functioning civic nodes. The qualities that increase the robustness of a place can be studied by noting the diverse activities available at the edge of buildings. The edge of a building is the interface between the street and the enclosed spaces. Different functions at the edge mean more pedestrians can participate in different activities. Robustness can also be studied by simply noting the different forms of human activities the place supports.

Two different spatial studies show the quality of robustness within the two civic nodes. The number of perimeter shops has been counted for both the sites (See Tables 7 and 8) and have been represented spatially (See Figures 81 and 82). Dalhousie Square's east corridor has the maximum number of perimeter shops (See Figure 81). These shops along the building's edge, and the presence of hawkers on the sidewalks provide shopping opportunities to pedestrian, increasing the robustness of the place. For the Salt Lake City Center the variety of shops available at the perimeter of the mall buildings have been spatially represented (See Figure 82). The wide range of shop types provided a number of choices and also increases activities at the perimeter

Prevalent human activities have been observed for both the sites (Figures 78 and 79). The activities, which are common for the civic nodes are sitting and talking. The two activities, which are unique to Dalhousie Square are sleeping in the open, and

playing cards. This is because Dalhousie Square is a public place and supports all levels of society living in Calcutta. Shopping is the most common activity in the Salt Lake City Center. A spatial analysis of the number of people sitting in the open spaces has been analyzed for both the sites, which demonstrates spatial robustness.



Sitting



Talking



Sleeping



Eating



Playing Cards



Interaction with vendors

Figure 78: Different activities within Dalhousie Square



Sitting



Talking



Eating



Shopping

Figure 79: Different activities within Salt Lake City Center



Dalhousie Square



Salt Lake City Center

Figure 80: Perimeter shops

Table 7: Attribute table of Dalhousie Square buildings showing number of ground floor shops

FID	Name	Use	GFlr_Shops
0	General Post Office	Administrative	0
1	Royal Insurance Building	Administrative	0
2	McLeod House	Commercial	0
3	Collectorate Building	Administrative	0
4	Reserve Bank of India	Administrative	0
5	Writer's Building	Administrative	0
6	St. Andrew's Church	Religious	0
7	Dead Letter Building	Administrative	0
8	Red Cross Place	Administrative	0
9	Standard Assurance Building	Administrative	2
10	HSBC	Commercial	0
11	Telephone Office	Administrative	0
12	Ice Room	Commercial	9
13	Treasury Building	Administrative	0
14	Dalhousie East 1	Commercial	4
15	Dalhousie East 2	Commercial	4
16	Stephen's Court	Commercial	7
17	Dalhousie East 3	Commercial	3
18	Dalhousie East 5	Commercial	0
19	Dalhousie East 6	Commercial	0
20	Dalhousie East 4	Commercial	4

Table 8: Attribute table of City Center buildings showing number of ground floor shops

FID	Name	Use	GFlr_Shops
35	Block A	Commercial	10
36	Block B	Commercial	5
37	Block E	Commercial	3
38	Block C	Commercial	7
39	Cineplex	Entertainment	1
40	Block A	Commercial	1
41	Block D	Commercial	9
42	Service Block	Services	0
43	Residency	Residential	0

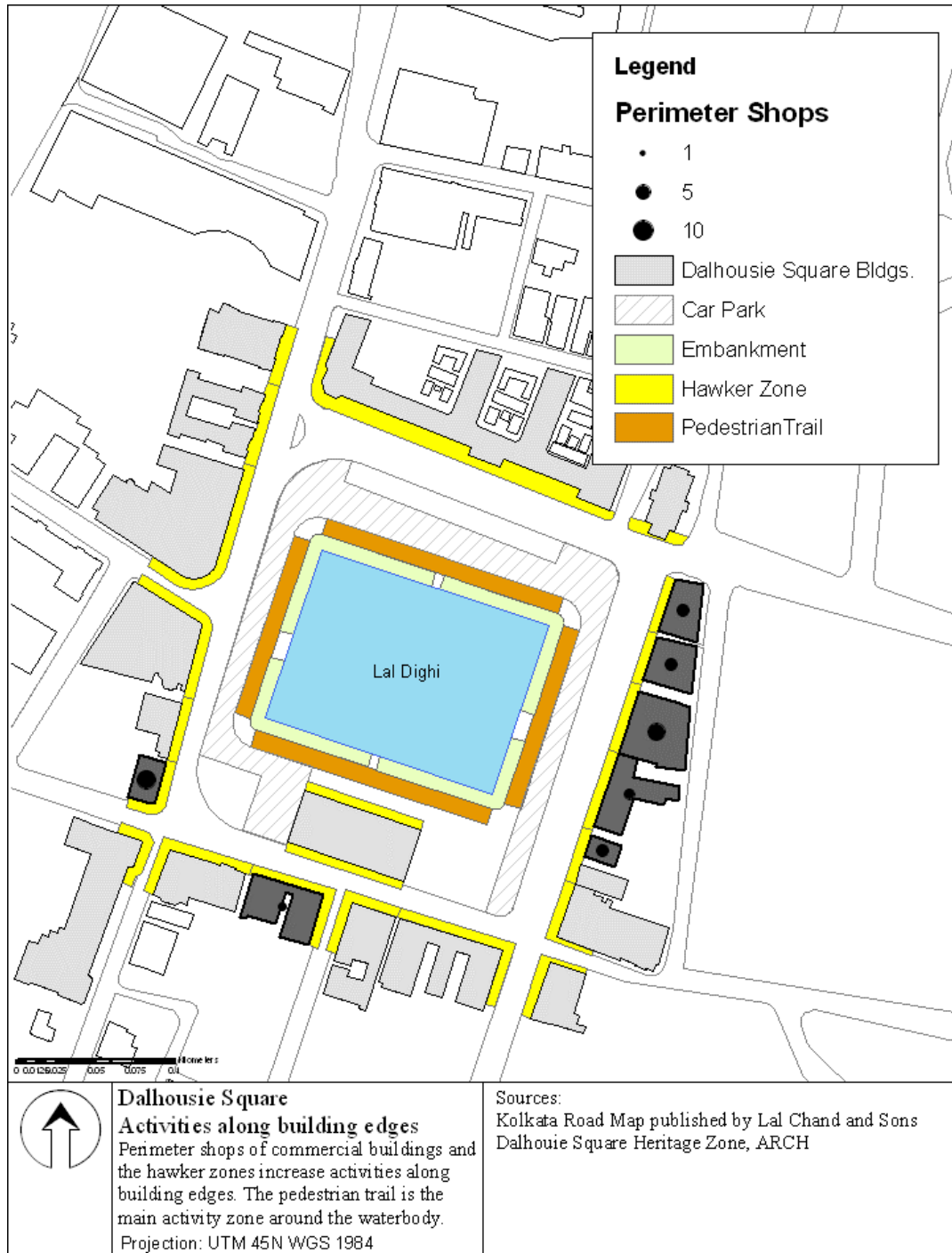


Figure 81: Buildings with perimeter shops, Dalhousie Square

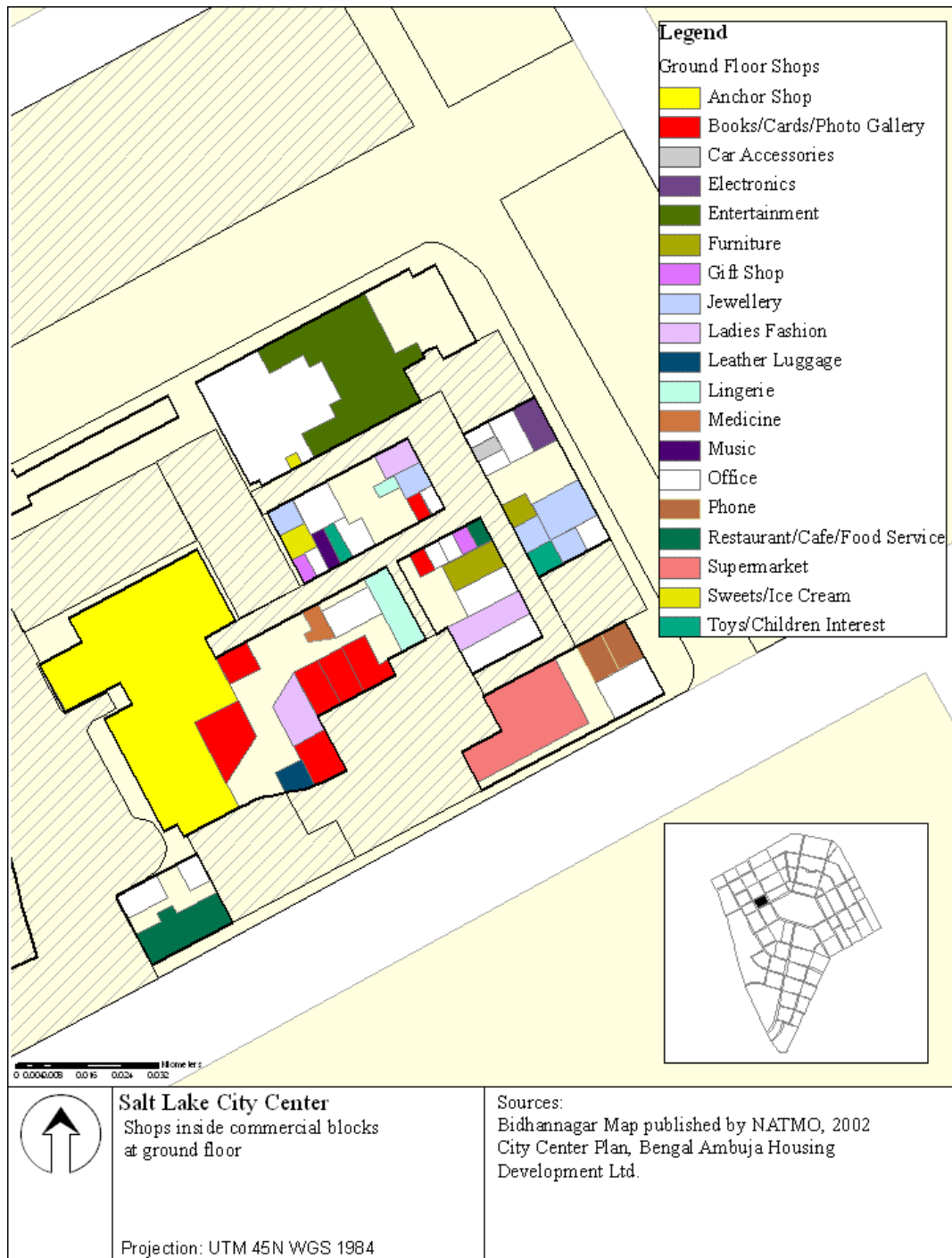


Figure 82: Ground floor shops, Salt Lake City Center

Demonstration of Spatial Analysis to Compare Number of People Sitting in Open Spaces

This section illustrates the spatial representation of a human activity (sitting) in the open spaces of the two civic nodes. Tables 9 and 10 are the attribute tables for the site zones. Pd_St indicates people sitting. The mean of the observation time periods are suffixed to this. Number of people sitting within each zone was counted at three specific time periods (See Table 3). These observations were then spatially represented showing the daily variation in usage (See Figures 83 and 84).

Table 9: Comparison of number of people sitting in pedestrian trail zone, Dalhousie Square

RD	Name	Pd_St_10AM	Pd_St_12N	Pd_St_5P
24	PedestrianTrail	35	53	47
25	PedestrianTrail	17	40	24
26	PedestrianTrail	27	116	73
27	PedestrianTrail	21	84	61

Table 10: Comparison of number of people sitting in open spaces, Salt Lake City Center

RD	Name	Pd_St_10AM	Pd_St_12N	Pd_St_5P
18	Entrance Plaza	0	0	0
19	Entrance Plaza	10	11	12
20	Entrance Plaza	0	0	0
21	Entrance Plaza	1	4	18
22	Shopping Spine	6	9	20
23	Plaza	9	35	94

A large number of people use the railings surrounding the Lal Dighi in Dalhousie Square as sitting area. This sitting area is within the pedestrian trail zones. The

illustration in figure 83 indicates that the peak usage time of this sitting area in Dalhousie Square is between 11AM and 1PM. Also the south pedestrian trail is the most heavily used one.

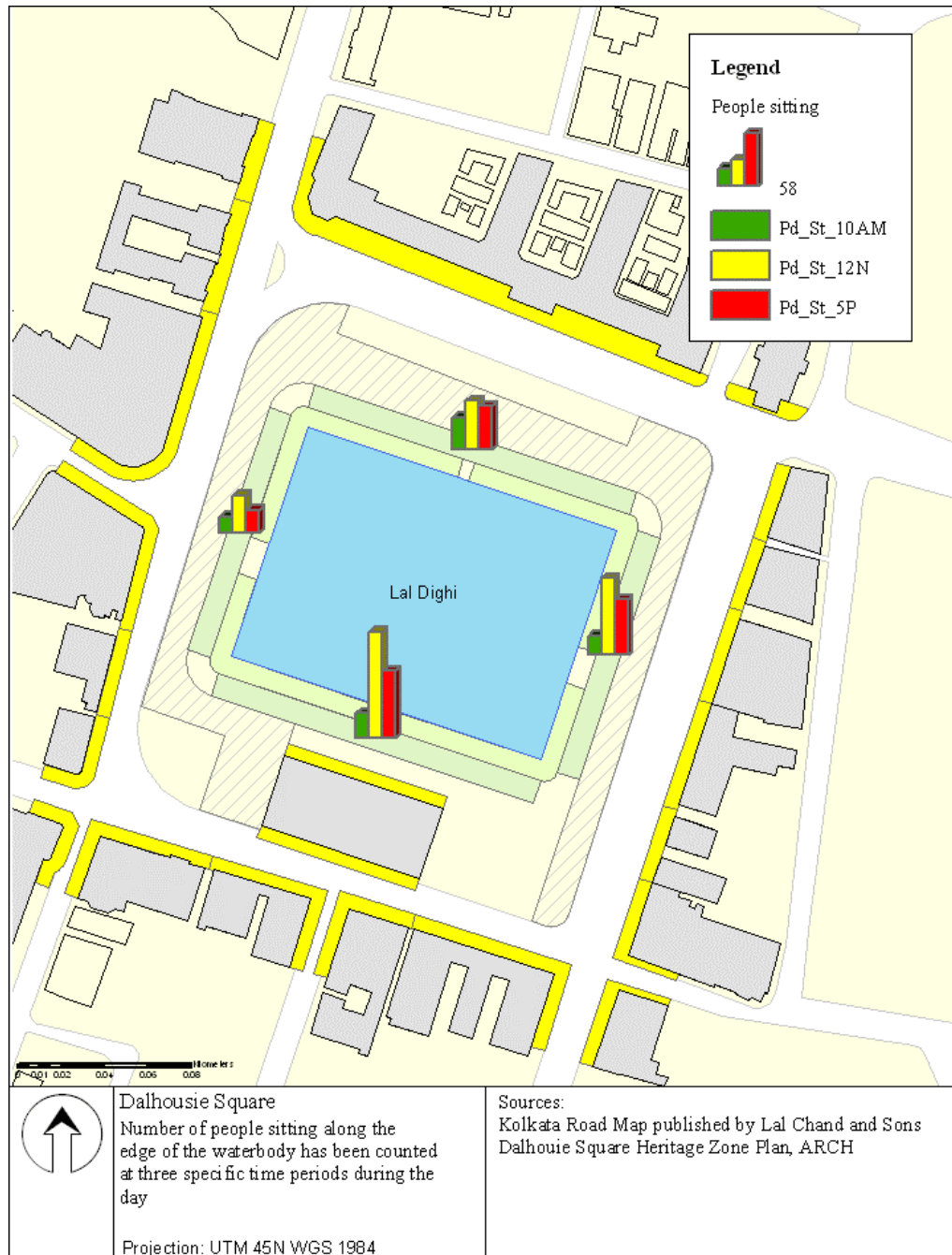


Figure 83: Number of people sitting inside pedestrian trail zones, Dalhousie Square

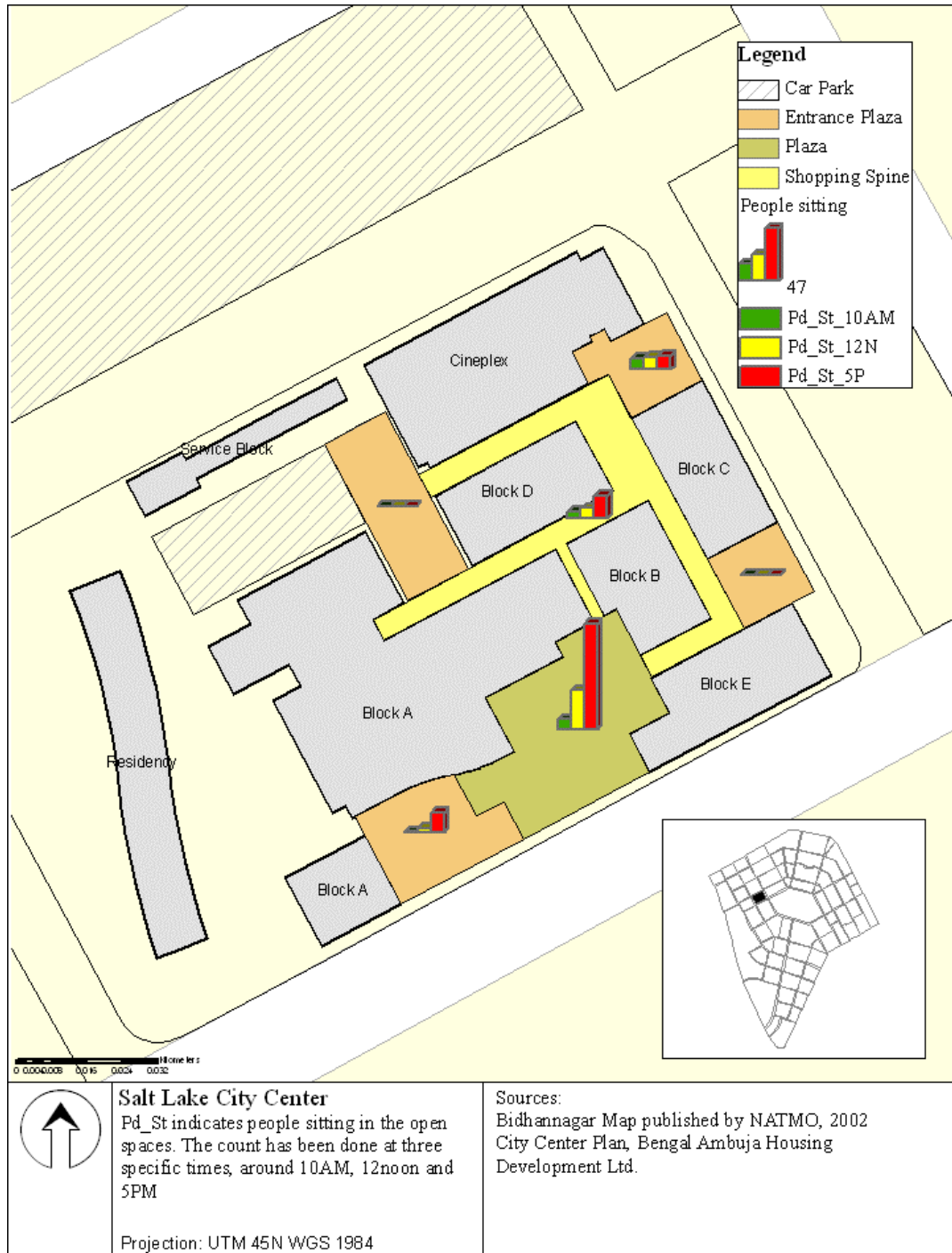


Figure 84: Number of people sitting in Salt Lake City Center plazas and open spaces

In the Salt Lake City Center the observations of people sitting in open spaces were done in the entrance plazas, the shopping spine and the main plaza. Figure 84 illustrates the graphical representation of the observations. The main plaza is most heavily used for the purpose of sitting. The peak usage for this node is in the evenings between 4 PM and 6 PM.

Sensory Qualities of the Two Civic Nodes

The sensory quality of vision within the two civic nodes has been studied by identifying visual landmarks. The sensory quality of sound and touch has been studied by illustrating the hawker-pedestrian interaction process in the nodes. Buildings having distinguishing characteristics were identified as landmarks for Dalhousie Square. These characteristics were attributed to the buildings feature class. Table 11 shows the attributes of the Dalhousie Square buildings classified according to use and history.

The Reserve Bank of India and the Telephone Office are post-colonial buildings and both have a dominating view within the Square and from a distance making them easily distinguishable iconic landmarks. The General Post Office and Stephen's Court also have a dominating presence from a distance and act as landmarks. The St. Andrew's Church, the only religious structure, also acts as a landmark. Figure 85 illustrates the buildings of Dalhousie Square according to three categories, history, use and dominating presence. The inventory of the buildings and their locations within the square is illustrated in Figure 29.

Table 11: Attribute table of Dalhousie Square buildings showing building use and history

FID	Name	Use	History
14	General Post Office	Administrative	Colonial
15	Royal Insurance Building	Administrative	Colonial
16	McLeod House	Commercial	Colonial
17	Collectorate Building	Administrative	Colonial
18	Reserve Bank of India	Administrative	Post-Colonial
19	Writer's Building	Administrative	Colonial
20	St. Andrews Church	Religious	Colonial
21	Dead Letter Building	Administrative	Colonial
22	Red Cross Place	Administrative	Colonial
23	Standard Assurance Building	Administrative	Colonial
24	HSEB	Commercial	Colonial
25	Telephone Office	Administrative	Post-Colonial
26	Ice Room	Commercial	Colonial
27	Treasury Building	Administrative	Colonial
28	Dalhousie East 1	Commercial	Colonial
29	Dalhousie East 2	Commercial	Colonial
30	Stephen's Court	Commercial	Colonial
31	Dalhousie East 3	Commercial	Colonial
32	Dalhousie East 5	Commercial	Colonial
33	Dalhousie East 6	Commercial	Colonial
34	Dalhousie East 4	Commercial	Colonial
151	Currency Building	Administrative	Colonial

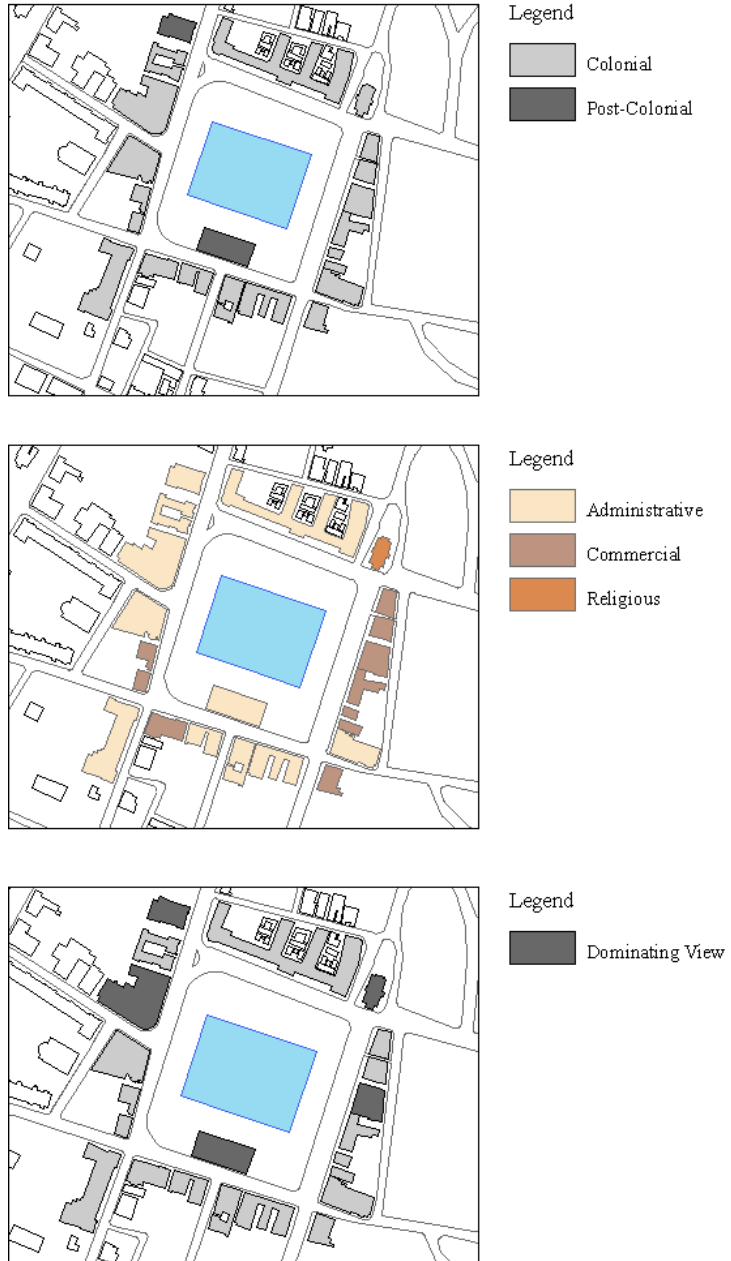


Figure 85: Landmarks within Dalhousie Square



St. Andrew's Church



Reserve Bank of India



General Post Office



Telephone Office



Stephen's Court



Writer's Building

Figure 86: Images of identified visual landmarks, Dalhousie Square

Within the City Center the sense of vision is affected by:

1. The Buildings
2. The features introduced within the site.

The buildings can be categorized by their use. For instance Cineplex is a distinguished building, which serves as a landmark because of its unique use and location. The advertisement signage on the buildings attracts attention. Of all the buildings, the office tower of Block A and the residential building have a dominating view and can be seen from a distance. These act as distant landmarks.

Correa introduced site features to serve as focal points of interest and as visual elements. These elements have been recorded on the map. The main visual elements that have been identified can be classified as

1. Building Features
2. Site elements
3. Signage

The repetitive element within the building features is the pergola. There are three pergolas, two at the roof of Block A, and one at the roof of Block E. The two most important site elements inside the City Center are the fountain at the center of the main plaza and the curio shop at the entrance plaza facing south. The fountain serves as a point of attraction and people use the ledge around the fountain as a sitting area. The curio shop has been designed as a horse drawn tram, which was a common mode of

transport in Calcutta at one time. Signage has been introduced to guide people through the site and is also an important visual element.

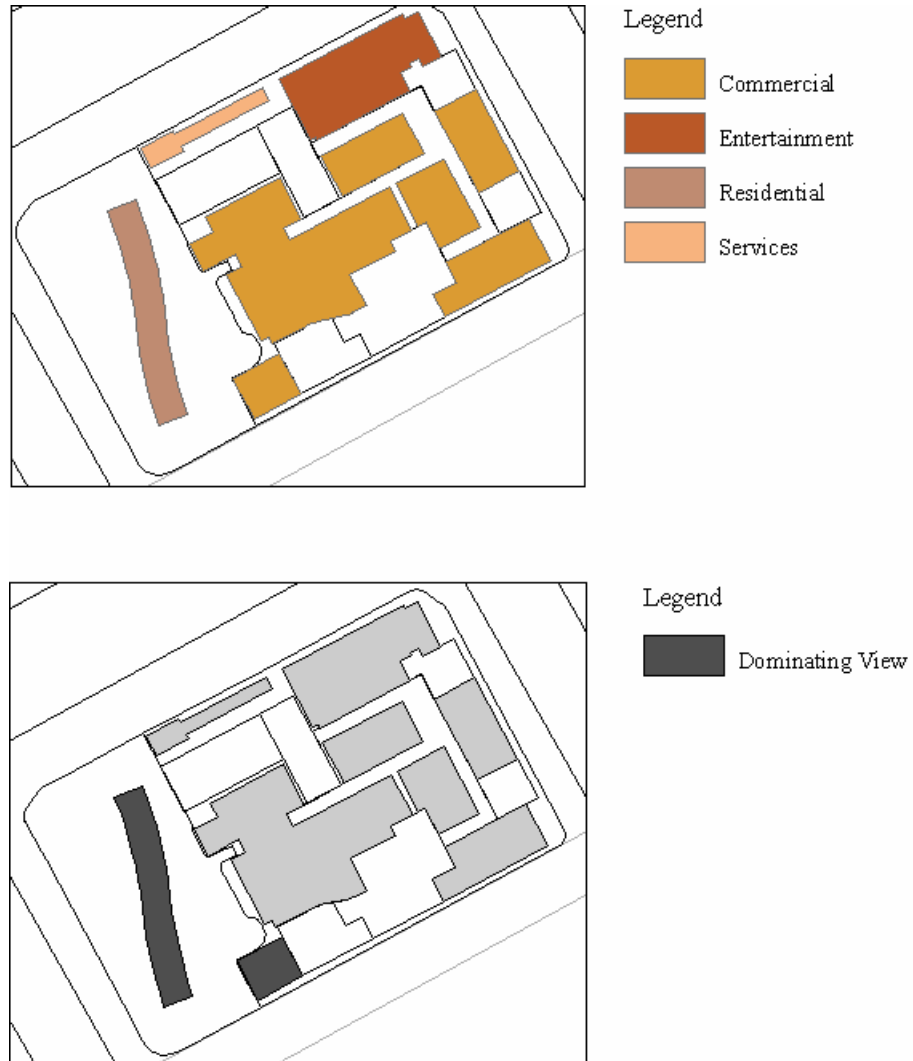


Figure 87: Landmarks in Salt Lake City Center



Figure 88: Visual elements within Salt Lake City Center



Pergola over Office Tower, Block A



Model of horse drawn tram (Curio shop), Entrance Plaza



Pergola over coffee shop, Block A



Fountain, Main Plaza



Signage



Cineplex

Figure 89: Images of visual elements and landmarks, Salt Lake City Center

Demonstration of Spatial Analysis of Pedestrian-Hawker Interaction

This section gives the graphical illustrations of the hawker-pedestrian interaction in the civic nodes to study the prevalent sensory quality of sound and touch. For Dalhousie Square the observations are attributed to the site zones feature class (See Table 12). The Adj_Bldg attribute indicates the adjacent buildings to the hawker zones and the hawker attribute indicates the number of hawkers present in a zone. For Salt Lake City Center the observations are attributed to the outdoor vendor feature class (See Table 13). The Pd_Hk attribute represents the number of pedestrians interacting with hawkers and the mean of the observation time period is also stored as an attribute.

To illustrate the observations graphically a column chart symbol has been used to display the variation of the interaction (See Figures 90 and 91). The illustrations indicate that the east corridor in Dalhousie Square and the shopping spine in the Salt Lake City Center have high sensory qualities of sound and touch due to higher intensity of pedestrian-hawker interaction. The hawker zone in front of the General Post Office in Dalhousie Square has the maximum interaction.

Table 12: Comparison of hawker-pedestrian interaction, Dalhousie Square

FID	Name	Adj_Bldg	Hawkers	Pd_Hk_10AM	Pd_Hk_12N	Pd_Hk_5P
1	Hawker Zone	Reserve Bank of India	0	0	0	0
2	Hawker Zone	Collectorate Bldg	14	6	13	7
3	Hawker Zone	GPO	27	9	39	22
4	Hawker Zone	Royal Insurance	7	0	11	6
5	Hawker Zone	McLeod	2	0	3	0
6	Hawker Zone	Ice Room	0	0	0	0
7	Hawker Zone	Treasury	0	0	0	0
8	Hawker Zone	HSEB	15	3	10	11
9	Hawker Zone	Standard Assurance	5	1	7	5
10	Hawker Zone	Dalhousie East 6	7	11	23	17
11	Hawker Zone	Currency Bldg	0	0	0	0
12	Hawker Zone	Dalhousie East 3	20	6	27	19
13	Hawker Zone	Stephen Court	3	1	11	3
14	Hawker Zone	Dalhousie East 2	15	9	17	6
15	Hawker Zone	Dalhousie East 1	14	4	16	5
16	Hawker Zone	Writer's Bldg	0	0	0	0
17	Hawker Zone	St. Andrew's Church	0	0	0	0
35	Hawker Zone	Telephone Office North	1	0	7	2
36	Hawker Zone	Telephone Office South	1	0	0	0
40	Hawker Zone	Red Cross Place	5	0	3	1
41	Hawker Zone	Dalhousie East 4 & 5	22	17	32	20
42	Hawker Zone	Dead Letter Building	6	1	3	0

Table 13: Comparison of outdoor vendor-pedestrian interaction, Salt Lake City Center

OBJECTID*	Location	Product	Pd_Hk10AM	Pd_Hk12N	Pd_Hk5PM
1	Entrance Plaza	Food	0	3	8
2	Shopping Spine	Tea	2	5	3
3	Shopping Spine	Food	0	3	4
4	Shopping Spine	Food	0	5	9
5	Shopping Spine	Jewelry	0	0	0
6	Shopping Spine	Flowers	0	0	1
8	Shopping Spine	Food	0	0	8
9	Plaza	Food	0	4	17

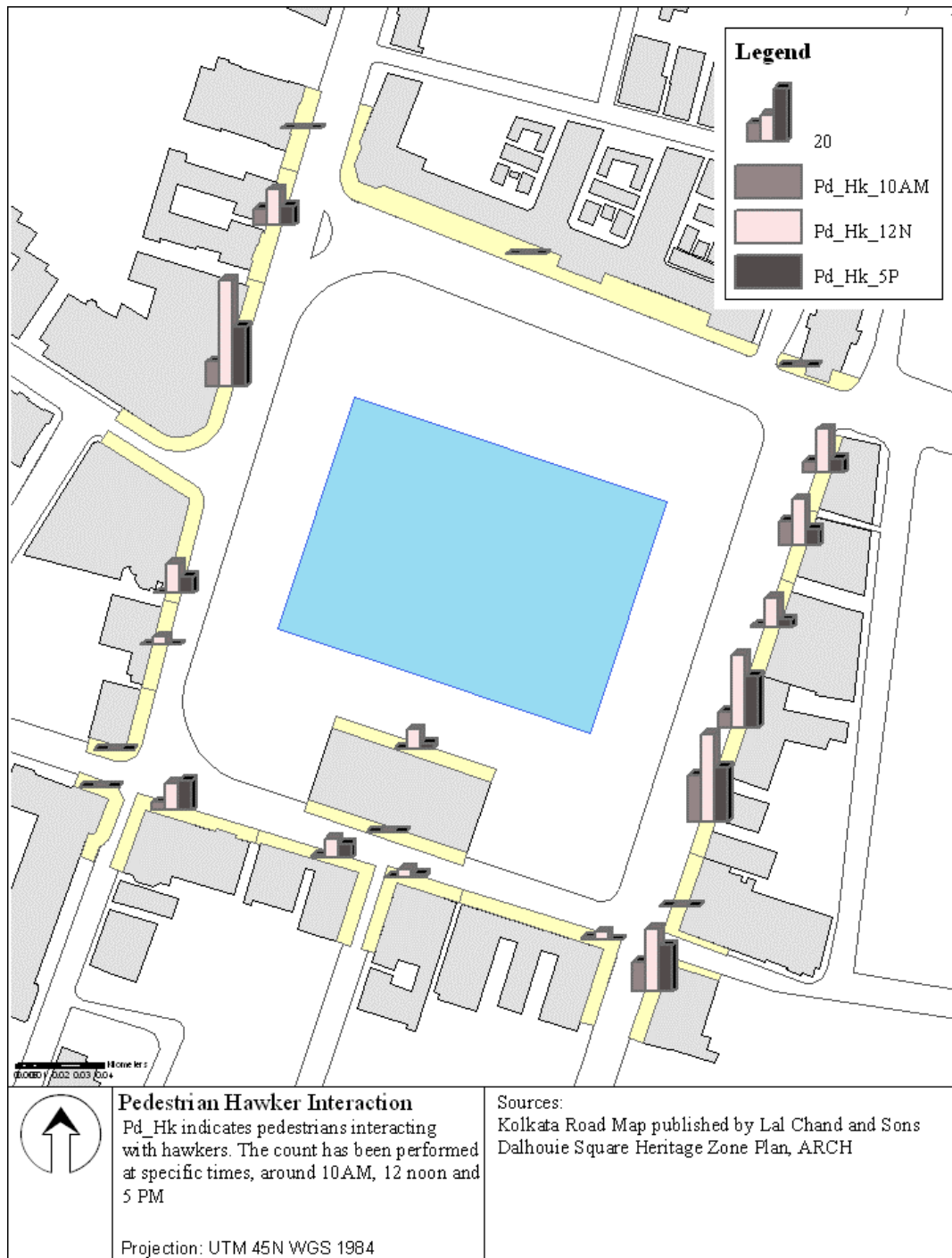


Figure 90: Hawker-pedestrian interaction, Dalhousie Square

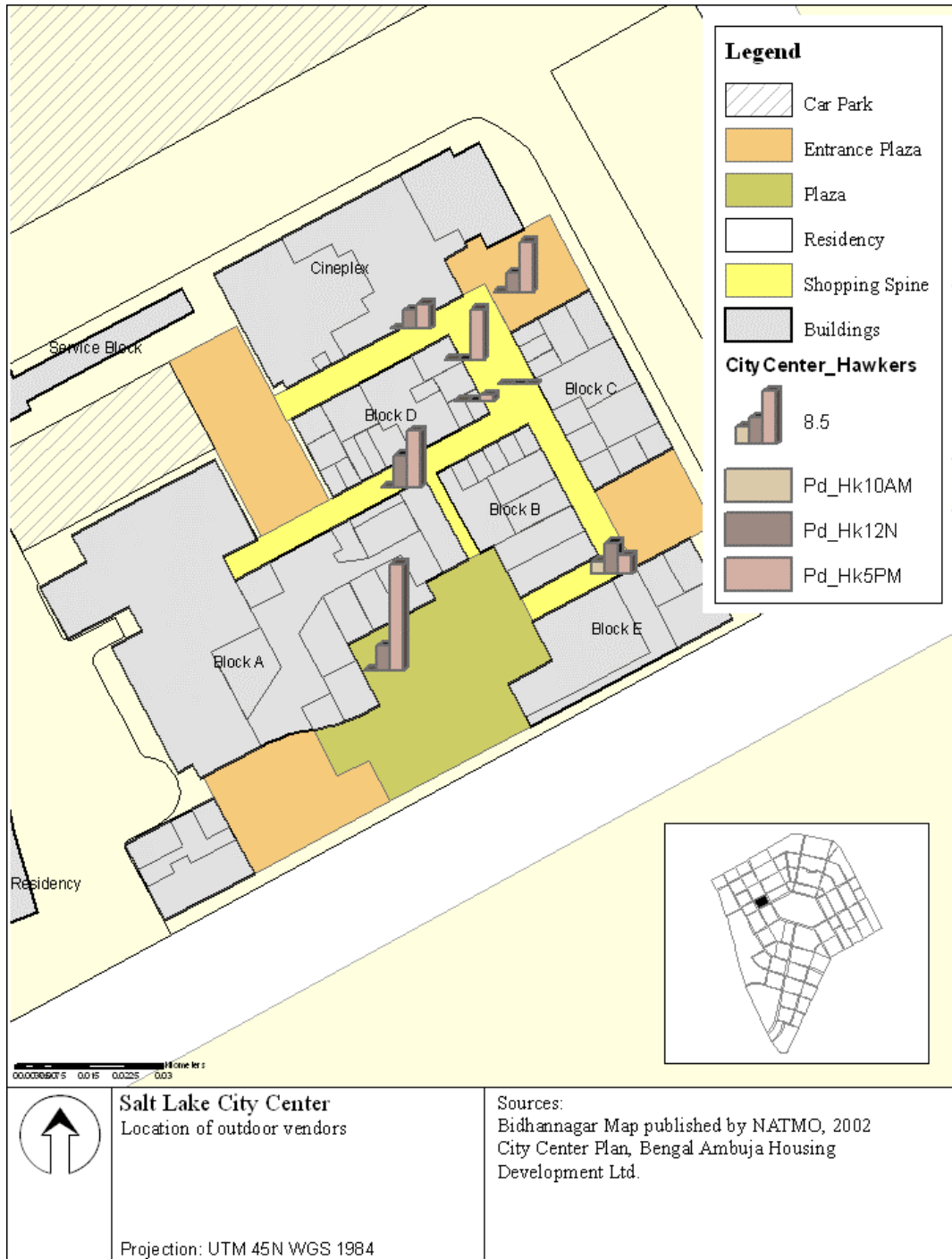


Figure 91: Outdoor vendor-pedestrian interaction, Salt Lake City Center



Figure 92: Hawker-Pedestrian Interaction, Dalhousie Square



Figure 93: Outdoor vendor, Salt Lake City Center

CHAPTER 5 - DISCUSSION OF FINDINGS

The findings of this study are discussed as two separate topics. The first is the summary of the responsive and sensory qualities of the two civic nodes. The second is the advantage of using GIS and how application of this system can benefit the study of urban places and their design by creating a virtual geodatabase of information related to responsive and sensory qualities.

Summary of the Responsive and Sensory Qualities of the two Civic Nodes

Site observations indicate that in the Dalhousie Square the space supports a wide range of activity, some of which were likely not expected by the original planners and designers. How the space is sensed today is far different from what it was sensed during the colonial period of Calcutta. Overcrowding of the city, existing economic conditions, law and order, and even political situation play an important role to shaping the sensory quality of the place. It has been observed that for Dalhousie Square, the colonial buildings, the element from the past, and the present activity of hawkers and pedestrians are the key factors that affect the visual quality as well as contribute to the sense of sound, touch and even smell. The data collected for the number of hawkers and pedestrians show that there is high density of people and personal observations on-site indicate there is a higher intensity of sound and touch in hawker areas.

It is important to discuss how the users perceive this intensity. It is evident that the existence of hawkers is due to the opportunity that exists in the space. A number of high-density pedestrian routes lead to important destinations. Most of these destinations are administrative buildings. They attract a population, which the hawkers target as potential customers. This is an economic condition as well as a symbiotic relationship of people and place that is the very essence of the streets of Calcutta.

Many people associate streets with the presence of these hawkers and take pleasure in interacting with them. At the same time, to many hawkers and pedestrians together spatially and temporal, at high traffic times for instance, leads to a feeling of overcrowded streets and is a disturbing phenomenon. The intensity of hawker use leads to encroachment on side walks inhibiting clear access, and both traffic volume and hawker activities lead to cleanliness challenges. It is evident local government is not totally against hawkers, or policy and action to relocate them or remove them from the place would have occurred. As noted in Figures 90, hawker zones with wider sidewalks or space between building facades and streets were perceived as more conducive to hawkers.

In contrast, the responsive and sensory quality perceived within the Salt Lake City Center is imposed by Correa's design. It has yet to reach a stage where the people and their activities play the key role in shaping the sense of the place. However, Correa has used prototypes of the old Calcutta environment in his design. The layout of the buildings within the City Center indicates that it has been an attempt to replicate the

street patterns of Calcutta. The shopping spine, which is a winding narrow lane with shops on both sides evokes a similar experience of the old lanes of Calcutta market places. The street experience has become even more pronounced with the outdoor vendors within the City Center. These vendors sell food, flowers, jewelry, giving a similar sense to the place as the streets of Calcutta.

The architecture of the mall buildings also repeats some elements of the old buildings but in a much simplified fashion. The buildings do not have elaborate facades but simple flat brick walls with square windows. Colonnaded facades have been used in the ground level facing the street similar to the many colonial buildings in the city. The plaza surrounded by buildings on all three sides is built in a courtyard style, which is common to many old buildings in the city. There is also a resemblance of the plaza with the street square since all the entrance plazas and the shopping spine leads to the main plaza with a small water body at the center. Though not exactly similar, there is a resemblance between the main plaza and the organization of the Dalhousie Square where the streets lead to the central square with the Lal Dighi at the center.

The study indicates that both the civic nodes have responsive and sensory qualities although they are in very different surrounding contexts. It is important for Calcutta to build new growth centers and civic nodes such as the Salt Lake City Center to meet the demands of people who are part of a new economy. At the same time it is important to retain the historic center to stop the decay in the older parts of the city. This will preserve the historic monuments and also revitalize the region of Central Calcutta.

This can reduce the demand for horizontal expansion. Table 10 presents a comparison of the two civic nodes based on the findings of the study and the site observations.

Table 14: Comparison of the two Civic Nodes

Dalhousie Square	Salt Lake City Center
<ul style="list-style-type: none"> • The square is a public place. • Accessible by alternate modes of mass transit. • Region around the square is highly legible due to presence of colonial structures and legible streets. • The administrative buildings and banks are the main anchors that draw people to the place. This makes the place more active during the day, but almost devoid of people during the evening. • Used by all sections of the society, including homeless people and independent hawkers. • The Esplanade and Park Street are major sub-districts within the central Calcutta region that supports Dalhousie Square. These places are used by all sections Calcutta society. • The square supports number of human activities, such as sitting, eating, sleeping and group activities such as card games. • The pedestrian routes surrounding the Square are the paths that have higher intensity of sensory qualities due to hawker-pedestrian interaction. 	<ul style="list-style-type: none"> • The City Center is privately owned. • Accessible through bus transit. More accessible with automobiles. • Region around the City Center is less legible with absence of landmark structures. The streets lack nomenclature and identity. • The mall and the Cineplex are the main attractants. This makes the place more active during the evenings. • Mostly used by the higher economic class. Homeless people are absent and the hawkers are controlled by the mall administration. • Sector 5, Salt Lake is the major supporting sub-district where the information technology and telecommunications industry are located. The major users are young professionals who are regular visitors to the Salt Lake City Center. • People sleeping and group activities such as card games are absent. • The shopping spine is the path with high sensory qualities due to presence of shops and outdoor vendors.

Advantages of using a Geographic Information System

Layers of information in a geodatabase within a Geographic Information System can be used to convey both responsive and sensory qualities. For example the geodatabase can contain the feature class of important paths and sequential images along the path to portray sensory experiences as illustrated in Figures 68 and 69. The overlay techniques in a GIS can be used effectively to isolate important zones within a block or important blocks within a city. For example identifying the legible districts within central Calcutta was possible by overlaying the important paths over the blocks.

With time the blocks, which surrounded these paths became legible districts as they developed a particular character. These characters can be found only in older sections of cities where there have been multiple layers of development. After spatially isolating these blocks they can be treated as individual zones to address a design issue. Managing the sense of these zones can enhance the paths leading to the civic nodes thus increasing accessibility and options.

Isolating areas with specific spatial behavior can help identifying important zones within the civic nodes spatially. For example the activities mapped within the Dalhousie Square area in ArcGIS as point feature classes can convey zones that support certain kinds of human activity. These include seating, talking, playing cards, reading books, sleeping and interacting with vendors. These diverse activities are performed only in specific locations comfortable to the users. It is possible to perform repeat observation of

these activities and present them on paper maps, but it is difficult to store these observations and overlay them in order to isolate zones. This task can be performed only if the zones are available as GIS shape files and the observations are stored as feature classes within the geodatabase. Thus storing of data and availability of it for further research is possible and enables temporal analysis of activities.

Spatial analysis can also be accomplished using the various tools available in ArcGIS to start the design process. Buffering the point feature classes of concentrated human activity and joining the buffer shapes can represent the area of the activity. For example playing cards within the Dalhousie Square plaza is an activity the space supports. This is a social activity of the local people. If redevelopment of the plaza is considered this activity must be considered and places should be generated within the plaza to support it. This would retain the responsive quality of opportunity that the plaza originally supported.

As mentioned the attribute data along with the shapes in GIS is the tool to record on-site observations. Certain observations that are performed for this thesis such as noting the number of people using a particular place is an indication of the both how a space is sensed and how the space responds. It has already been mentioned that hawker-pedestrian interaction increases the sense of touch in the streets of Calcutta. However understanding the intensity of this sense is easier if the observations can be represented both graphically and statistically. GIS support this ability of visual and statistical thinking.

In conclusion designers can benefit by collectively contributing to GIS resources and making them available via the internet. The availability of data as a base line for future studies is critical for analyzing the temporal aspects across historic time. As we make further addition to our cities the ability to use such analytic techniques along with factors contributing to human perception and senses will prove beneficial. It will help us create design processes that will be capable of considering multiple parameters that are essential for reshaping our urban environments.

BIBLIOGRAPHY

Bentley, Ian & et al., Responsive Environments: A Manual for Designers, London: Architectural Press, 1985.

Correa, Charles, The New Landscape: Urbanisation in the Third World, Butterworth Architecture, 1980.

Chakravorty, Sajoy, From Colonial City to Globalizing City? The Far-from-complete Spatial Transformation of Calcutta; Globalizing Cities: A New Spatial Order. Marcuse, Peter and Kempen, Ronald Van. ed, Oxford: Blackwell Publishers, 2000.

Chaudhuri, Sukanta. ed., Calcutta: The Living City, Calcutta: Oxford University Press, 1990.

Greene, P., Richard, Pick, B., James, Exploring the Urban Community A GIS Approach, NJ: Pearson Education Inc., 2006.

<http://www.esri.com>, ESRI Website. Retrieved May 7, 2006.

<http://smi.curtin.edu.au/ecai/>, Internationalising South Asian Scholarly Data Website. Retrieved February 10, 2006.

Lynch, Kevin, The Image of the City, Cambridge: The MIT Press, 1959.

Lynch, Kevin, Managing the Sense of a Region, Cambridge: The MIT Press, 1976.

Moughtin, Cliff, *Urban Design Street and Square*, Oxford: Architectural Press, 2003.

O'Looney, John, *Beyond Maps GIS and Decision Making in Local Government*, California: ESRI Press, 2000.

Whyte, William, *The Social Life of Small Urban Spaces*, Washington, D.C.: The Conservation Foundation, 1980.

APPENDIX A: Summary of Glossary of Techniques for Recording and Managing the Sense of a Region by Kevin Lynch

Spatial Form

Spatial form refers to the morphology of the region. Physical or computer generated models are effective ways to study this aspect. Scale is an important element of spatial form since large scale representation can give an experiential quality to the study. To interpret the sensory qualities from spatial form Lynch, gives some guidelines to analyze and record certain general judgments. These include

1. Light, sound and texture and their influence on the character of the space
2. Relation between visible human activity in a space with the size and shape of built forms
3. Interconnection of spaces visually and functionally
4. Entrances of buildings and other private domain

Temporal Form

Temporal form denotes recording the space through time. Time lapse motion pictures effectively used by William Whyte in '*The Social Life of Small Urban Spaces*' is an excellent example of recording the temporal form. The goal is to locate change within a region which could be either addressed in a historic context or on a cycle of activity context. These changes may be analyzed by way of maps linked with factors causing the changes.

Sequences

The sequential analysis is a part of visual analysis depicting the way a place is experienced from a particular path within the region. The usual techniques used in this case include a combination of photographs and network diagrams or a motion picture. Lynch however strived for a technique that would be more interpretive by using selective notations. These notations could indicate a sense of entry or symbolize the legibility of principle decision point within the site.

Visibility

Visibility assessment of a region identifies landmarks and visual paths. These can be represented in maps in various ways. Visual corridors for instance are paths including the different possible views from it.

Ambient Qualities

Ambient quality of a place is associated with its microclimate. In an urban environment this includes recording qualities such as shade, glare and noise.

Details and Surfaces

This includes the various man-made objects within the region. Examples of details given by Lynch include waste receptacles, doorways, cornices, drinking fountains, curbs, public toilets, shelters, arcades, newsstands. Surface study includes recording the descriptions of the building facades and also the floor of the urban space.

Information

In a planned locality signs play an important role in guiding people or conveying information to them. Traffic signals can be studied to understand the information available to people with cars. Lynch talks about more impressionistic mapping such as studying the regions of overload, or of extreme under-load, or the areas of stimulus and calm.

Natural Features

To study natural features and their effect on human senses Lynch suggests analyzing landform by visual characteristics or studying the texture and type of tree cover and its relative sensitivity to visual intrusion.

Visible Activity

According to Lynch study of visible activity can be done by making records on a map at various times in a day. Human activity differs by time as well as by space. For instance certain areas within a city are more active during night than the day. The activity in a mixed use space is different from a single use space.

Spatial Behavior

Human behavioral patterns are good indicators of the character of urban space. Whyte studied these patterns in New Yorks plazas to understand what factors contribute to a good plaza space. Various techniques for the study of environmental behavior have been

provided by urban designers and planners, recently by Philip Thiel. According to Lynch spatial behavior can be recorded by noting the tangible use of physical settings.

Images

This category has been extensively used by interviewing people about their perception or mental image of a place. Cognitive maps are generated when residents of a locality draw the image of a place in two dimensional formats. The image may vary from person to person and group to group. Images can be good indicators of spatial importance of a particular location in a city.

APPENDIX B: ABBREVIATIONS

ARCH – Action Research in Conservation of Heritage

A registered society based in Calcutta, India engaged in conservation of heritage buildings.

ESRI – Environmental Systems Research Institute

A privately held company in Redlands, California engaged in research, development and production of GIS softwares.

NATMO – National Atlas and Thematic Mapping Organization

A thematic map and atlas making organization under the Union Ministry of Science and Technology, India.

UTM – Universal Transverse Mercator

A projected coordinate system that divides the world into 60 north and south zones, six degrees wide.

APPENDIX C: ESRI DEFINITIONS

ArcGIS

ArcGIS is an integrated collection of GIS software products for building a complete GIS for an organization. The ArcGIS framework enables one to deploy GIS functionality and business logic wherever it is needed—in desktops, servers (including the Web), or mobile devices. This architecture, coupled with the geodatabase, provides the tools to assemble intelligent geographic information systems.

ArcMap

ArcMap is the central application in ArcGIS Desktop for all map-based tasks including cartography, map analysis, and editing. ArcMap is a comprehensive map authoring application for ArcGIS Desktop.

ArcMap offers two types of map view

- **Geographic data view**—an environment where geographic layers are symbolized, analyzed, and compiled into GIS data sets. A table of contents interface that organizes and controls the drawing properties of the GIS data layers in the data frame. The data view is a window into any GIS data set for a given area.
- **Page layout view**—an environment where map pages contain geographic data views as well as other map elements such as scale bars, legends, north arrows, and

reference maps. The page layout view is used to compose maps on pages for printing and publishing.

ArcCatalog

The ArcCatalog application organizes and manages all GIS information such as maps, globes, data sets, models, metadata, and services. It includes tools to

- Browse and find geographic information
- Record, view, and manage metadata
- Define, export, and import geodatabase schemas and designs
- Search and browse GIS data on local networks and the Web
- Administer an ArcGIS server

Users employ ArcCatalog to organize, find, and use GIS data as well as document data holdings using standards-based metadata. A GIS database administrator uses ArcCatalog to define and build geodatabases. A GIS server administrator uses ArcCatalog to administer the GIS server framework.

ArcToolbox

ArcToolbox contains a comprehensive collection of geoprocessing functions including tools for ArcToolbox. It is embedded in ArcCatalog and ArcMap and is available in ArcView, ArcEditor, and ArcInfo.

- Data management
- Data conversion

- Coverage processing
- Vector analysis
- Geocoding
- Statistical Analysis

Attribute

1. Spatial information about a geographic feature in a GIS, usually stored in a table and linked to the feature by a unique identifier. For example, attributes of a river might include its name, length, and sediment load at a gauging station
2. In raster datasets, information associated with each unique value of a raster cell.
3. Information that specifies how features are displayed and labeled on a map; for example, the graphic attributes of a river might include line thickness, line length, color, and font for labeling.

Attribute Data

Tabular and/or textual data describing the geographic characteristics of features.

Attribute Table

A database or tabular file containing information about a set of geographic features, usually arranged so that each row represents a feature and each column represents one feature attribute. In raster datasets, each row of an attribute table corresponds to a certain zone of cells having the same value. In a GIS, attribute tables are often joined or related to spatial data layers, and the attribute values they contain can be used to find, query, and symbolize features or raster cells.

Feature Class

In ArcGIS, a collection of geographic features with the same geometry type (such as point, line, or polygon), the same attributes, and the same spatial reference is known as a feature class. Feature classes can be stored in geodatabases, shapefiles, coverages, or other data formats. Feature classes allow homogeneous features to be grouped into a single unit for data storage purposes. For example, highways, primary roads, and secondary roads can be grouped into a line feature class named "roads." In a geodatabase, feature classes can also store annotation and dimensions.

Field

1. A column in a table that stores the values for a single attribute.
2. The place in a database record, or in a graphical user interface (GUI), where data can be entered.

Geodatabase

A collection of geographic datasets for use by ArcGIS. There are various types of geographic datasets, including feature classes, attribute tables, raster datasets, network datasets, topologies, and many others.

Geographic Coordinate System

A reference system that uses latitude and longitude to define the locations of points on the surface of a sphere or spheroid. A geographic coordinate system definition includes a datum, prime meridian, and angular unit.

Geoprocessing

A GIS operation used to manipulate GIS data. A typical geoprocessing operation takes an input dataset, performs an operation on that dataset, and returns the result of the operation as an output dataset. Common geoprocessing operations include geographic feature overlay, feature selection and analysis, topology processing, raster processing, and data conversion. Geoprocessing allows for definition, management, and analysis of information used to form decisions.

Georeferencing

Aligning geographic data to a known coordinate system so it can be viewed, queried, and analyzed with other geographic data. Georeferencing may involve shifting, rotating, scaling, skewing, and in some cases warping, rubber sheeting, or orthorectifying the data.

Layer

In ArcGIS, a reference to a data source, such as a shapefile, coverage, geodatabase feature class, or raster, that defines how the data should be symbolized on a map. Layers can also define additional properties, such as selecting features from the data source are

included. Layers can be stored in map documents (.mxd) or saved individually as layer files (.lyr).

Metadata

Information that describes the content, quality, condition, origin, and other characteristics of data or other pieces of information. Metadata for spatial data may describe and document its subject matter; how, when, where, and by whom the data was collected; availability and distribution information; its projection, scale, resolution, and accuracy; and its reliability with regard to some standard. Metadata consists of properties and documentation. Properties are derived from the data source (for example, the coordinate system and projection of the data), while documentation is entered by a person (for example, keywords used to describe the data).

Projected Coordinate System

A reference system used to locate x, y, and z positions of point, line, and area features in two or three dimensions. A projected coordinate system is defined by a geographic coordinate system, a map projection, any parameters needed by the map projection, and a linear unit of measure.

Shapefile

A vector data storage format for storing the location, shape, and attributes of geographic features. A shapefile is stored in a set of related files and contains one feature class.