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Buket Aysegul Ozbakir
AUTEUR DE LA THÈSE / AUTHOR OF THESIS

Ph.D. (Geography)
GRADE / DEGREE

Department of Geography
FACULTÉ, ÉCOLE, DÉPARTEMENT / FACULTY, SCHOOL, DEPARTMENT

A New Model for Quality of Urban Place : Contribution of Community Structures and Information Technologies

TITRE DE LA THÈSE / TITLE OF THESIS

Abdou Bannari
DIRECTEUR (DIRECTRICE) DE LA THÈSE / THESIS SUPERVISOR

CO-DIRECTEUR (CO-DIRECTRICE) DE LA THÈSE / THESIS CO-SUPERVISOR

EXAMINATEURS (EXAMINATRICES) DE LA THÈSE / THESIS EXAMINERS

Huhua Cao

Michael Sawada

Anne Gilbert

Mark Rosenberg

Gary W. Slater
Le Doyen de la Faculté des études supérieures et postdoctorales / Dean of the Faculty of Graduate and Postdoctoral Studies

University of Ottawa

Department of Geography

A NEW MODEL FOR THE QUALITY OF URBAN PLACES: INTEGRATION OF OBJECTIVE AND SUBJECTIVE INDICATORS USING INFORMATION TECHNOLOGIES

by

Buket Ayşegül ÖZBAKIR

A thesis presented to the Department of Geography, University of Ottawa
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy (Geography)

Your file Votre référence
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DEDICATION

This work is dedicated to my parents,

Ethem and Gonca Ozbakir

without their tireless encouragements,

I would have given up long ago…

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ASI	Average subjective quality of place index
CAD	Canadian dollar
CBD	Central business district
CGIS	Canada geographic information system
CMA	Census metropolitan area
CSD	Census subdivision
CT	Census tract
DIME-GBF	Dual independent map encoding-geographic database files
EA	Enumeration area
GCP	Ground control points
GIS	Geographical information system
IQOPI	Integrated quality of place index
IRS-1D	Indian remote sensing satellite
IWB	Index of well-being
LISS-III	Linear self scanning camera
MAUP	Modifiable areal unit problem
MCDA	Multi-criteria decision analysis
MCE	Multi-criteria evaluation
MSA	Metropolitan statistical areas
NAD	North American datum
NASA	National Aeronautics and Space Administration
NDVI	Normalized difference vegetation index
NIR	Near infrared reflectance
OECD	Organization for Economic Co-operation and Development
QOL	Quality of life
QOP	Quality of place
QOP_{cs}	Quality of place index (using census data)
PCA	Principal component analysis
PCA_{rs}	Principal component analysis in remote sensing environment
PCA_{st}	Principal component analysis in statistical environment
RMSE	Root mean square error
RS	Remote sensing

SAVI	Soil adjusted vegetation index
SES	Socio-economic status
SQOPI	Subjective quality of place index
TDVI	Transformed difference vegetation index
TPU	Tertiary planning units
UTM	Universal transverse mercator
VI	Vegetation indices
WIFS	Wide field sensor
WLC	Weighted linear combination

ABSTRACT

Quality of place (QOP) is essential for building a "competitive and livable city" and the competitiveness is determined by the opportunities that the city can provide. Therefore not only physical characteristics of the neighborhoods but also social structure and personal satisfaction about a place are significant in the assessment of QOP. This thesis discusses how to measure the performance of places from different perspectives. Measuring the QOP is a hard task since it involves both objective and subjective dimensions. Most of the research on QOP have focused on either subjective or objective measures and a limited number of efforts have been made in recent years to collect both types of indicators. Hence, the main objective of this research has been to offer a new definition for QOP where both dimensions are integrated and to introduce a new methodology where information technologies such as geographical information systems (GIS) and remote sensing (RS) can be applied to understand the contribution of these two dimensions of QOP. The proposed methodological approach is tested for Montréal as a study case where social, physical and experiential community structural information are analyzed using different sources of data (census, survey, GIS based ancillary data and satellite images). Social structural information is analyzed using census data which help to understand the link between the socio-demographic/economic characteristics and QOP in census tract (CT) at city-wide scale. Then, physical structural information through accessibility to public services and urban land use is analyzed with the help of RS and GIS techniques. In the subjective dimension, survey data are used to explore the experiential community structural information that helps to understand the individual's own perceptions about the QOP where they live. Finally, both of the objective and subjective dimensions are integrated through multi-criteria evaluation (MCE) in a GIS environment. The results indicate that a place may be explained through some objective criteria; however, the situation may be different when the personal evaluations of people living in that area are considered. Thus, the results support that both dimensions are necessary to evaluate the complete picture of QOP.

Key words: Quality of Place, Objective and Subjective Dimensions, Community Structures, Remote Sensing, Geographical Information Systems, Transformed Difference Vegetation Index, Spatial Analysis, Principal Component Analysis, Multi-Criteria Evaluation, Montréal.

1 A New Model for Quality of Place: An Introduction

> "The place changes: it is tranquil now, now a mad rush of traffic, now a tie-up in the traffic because of an accident; there is brilliant sunshine, or an overcast sky, or snow and ice; the "place" to which I am going is either a place I want to go, or do not want to go, and thus the locations through which I travel all have a different sense, a different meaning, as being "on the way" to that place at the end of my journey".[1]

1.1 Introduction

"Place" can be considered as one of the most frequently used words in the English language. It is used to indicate a physical location (what places did you visit?), a psychological state (I'm not in a good place now), the location of something in one's mind (I can't quite place it), a social status (he doesn't know his place) or to express an evaluation (there's a time and place for everything) and so on. This richness is not accidental: imagine several people walking along the sidewalk in Montréal's St. Catherine Avenue shopping and entertainment district on a busy day. What kind of place is it for them or how good is the place for them? These are not easy questions to answer without knowing more about the people and how they came to be there. The meaning of the place will definitely be very different for a mother with children than a business person on the same sidewalk and hence, their evaluation about the quality of that place will also differ. Obviously, each individual would experience a personal sense of place on that busy sidewalk, each stimulated by different feelings or opportunities.

This scenario along the sidewalk in Montréal's St. Catherine Avenue shows that any evaluation about "place" can not be described as simply a function of its physical characteristics; but other factors such as individual perceptions and the mood of the

[1] Flay, C.J, (1989), "Place and places" in *Common Places – Essays on the Nature of Place* , Black D.W, Donald K. and Pickles J., University Press of America, New York, p.4

persons who are experiencing the place should also be considered. Because of this complexity, the scientific approaches to the idea of place have also been looked at different dimensions. Researchers like Relph (1976) and Tuan (2001) discussed the concept in a humanistic approach while Auge (1995) talked about place in anthropological considerations, or Agnew (1987) and Johnston (1991) have discussed place in a political geographical perspective where place is seen as the intersection between state and society, and interpreted as a function of public policies.

Satisfaction from a place is essential for quality of place (QOP) measurements which can be analyzed through different perspectives. These measurements involve a multi-faceted understanding of the coming together of both physical and living environments. While QOP can be viewed from a personal point of view such as the Montréal's St. Catherine Avenue example, it can also be explained in a more collective approach as it relates to other concepts such as quality of life (QOL) and well-being.

QOL has been defined by many researchers from different points of view. For example, according to Pacione (1982), QOL is a term that is intended to refer either to the conditions of the environment in which people live (such as air and water pollution or poor housing, for example), or to some attribute of people themselves such as health or educational achievement. Although the meaning of the term "quality" is agreed to imply a sense of satisfaction of the people within the environment in which they live, the attributes and the measurement techniques for the concept have always been problematic. At this point, the question can be asked, "why is it important to assess QOL? Pacione (1982) argues that one of the reasons for the growing interest in this field is the 'paradox of affluence' in modern societies, in which concern with quality of life has paradoxically appeared to increase with technological progress and increases in income. He also notes that people in developed countries have come to realize that QOL is not necessarily a simple function of material wealth.

This means that although 'income' is an indicator of QOL, how satisfied people are with their environment (meaning such elements as green spaces, housing conditions, traffic problems, clean air, etc.) is also very important. QOP allows one to focus on the assessment of the place that the individual or the community lives. While disciplines like psychology, economics or sociology are interested in analyzing quality of lives experienced by individuals or groups, other disciplines like urban planning and geography are specialized in analyzing the related qualities of those places where these individuals and groups live on a daily basis.

Measuring the QOP is both complex and a hard task since it involves both objective and subjective dimensions. A definition in objective terms would refer, for instance, to measures of income and expenditure. Satisfaction and happiness, by contrast, would be subjective terms (Michalos, 1983; Wilkening and McGranahan, 1978). Most of the research on QOL, well-being and QOP have focused on either subjective or objective measures. A limited number of efforts have been made in recent years to collect both types of indicators within the same study based on the belief that one type of indicator can contribute to the interpretation of the other (Townshend, 2001; Williams *et al.*, 2001; Langlois and Gilbert 2005).

Many factors, including personal and social characteristics such as age, income or education, intervene between the objective world and an individual's evaluation of it, and these may act as filters to distort objective conditions. Therefore, individual perceptions transform what is initially seen as a universal objective situation into a highly individualistic interpretation of that condition. Although subjective indicators also have their problems such as a lack of common meaning/understanding for all concerned (Knox, 1976), it is essential to measure the privately evaluated aspects of QOP by people simply because the same circumstances and same environment may be enjoyable and satisfying to some but not to others. Thus, this thesis will contribute in finding a better way to utilize both types of indicators, developing a new definition of QOP and testing a new methodology.

Furthermore, measuring the quality of a place is also considered as an essential requirement for building a "competitive" city. Economically successful and vibrant cities of the future will be those that engage the creativity of their residents, encourage and welcome immigrants, invest in the work of artist and scientists and maintain authentic and environmentally sustainable urban places. Since real economic development in recent years is people-oriented, organic and community-based, there has been an increasing interest in measuring the QOL of urban communities and QOP (Pacione, 1982; Paim, 1995; Beesley and Russwurm, 1989; Keng and Hooi, 1995; Anderson and Langlois, 2002; Hanna and Walton-Roberts, 2004; Sénécal, Hamel and Vachon, 2005; Langlois and Gilbert, 2005; Urry, 2005).

Measuring the performance of urban places is on the agenda of many interest groups such as central and local governments, real-estate developers, environmental scientists, non-governmental and community groups, stake holders and residents who express their concerns about the trends in poverty rates, homelessness or urban deprivation in their neighbourhood. There is also a shift in governments to 'community accountability' where they attempt to report to citizens on the basis of achievements including where and how public money is spent in an effort to increase QOL. Efforts for measuring QOL and QOP, therefore, play an important role in analyzing the relationship between the social progress within the community and the urban environment.

1.2. Objectives and scope

The objectives and the scope of this thesis are: first to propose a new conceptual definition of "quality of place", where it is conceptually differentiated from "quality of life" and "well being" by using both "objective" and "subjective" dimensions; and secondly to develop a new methodology to measure QOP.

The conceptual framework in this thesis proposes to locate QOP both of the intersection of QOL and well-being which are defined in objective and subjective dimensions. In this model, QOL is basically determined where the individual's needs are met with the resources provided by the environment. For this reason, while QOL resides in the objective dimension, well-being on the other hand, is based on QOL but adds on different values and experience of each individual, and therefore is located in the subjective dimension. The contribution of this thesis from a conceptual point of view is to introduce QOP in measuring one's physical environment through a combination of the components that are related with "place" from both QOL and well-being.

The major contribution from the methodological point of view is the integration of both objective and subjective dimensions of QOP through the use of a geographical information system (GIS) and remote sensing (RS). GISystems are computer-based systems used to store and manipulate geographical data, and perform spatial analysis. These systems serve to reveal the patterns, relationships and anomalies or sometimes invisible characteristics of the geographical data in various applications. Because of this complexity, many definitions of GIS have been suggested over the years and none of them is entirely satisfactory. Longley *et al.* (2002) define the label GIS in reference to its different components: its automate production of maps, capability of supporting spatial decisions, use of as a tool for solving geographic problems, serving as an inventory of geographically distributed features and facilities or as a tool for revealing what is invisible in geographic information.

On the other hand, RS technology provides data from which updated information about urban systems can be extracted efficiently and economically through satellite images. This technology also played a part in the development of GIS as a source of technology as well as a source of data. Recently, these two technologies have been used independently from each other or only in one direction (either GIS benefited from RS or vice versa). However, due to the improvements in computer technology, many researchers have started using GIS and RS techniques together, to enhance mutually their performance and scope (Janssen *et al.,* 1990; Kam, 1995; Milanova *et al.,* 1999; Thompson and Hardin, 2000).

In this study, the proposed methodology seeks an alternative way to integrate the objective and subjective dimensions of QOP using GIS and RS technologies. An objective dimension of QOP will be analyzed through two types of information. First, "social structural information" will be analyzed using census data which helps to understand the link between the socio-demographic/economic characteristics and QOP in census tract (CT) level at a city-wide scale. Secondly, accessibility to public services and urban land use will be analyzed with the help of RS and GIS techniques. In addition, the subjective dimension of QOP will be analyzed through survey data which will be used to explore the "experiential community structural information". This will help to understand the role of the individual's own perceptions about the quality of the place where he or she lives. Finally, both of the objective and subjective dimensions will be integrated through multi-criteria evaluation (MCE) in a GIS environment.

The proposed methodological approach will be tested for Montréal as a case study. This city has been chosen because it experienced significant problems such as the loss of manufacturing activity and employment, and the out-migration of businesses and residents from core areas to the suburbs. Moreover, according to some economic figures (such as unemployment rates, median family income, and percentage of low-income families), Montréal was considered the most deprived city in Canada during the period 1991 to 1996 (Langlois and Kitchen, 2001).

1.3. Structure of the thesis

This thesis is structured in seven chapters. The aim of this first chapter is to assess the importance of conducting QOL and QOP studies and explain the main objectives and the scope of the thesis. In the second chapter, the problem will be defined with a review of the relevant literature. First, the literature on the concepts of QOL, QOP and well being will be reviewed. Secondly, since GIS and RS techniques will be used to measure both dimensions of QOP, this chapter will provide a literature review on the applications of these techniques on QOP. The third section will cover the technical background on some of the commonly used GIS/RS techniques (such as vegetation indices, principal component analysis (PCA), digital image classification and spatial analysis techniques). The chapter will conclude with a problem definition as a result of this literature review.

Based on these conceptual and technical reviews, the goal of the third chapter will be to propose a new conceptual model that will identify the relationships among QOL, QOP and well being. Following the new conceptual model, the proposed methodological framework will also be introduced to analyze both objective and subjective dimensions in statistical, GIS and RS environments.

The case study, data sources and the variables selected for the study will be the core of chapter 4. The goal is to indicate the reasons why Montréal has been selected for this study, and explain some characteristics of the city that are linked to the main subject of this thesis.

The results of the analysis for objective and subjective dimensions will be provided in chapter 5. This chapter will show the results of PCA_{st}[2] and "quality of place index" (QOP_{cs}[3]) derivation based on the census data in statistical and GIS

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[2] Hereinafter referred to as the "*principal component analysis in statistical environment*".

[3] QOP_{cs} is derived using census data to analyze the social structural information.

environments. In addition, the results for the urban land use extraction from remotely sensed data and the accessibility to public services using GIS and RS will be presented. Being introduced as a new vegetation index to the RS literature, special attention will be given to the "Transformed Difference Vegetation Index" (TDVI) and applied to the remotely sensed data. With the help of TDVI and PCA_{rs}[4], a digital image classification will be performed to extract land use information. Furthermore, spatial analysis techniques will also be applied in GIS to analyze accessibility to public services. Following this analysis in the objective dimension, statistical description of the survey data will be provided. The "subjective quality of place index" (SQOPI) derivation will be the final step of chapter 5.

Integration of the results in both objective and subjective dimensions obtained in the previous chapter will be provided in chapter 6. PCA_{st} will be applied to understand the contribution of both dimensions to QOP. The chapter will end up with the "integrated QOP index" (IQOPI) derivation based on weighted linear combination (WLC) and the analysis of the spatial distribution of this index in Montréal.

Finally, chapter 7 will discuss the results and explain the contribution of this thesis to QOP studies. Advantages, disadvantages and the difficulties experienced during the study will also be covered in this chapter and some recommendations will be provided.

[4] Hereinafter referred to as the "*principal component analysis in remote sensing environment*".

2 Literature Review and Problem Definition

"Almost everything that happens, happens somewhere. Knowing where something happens is critically important."[2]

2.1. Introduction

QOL, well-being and QOP are complex concepts which have no agreed-on definitions since many indicators and different techniques can be used to measure them. Another problem that has been attached to this complexity is their inconsistently or interchangeably use or the lack of distinction between them. The main goal of this chapter is to provide a literature review of the previous works on the concepts of QOL, well-being and QOP in order to highlight better the potential of QOP for the study of human beings' relationship to their environment and to review applications of information technologies (RS and GIS) on QOP. Following the conceptual and technical literature reviews, problem definition will be made.

The review of the literature will be divided in two sections. First, an overview of the research on QOL, well-being and QOP from 1960s to recent years will be provided where the literature will be discussed on the development of the three concepts. The reason for the time period selected for this literature review is that the interest in QOL and the methodological development of the social indicators grew significantly during the late 1960s (Bauer, 1966; Gross, 1966; Wellar, 1968; Sheldon and Moore, 1968; Bradburn, 1969; Smith, 1973). Next, after the conceptual literature review, a summary of the previous work will be covered where some researchers applied RS and GIS to analyze QOL, well-being or QOP. Furthermore, the technical background on specific techniques used in RS and GIS (like vegetation indices (VI),

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[2] Longley P.A. *et al.* (2002), *Geographic Information Systems and Science*, John Wiley & Sons Ltd., England, p.2

PCA, and spatial analysis techniques), will be covered in this chapter since these methods will be applied to analyze QOP in chapter 5.

Finally, based on the literature review, the research problem of the thesis will be defined to provide a background for the new conceptual and methodological frameworks which will be proposed in chapter 3.

2.2. Literature review on the concepts of QOL, well-being and QOP

Over the past decades, the literature on urban studies and geography has demonstrated a growing interest in measuring QOL and social indicators in cities, both in Canada and around the world. Social indicators movement, alternatively described as "social accounting", "social reporting" or "monitoring social change and QOL", involves the measurement of social conditions as they vary in time and space (Smith, 1973). The main idea of this movement is that the nature and performance of the social system is as important as of the economic system.

According to Smith (1973), much of the recent interest in social indicators has been connected with the proposal for a regular national report. A well-known study entitled "*Recent Social Trends in the United States*" was one of the initial attempts to analyze social factors for public policies of the United States (United States, President's Research Committee on Social Trends, 1933). However, very little progress was made in regular social reporting until the very end of that period. In the 1950s, a project of the United Nations also made important contributions to link the social indicators with QOL, where the measurement of the level of living has been improved by introducing indicators and identifying components of welfare (Moser, 1970). Smith (1973) indicates that, between 1959 and 1966, the publication of "HEW Indicators and HEW Trends", represented a small step towards expanding the available social statistics, although the indicators used were rather conventional.

In 1966, Bauer (1966) was the first person to originate the term "social indicators", using it in a project he undertook for the National Aeronautics and Space

Administration (NASA) in the mid 1960s. According to this author, social indicators were "*statistics, statistical series, and all other forms of evidence that enable us to assess where we stand and are going with respect to our values and goals*". Another description for social indicators was made within the publication of "Toward a Social Report" (U.S. Department of Health, Education and Welfare, 1969) as follows:

> *"A social indicator, as the term is used here, may be defined to be a statistic of direct normative interest which facilitated concise, comprehensive and balanced judgement about the condition of major aspects of a society. It is in all cases a direct measure of welfare and is subject to the interpretation that, if it changes in the "right" direction, while other things remain equal, things have gotten better, or people are "better off".*

Based on the description above, Smith (1973) suggests that statistics about one phenomenon can not be solely considered as social indicators. He argues that numbers of doctors or policemen are not strictly social indicators, as an increase in their number does not necessarily increase human welfare by reducing illness or crime. True social indicators in these areas would be direct measures of health and criminal activity, such as years of healthy life expectancy and monetary losses through crime.

According to Perloff (1969), social indicators are normally used to describe the condition of a single element, factor, or the like, which is part of a complex interrelated system. Furthermore, Culyer, Lavers and Williams (1971) make a useful distinction between indicators of the present condition or state, indicators of the gap between the existing and desired state, and indicators of the effectiveness of programs designed to close the gap.

Although the early approaches to social indicators were first introduced in the U.S., the idea spread out to other countries and organizations very quickly and "social indicators movement" emerged. There are two reasons why the social indicators approach has been so successful. One reason is that it had an enormous impact and was undertaken with a strong sense of commitment and also it had a sense of mission.

The second reason is the existence of a research need and interest among both the politicians and the social scientists to measure social situations and social development with "quantitative methods". Therefore, "social indicators" provided promising solutions. It is also important to indicate the particular political climate of the 1960s when for the first time doubts were raised in the highly economically developed countries about economic growth as the major objective of their societal progress. Hence, it was this time period that preferring quality to quantity has become a public demand.

In the 1970s, social indicators research was gaining acceptance as a field of academic social science (Table 2.1), resulting in regular social reporting efforts and specific data generation for societal monitoring (Smith, 1973; Liu, 1975; Campbell, 1976). It was also in this period that two broad types of social indicators, "objective" and "subjective", were introduced.

Objective indicators are those trying to describe both the physical and the social environments in which people live and work (like health care provision, education, unemployment rate, leisure activities or housing condition). They represent social and physical facts independently of personal evaluations whereas subjective indicators are designed to describe the ways people perceive and evaluate conditions around them (like job satisfaction, perception of distributional justice or class identification).

Table 2.1: Time periods for social indicators research

Time Periods	Characteristics
1960 – 1970	Formation of the social indicators movement
1970s	- Acceptance of social indicators research as a field of academic social science, - Regular social reporting efforts, - Specific data generation for societal monitoring.
1980s	Stagnation and decrease in the interest of social indicators research due to the changes in economies of all countries in the world (impacts of globalization).
1990s to present	Again, there is an increase in the interest of QOL research because of the need in reconsidering the concepts of welfare and QOL. This is necessary in terms of evaluating the changed social contexts and problems (like crisis of welfare state or the global ecological problems).

(*Source: adopted and developed from Smith, 1973 and Pacione, 1982*)

During the 1960s and 1970s, many different studies emerged, such as Liu's (1976) report on conditions in American cities using objective indicators, as well as surveys such as Bradburn's study (1969) using subjective indicators. However, *"...most of the main statements and reports published up to the early 1970s were almost entirely non-spatial in their content"* (Pacione, 1982, p.496). The "spatial dimension" was introduced to QOL studies with the entry of geographers into this field such as analysis of QOL at local, city or regional and international scales.

Although the roots of "territorial social indicators" were in the 1970s (Smith, 1973), much of the development occurred in the 1980s. This time period witnessed an increasing interest in the complementarities of the objective and subjective indicators. One of the most important ideas of the 1980s was the awareness of the importance of linking social indicators to public policy, and engaging stakeholders' engagement in the development and selection of indicators. It is also because of this reason that the term "social reporting', became very popular (Beesley and Russwurm, 1989). Social reporting aims at providing information on social structures, processes, preconditions and the consequences of social policy, regularly and systematically in time (Smith, 1973). It is a presentation of data which enable the evaluation of living conditions of the population and their change over time. There are many examples of countries that prepare social reporting like "Social Trends" for Britain (Central Statistical Office of Great Britain), the Dutch "Social and Cultural Report" and the French "Données Sociales". In contrast to the United States, which failed to institutionalize regular social reporting at the national level, Canada certainly belongs to the best developed countries in this respect. Statistics Canada, for example, has published for many years the quarterly "Canadian Social Trends", which reports on various topics of living conditions and welfare in this country and also includes a sample of social indicator time series. There are also other organizations who conduct such projects and social reporting, like United Nations and Organization for Economic Co-Operation and Development (OECD) (United Nations, 1975; OECD, 1982).

In addition to changes in the focus of QOL studies, the 1980s were also the time of significant economic change. For example, globalization resulted in changes in urban functions that in turn had different sociological and physical effects on city neighbourhoods. These have been observed in many Canadian cities. As Ley and Bourne (1993) explain, "*...there is evidence that such gaps in well-being between metropolitan areas have intensified over the past twenty years*". Moreover, according to Statistics Canada (2000), neighbourhood inequality has been increasing since 1980 and the need for policy-relevant, intra-city research on QOL has never been stronger. For these reasons, many researchers have conducted QOL studies in different cities in

Canada (Williams *et al.*, 2001; Townshend, 2001; Sénécal, Hamel and Vachon, 2005; Langlois and Gilbert, 2005).

One such study, by Williams *et al.* (2001), conducted in Saskatoon, used a multi-stakeholder approach to derive QOL indicators. They used "subjective indicators", including "personal QOL", community QOL, government activities, government spending as well as demographics. While determining residents' QOL, the research examines how evaluations of QOL differ across three locales (each made up of a number of census tract clusters) representing low, medium and high socio-economic status (SES). One of the research questions posed in this study and of interest to geographers is that how the differing neighbourhood characteristics (locales) influence QOL for persons in similar SES circumstances. The study demonstrated that much of the satisfaction or dissatisfaction of the residents occurs not at the city level, but at the neighbourhood level. Furthermore, there has been a clear focus on the need for implementing appropriate measures for improved QOL in the low SES neighbourhoods.

Among other studies, Townshend (2001) stands out from a geographical perspective where he analyzed the contribution of neighbourhood social structures to the geography of well-being in Lethbridge, Alberta. Being an original contribution to the QOL literature, this research integrates a traditional *quantitative description* of urban social structure with the *qualitative dimension* more associated with QOL studies. Hence, Townshend's study not only contributes to the QOL research, but also he takes urban factorial ecology one step further. He points out one of the principal criticisms of these models, which is their inability to incorporate behavioural, cognitive or affective characteristics of communities.

Townshend (2001) showed that there is much stronger statistical explanatory relationship between "experiential community structures" (like the behavioural, cognitive and affective experiences of place) and the geography of well-being than there is between the census-based social structural variables and well-being. To derive the domains of "experiential community structure", a survey of 200 items was used (where a broad literature review was used to select the variables). From the 300 useable responses, the Index of Well-Being (IWB) was calculated. On the other hand, 1996 census data were used to obtain social structural information at the Enumeration Area (EA) scale. For both data sets, the indices were subjected to PCA to identify and separate different dimensions. Individual IWB scores were mean-aggregated to the EA scale and the visualization of this ecology was enhanced by generating an interpolated "surface" of well-being for the city. Then EA centroid coordinates were identified by GIS. And a city-wide "surface" of well-being was interpolated from these point-specific locations and mean well-being indices. Finally, multiple regression models were applied to see the relation between the "community structures", "social structures" and the well-being surface.

As a result of Townshend's (2001) study, 16 dimensions for "community structure" and 11 dimensions for "social structure" were identified (like "informal interaction", "facility use", "political participation", "people similarity", "family and age", "mobility", etc.). It was found that these dimensions contribute to the urban ecology of well-being. At the EA scale of analysis, the different "topographies" or surfaces of social structure were not adequate predictors of the intra-urban geography of well-being. It has been argued in this research that well-being must be directed not to structural factors but to human agency factors.

Townshend (2001) also showed that community surfaces act in the geography of well-being. "Community" is a multidimensional construct in which different dimensions act in well-being. At a city-wide scale, a number of distinctive features of community are unique predictors of well-being. However, at an intra-urban scale of social regions different relationships occur which varies from one neighbourhood to another because in one place or a region, community structures can be efficient to describe well-being on a collective basis, but on another region they can be poor to identify some domains. Therefore, this study extends the literature of QOL because of its success in defining the term within a more complex structure and combining both subjective and objective measurements through survey and census data.

One aspect to highlight in Townshend's (2001) study is the difference between the term "QOL" and "well-being". According to him, QOL is more complex than well-being because it includes well-being in addition to other individual psychological attributes and it can be linked to both objective and subjective domains. Differences between QOL and well-being were also underlined in Wheeler's study (1991). He notes that the global well-being of an individual is determined by seven dimensions: emotions, beliefs, temperaments, behaviours, situations, experiences and health. On the other hand, Chamberlain (1988) considered the concept of "subjective well-being" to have both "cognitive" and "affective" dimensions. Bradburn (1969) concluded that an individual can simultaneously experience both positive and negative affect of a life domain; for example an individual may be happy at work but unhappy because of traffic problems getting to and from work.

The study conducted by Williams *et al.* (2001) is similar to that by Townshend (2001) both in terms of the conceptual and methodological framework. They have both worked at an intra-urban level and used questionnaire surveys. However, Williams *et al.* (2001) have defined the dimensions and the variables for their study based on input from the community itself, whereas Townshend (2001) used the literature. For that purpose, Williams *et al.* (2001) used a participatory action research approach applied in Saskatoon where community members came together and a number of forums were used to discuss the survey draft and get feedback. As a next step, neighbourhoods of Saskatoon were grouped according to the socio-economic indicators obtained from 1996 Census data using SPSS. As a result, three neighbouring clusters were obtained: lower income families, mixed households and middle class families. The cluster analysis identified neighbourhoods that shared socio-economic characteristics, but represented relatively diverse physical and development characteristics. Then, with the help of GIS, using the neighbourhood boundaries, a telephone database for each neighbourhood group was obtained. For the following variables some frequencies were examined to see how different neighbouring characteristics affect QOL for individuals:

- overall quality of life,
- perception of happiness,
- change in life satisfaction,
- satisfaction with own neighbourhood,
- satisfaction with city.

The results of these frequencies showed that much of the degree of satisfaction or dissatisfaction occurs not at the city level but neighbourhood level. Williams *et al.* (2001) find that there are statistically significant variations in perceptions of neighbourhood attributes between the low income neighbourhoods on the one hand, and the medium and high income neighbourhoods on the other.

Among other important contributions to the reflection on the role of the environment on QOL comes from the Quality of Research Unit of the University of Toronto (Raphael *et al.,* 1996). These authors were interested in developing a broader conceptualization of QOL of the elderly than had been used in previous studies. The conceptual framework they proposed had three life domains (Table 2.2): being (who one is), belonging (one's fit with one's environment) and becoming (one's purposeful activities in life). These life domains are all shaped by two factors: importance and enjoyment, such that QOL results from the individual's own perceptions and evaluations. The questionnaire they developed consisted of 111 items applied to elderly people based on a score for both factors (importance and enjoyment) on a scale of 0-5. The QOL scores were calculated using the formula[3] below (which will also be used in this thesis):

$$\text{QOL} = [(\text{importance score}/3) \times (\text{enjoyment score} - 3)] \qquad (2.1)$$

The study of Raphael *et al.* (1996) was original because it showed that QOL indicators can be used for determining the health and service needs of seniors, and

[3]The range of the QOL scores are between -3.33 and +3.33. See chapter 3 for details.

analyzed both importance and enjoyment with respect to the life domains of an individual.

Table 2.2: The three life domains and their sub-domains

Being	Belonging	Becoming
• Physical • Psychological • Spiritual	• Physical • Social • Community	• Practical • Leisure • Growth

(Source: adopted from Raphael et al., 1996)

Another recent study, from Anderson and Langlois (2002), explores the effect of the environment on QOL. The model they propose has an objective and a subjective sphere that influence both the environment and the individual. QOL is part of the objective sphere, and is assessed by the ability of the environment to meet the physical needs of the individuals. Well-being, on the other hand, resides in the subjective sphere, and emerges from the assessments individuals make of the social and physical circumstances of their lives. Well-being is based on QOL, but is an extension and elaboration of it. Their model is explored in more detail in chapter 3.

Similarly, the integration of objective and subjective dimensions for QOL studies has also been suggested by Gilbert and Langlois (2004). They argue that despite the renewed interest in understanding the interrelation between objective and subjective measures, there have been few attempts in geography to move in this direction. Their study, hence, aims to fill this gap by comparing an objective measurement of the quality of life of the elderly population of the Outaouais region in Québec with data on its well-being collected through a survey. Residential capital, social capital and human capital were the three factors of well-being that these authors considered. Their results showed that both types of measures relate but they do not coincide entirely. The effect of the social environment on satisfaction, as revealed by the survey, was not well tackled by objective data. Gilbert and Langlois (2004) also conclude that gender, income and education are important to perceived well-being.

QOP, as such, was introduced by Andrews a few years ago. He defines QOP as: "*...an aggregate measure of the factors in the external environment that contribute to quality-of-life (QOL), which I in turn define as a feeling of well-being, fulfillment or satisfaction on the part of residents of or visitors to that place.*" (Andrews, 2001, p.201). According to this author, cultural amenities, crime, green spaces, and congestion are a few of the factors determining local QOP. Additional popular measures include:

- physical planning factors such as availability and diversity of housing and transportation options,
- economic factors such as employment opportunities and stability of property values,
- social factors such as educational opportunities, crime rates and sense of community,
- political factors such as trust in government and civic engagement.

Andrews (2001) finds that there are persistent problems in measuring QOP, highly personal links between individual QOP perceptions and aggregate QOP measurements, mostly unintended impacts of public policy decisions on QOP outcomes and inadequate triangulation across model approximations and data limitations when building tools to support local decision making. He suggests that ecological fallacy presents one hurdle, because QOL is perceived at the individual level by people with distinct world-views, whereas most QOP measures are aggregates applied to large populations. According to this author, it is inappropriate to claim that there are robust, deterministic links between measured QOP and perceived QOL. He argues that QOP is more complex than QOL. However, this latter view is questionable and is the main focus of this thesis because of the fact that QOP is interested in the factors related with place. The qualities of a place result from complex interactions among individual humans, their beliefs, institutions and the natural environment where they live. For these reasons, QOP is both similar and distinct to QOL. Andrews (2001) is among the few researchers who used the term "QOP" in the literature; however, the factors related with place should be defined in QOP, not in QOL. Therefore, QOP is defined at the intersection of QOL and well-being in this thesis and can not be more complex than QOL since it does not cover all the factors of life but instead covers the ones related with place. Another key point that QOP has gained much attention lately is the necessity of conducting such analysis among the citizens in today's cities. In particular, there has been growing interest by researchers (Donald, 2001; Hill and Markusen, 2000 and Florida *et al.*, 2000), municipal politicians and business leaders in the degree to which QOP serves to attract and retain the high-skilled employees, the worker who generates the ideas, creativity and imagination for knowledge-intensive production; that are regarded as important actors for success in the "new economy". The major characteristics of this worker are high mobility, attracted to cities that offer certain attributes (hence a better QOP) in terms of economic opportunity and diversity.

Florida *et al.* (2000) has based this argument on the fact that economic opportunity which causes high-technology workers to choose locations is not just an opportunity to work at a single job but rather it is a variety of good job opportunities that can be favoured over the others and also increasingly becoming important for spouses or partners of these workers. People previously used to be marginalised (women and other minorities) have started to work in every kind of jobs and started to expect a much broader range of opportunities. For instance, women working outside the home prefer places where there is more flexibility for their working hours, child care options and so on. It is also obvious that since women became more talented and better represented in the workforce, mobility became more difficult since the locations decision is now given by both of the spouses instead of one. This advantages certain places over the others and those cities that offer more opportunities and a better QOP for skilled spouses will better be able to attract couples. Florida *et al.* (2000) have also addressed social cohesion as an important key factor for the need of QOP studies. In their work, they cite Gates *et al.* (2000) who searched local diversity by measuring the concentration of gay couples within Metropolitan Statistical Areas (MSA). Florida *et al.* (2000) calls this index "Gay Index" as a reflection of a region's openness and attractiveness to alternative lifestyles.

An important issue raised in the literature concerns the adequacy of QOP measurements whether QOL perceptions and QOP measurements are linked or not. Andrews (2001) reports that QOP measures fail to capture all of the factors in the external environment that contribute to QOL. The links between them have been problematic because QOL is perceived at the individual level by people with distinct world views, whereas most QOP measures are aggregates applied to large populations. On the other hand, there is a problem of not uniform availability of data across place types (for example, while census data is provided at census tract areas, public health data at the county level). Besides, individuals have different preferences, which create a difficulty in establishing a relation between measured QOP and perceived QOL. Because of these reasons, it is hard to expect a strong linkage between the two terms.

To conclude, there is a high potential of studying QOP since it helps to keep in balance the various elements of our urban system such as environmental protection, sustainability and social equity. The interactions between economic growth and the hierarchy of personal needs imply the need for conducting QOP studies. In addition, public demand for improvements to QOP has also encouraged public officials to act and revise their policies. For this reason, Andrews (2001) argues that researchers and analysts are expected to offer facts to the public debates which includes the state of knowledge about QOP and efforts to measure, model and prescribe changes to it.

2.3. Literature review on RS and GIS applications on QOP

Having reviewed the literature about the concepts of QOL/well-being/QOP, this section is devoted to analyzing the attempts in information technology (RS and GIS) for measuring these concepts. The literature survey made about the GIS and RS applications on QOP studies showed that many methods have been used to derive relationships between remotely sensed data and socio-economic structure of cities.

Until the Second World War, remote sensing techniques had remained essentially the same since the acquisition of the first aerial photographs. The war, however, brought a dramatic increase in awareness of the potential of remote sensing in urban areas. A textbook published in 1948 showed the high potential of aerial photography in urban analysis (Branch, 1948). Many research projects and papers then followed which attempted to analyze or develop the applications and methods originally suggested by Branch. Witenstein (1954, 1955, 1956) and Wray (1960) studied the planning use of aerial photography. Wray (1960) developed a methodology for implementing part of the analytical process outlined by Witenstein. This work laid the foundations for later contributions to the USGS Census Cities Project (Wray, 1970). Other studies involving dwelling unit estimation include Hadfield (1963) and Binsell (1967). The use of black and white photography in socio-economic and demographic studies, as suggested by Branch (1948), was further extended by Green (1957), Green and Monier (1959) and Mumbower and Donoghue (1967) to analyze social variables and housing quality.

Green's (1957) work on the social structure of Birmingham, Alabama is considered as the initial research where physical data obtained from aerial photographs were related to socio-economic data. The research problem of his study focuses on the derivation of socio-physical relationships for predicting social structural information from the photo interpretation. He argues that aerial photographs do not contain social data but they instead, have physical data which can give input for social analysis. Moreover, Green (1957) notes that physical conditions affect the social structure and the way people live in cities. His study showed that the interpretation of aerial photographs contribute much to the socio-economic analysis of urban areas. According to the results of this study, 99% of the total housing structures were correctly identified where only 7% of the individual houses and 1.7% of the density of dwellings per block were underestimated.

The goal of these early studies was to predict socio-economic variables from photo-interpreted data. Extensive literature was cited as evidence for social values attached to housing and residential communities and, by extension, that observable physical data have meaningful sociological correlates. The generality of Green's approach, his aggregate treatment of data, and the choice of data items were criticized by Witenstein (1957) and Wellar (1968). Nevertheless, it is still significant that Green's scale of residential desirability accounted for 78% of the variation in his socio-economic status scale.

Mumbower and Donoghue (1967) also used aerial photographs to work on urban poverty of nine U.S and Puerto-Rican metropolitan areas. A dot matrix method which applies a sampling technique based on the super-imposition of a grid matrix containing spaced dots over the photographic area is used to make the population, density and dwelling unit computations. Then, for each city, a detailed land use map was made to analyze eight types of information on poverty: residential location, structure type, density, adjacent land use, transportation routes, presence of yard litter, absence of land/scaping and off-street parking. According to the results of their study, major characteristics of the poverty areas (or named as "disadvantaged") in the city are as follows:

- the population of these areas is generally located in central city where small and closely-placed buildings, debris and lack of infrastructure dominate,
- these areas are mainly close to industrial, commercial and transportation activities,
- housing density increases in poverty areas.

In a similar perspective, Metivier and McCoy (1971) manually interpreted aerial photographs of Lexington for housing density as an indicator of poverty.

The use of aerial photography as auxiliary census data was studied by Eyre *et al.* (1970). Although a number of difficulties were encountered, the techniques devised were considered most useful for intercensal extrapolation of census data. Research in Britain by Collins and Bush (1969), Collins and El-Beik (1971) and Gibson (1976) has further extended the use of conventional aerial photographs in the acquisition of urban land use information and for land use studies, by applying previously researched techniques to real world examples. However, De Bruijn *et al.* (1976) suggest that techniques developed elsewhere, especially for American cities, have not been particularly applicable to the more complex urban structures in Europe.

When we analyze those studies of the 1960s and 70s, it can be observed that these years saw a gradual change in the conventional approach to remote sensing with the introduction of color, color infrared, multiband, small scale, and space photography where digital images were collected through satellites. As a natural result of the trend towards smaller scales and greater coverage, research using these advanced techniques has emphasized regional rather than intra-city application, with the exception of housing quality studies (Westerlund, 1972).

Application of multiband and color infrared photography to the evaluation of housing quality, neighbourhood environment, and soci-economic criteria was conducted by Northwestern University and the University of California-Riverside in a joint research program during 1968 to 1970. Much of this work built upon the earlier studies of Green (1957) and Mumbover and Donoghue (1967). Wellar (1968) used large scale aerial photography in nine spectral bands to evaluate the quality of housing and neighbourhood environment. He found that 20 of the 24 items used by the American Public Health Association as criteria for housing environment appraisal could be consistently interpreted from the photography.

In a study by Tuyahov *et al.* (1973) various levels of housing and environmental quality were assessed and mapped using conventional black and white photography at a scale of 1:23 000 and color infrared photography at a scale of 1:190 000. Eighteen indicators or image signatures of different socio-economic classes were identified. Those considered potentially observable from satellite imagery included housing density, geographic pattern and uniformity, surrounding amounts of vegetation and percentage of roof cover. They concluded in part that the location, spatial arrangement, density and character of the housing units have ecological meaning in that exterior characteristics are surrogate measures for interior conditions.

Since the launching of the first Landsat satellite (first named as ERTS 1), most of the research in urban areas has been directed towards urban land use or land cover classification, which is in marked contrast to the studies of housing density, housing quality, poverty areas, demography and other socio-economic factors which were so apparent with larger scale aerial photographs. A number of researchers have, however, pointed to the potential of Landsat for image surrogate application. Erb (1974) suggests that a measure of vegetative cover can be used to determine density and age. Todd *et al.* (1973) discuss associations between the classified imagery and published socio-economic data. One association suggested was that between medium family income and various land use classes. Inner city classification compared well with the distribution of low income areas, while wooded suburb classification was essentially correlated with high income areas.

Another extensive study of relationship between Landsat data and socio-economic data was carried out by Landini and McLeod (1979). The Landsat data items were used as independent variables in a multiple regression analysis to predict a number of socio-economic variables. Single family land use and open vacant use were shown to be the most significant Landsat data items in predicting total population.

Associated with the greater use of Landsat data has been the increasing application of computerized methods. Furthermore, with the development of the first GIS in the mid-1960s, the "Canada Geographic Information System (CGIS)", the research in urban areas has experienced major improvements. The Canada Land Inventory was an effort by the federal and provincial governments to identify the nation's land resources and their existing, and potential uses. Following CGIS, in 1967, the US Bureau of Census developed "Dual Independent Map Encoding-Geographic Database Files (DIME-GBF)", a data structure and street address database for the 1970 census which supported automatic referencing and aggregation of census records. Remote sensing, on the other hand, also played a part in the development of GIS, as a source of technology as well as a source of data.

It is not before the 1980s that GIS really began to take off when the price of computing hardware had fallen to a level that could sustain a significant software industry and cost-effective applications. It is, therefore, since these years that spatial analysis and cartographic modelling techniques in GIS and digital image processing techniques in remote sensing could enhance each other's operations in urban applications (Hutchinson, 1982; Richards *et al.*, 1982; Wang and Newkirk, 1987).

When we analyze the studies of the 1960s and 70s, it is observed that the socio-economic and physical variables that have been used like income level, educational achievement, occupation or housing condition, are still the relevant types of variables for the assessment of QOL. However, at those times, both the social and the physical structure of the cities were different from the metropolitan cities of today which has been explained in the previous section. Therefore, while the variables selected for those studies still keep their relevancy, the meaning attached to them has undergone a significant change due to the new urban dynamics. In addition, with the technical improvements in RS, GIS and computer technology as it is explained above, it is now easier to carry out such studies from satellite images that enable users to make digital image enhancement processes according to the goals of their research studies (Lo and Faber, 1997; Fung and Siu, 2000; Reginster and Nagot, 2005).

Weber and Hirsch (1992), have used such a computer-assisted approach on the development of urban quality of life indices for Strasbourg where they have integrated SPOT-XS digital image and census data. The SPOT multispectral images were first rectified and classified into eight classes of land cover and were then related to population and dwelling density data from the census data by using multiple regression analysis. Their findings pointed out that the relations between population structure and remote sensing data were not as obvious as those between housing structure and remote sensing data.

A very recent study conducted by Reginster and Nagot (2005) aimed to analyse empirically the effects of environmental quality on residential location choices in two Belgian cities, using a detailed description of the urban environment derived from remotely sensed data and using GIS tools. These authors have discussed that according to urban models which include amenities, environmental quality may influence land rents and location by income in the city. In order to test these relations, average land rents and mean income per district are regressed on distance to the distance to the center and several environmental characteristics. Fourteen environmental variables, representing socioeconomic facilities and natural attributes are obtained from aerial photographs, satellite images and ancillary data. Their spatial representations are constructed using GIS functions. Their results confirmed that the impact of greenery on location choice and the existence of a higher environmental quality at the periphery than near the center of the two cities. Another study by Lo (1995), contributes to the QOL studies for the estimation of population data and dwelling units where he has applied image classification and statistical methods for the metropolitan area of Hong Kong. The results of the estimations made in this study were compared with the actual population data. It is observed that the accuracy of each method varies in the macro (general estimations for the whole study area) and micro (estimations at the smallest areal units called "Tertiary Planning Units" (TPU)) levels.

Gomes and Lins (2002) have also studied urban QOL through an application of the integration between GIS and Multi-Criteria Decision Analysis (MCDA) to aid spatial decisions. The research presents a hypothetical case study to illustrate the GIS-MCDA integration towards a selection of the best municipal district of Rio de Janerio State, Brazil, in relation to quality of urban life. The authors surveyed the existence of the variables that could represent the quality of life (particularly the variables that are related to the quality of the public services) in the Brazilian agencies of information and how to use them to subsidize the decision-making process. As for the selected criteria, they argue that an urban society where the essential needs are almost satisfied, such as leisure options, climate, ease of movement and architectural/urban factors, must be included to evaluate the quality of urban life.

Being one of the very few and recent examples of QOL studies in remote sensing field, the study of Lo and Faber (1997) is of particular interest for this thesis. The basic assumption of the study is that there is a relation between greenness and the QOL. They studied Athens-Clarke County using Landsat-TM digital image, black and white panchromatic aerial photographs, 1990 census and housing data and census block group boundaries. As a first step of the study, both census block group data and Landsat-TM images were georeferenced to Universal Transverse Mercator (UTM) and registered using topographic map sheets with ground control points. Secondly, the block group file was converted into raster format for creating socio-economic data layers. Then, biophysical parameters and land cover information were extracted. For this purpose, three major types of environmental information were extracted from TM data: land use/cover information, Normalized Difference Vegetation Index (NDVI) and surface temperatures.

Since "greenness" is a desirable quality of a morphological environment, in this study, as a next step, NDVI is calculated to assess this characteristic (technical background on vegetation indices will be provided in section 2.4 of this chapter). Then, these NDVI values had to be aggregated into block groups for the purpose of integration of census data in a GIS environment. Therefore NDVI values of the pixels within a boundary of a block group were averaged to give one value. Furthermore, like the NDVI values, the temperature values are also needed to integrate with block groups and for this purpose, they were averaged. Following these, 4 types of socio-economic variables were extracted from census data: population density, per capita income, median home value and percentage of college graduates. A map of these variables was then converted into raster format. For the integration purpose, PCA and GIS overlay approaches were used. First, seven layers of image data were subjected to PCA as: percentage of urban use, NDVI, surface temperatures, population density, per capita income, median home values, percentage of college graduates. Then, these are all aggregated at the census block-group level. Table 2.3 shows the positive and negative correlation for these variables.

Table 2.3: Positive and negative correlations obtained from PCA

Relationship / PCA Component	Variables with positive loading	Variables with negative loading
PC1	- NDVI - Per capita income - Median home value - % of college graduates	- % of urban use - Surface temperature - Population density
PC2	- Per capita income - Median home value - % of college graduates - % of urban use - Surface temperature - Population density	- NDVI

(Source: based on Lo and Faber, 1997)

From Table 2.3, it is observed that, Lo and Faber (1997) make an important contribution showing that the NVDI is related to the socio-economic characteristics of the area. Since it is a biophysical variable, which is strongly correlated with surface temperature and urban use, it provides a linkage to the socio-economic data. The results of their study showed that there is a strong relationship between biophysical parameters extracted from remotely sensed data and socio-economic data. Being one of the biophysical variable NDVI (a good measure of greenness), gives a useful way of QOL assessment of a place and it is a good indicator of the socio-economic conditions of the area. They use two integration approaches (PCA and GIS overlay) and although they are not new methods for remote sensing applications, the study brings a different perspective to QOL assessment. Due to the improvements in RS and GIS techniques, more recent vegetation indices yielding better results, post-classification and new spatial analysis techniques will serve to increase of the accuracy of these studies. Therefore, an emphasis on a technical review will be provided in the next section, to highlight both how these recent developments and major traditional methods (like PCA or spatial analysis) could be used for QOP measurement.

2.4. Technical review on TDVI, PCA and spatial analysis

Transformed Difference Vegetation Index (TDVI):

The quantity and the quality of the green areas in cities are one of the highly desirable variables of QOP (Lo and Faber, 1997). The literature in both urban geography and remote sensing shows that there is a strong relationship between urban QOP and the presence of greenness that can be extracted from remotely sensed data (Wellar, 1968; Weber and Hirsch, 1992; Fung and Siu, 2000). In the last decade, over forty vegetation indices were introduced in the remote sensing literature, to measure the vegetation cover in different applications (Bannari *et al.*, 1995a). Since soil brightness, environmental effects, soil color, moisture and shadow are major complex mixtures of vegetated areas; vegetation indices make an effort in minimizing the effect of those sources and enhance the vegetation response.

The main principle of vegetation indices is a combination of the red and near-infrared reflectance (NIR) since the red reflectance is sensitive to chlorophyll content and NIR reflectance is sensitive to biomass. In a given image, hence, the greater the difference between the red and NIR reflectance, the greater the amount of green vegetation present while small differences indicate mostly bare soil or other non-green materials. However, the signals at the sensor are affected by various physical effects such as atmospheric effects, topographical effects, drift of the sensor radiometric calibration, spatial and spectral characteristics of the sensors, the optical properties of the bare soil subjacent to the vegetation cover (those are even more complex in urban environments) and problems of saturation and linearity (Bannari *et al.*, 1995a). Consequently, a good recognition of the vegetation cover is limited by factors that decrease or increase reflectance in the red and NIR spectral bands. Hence, the errors in the interpretation and analysis of the results provided by the vegetation indices should be considered carefully. The analysis of vegetation indices is also very important for urban geographers and planners who have to rely on an accurate level of information about the types of vegetation cover (such as urban forests, parks and cemeteries) in the city neighborhoods.

Therefore, the main goal of this thesis is to analyze the performance of a new vegetation index, TDVI developed by Bannari *et al.* (2002), and to see how it behaves in urban environment to understand the greenness component of QOP. Furthermore, the potential of TDVI is also analyzed in chapter 5 through a comparison of two conventional and popular vegetation indices, Soil Adjusted Vegetation Index (SAVI) which minimizes errors resulting from the optical properties of bare soil (Huete, 1988) and NDVI (Rouse *et al.*, 1974):

$$NDVI = (NIR - R) / (NIR + R) \tag{2.2}$$

$$SAVI = (1 + L) (NIR - R) / (NIR + R + L) \tag{2.3}$$

$$TDVI = 1.5 * [(NIR - R) / (NIR^2 + R + 0.5)^{1/2}] \tag{2.4}$$

R = reflectance in the red channel,

NIR = reflectance in the near- infrared channel,

L=0.5

Principal Component Analysis:

Statistical methods have been commonly used to understand the community structure of the cities and the relation between different variables of this structure. Among these, PCA has become a very popular method. It was originated by Pearson (1901) and later developed by Hotelling (1933). The literature review on QOL and QOP in the previous section has indicated that many researchers applied PCA to analyze the correlation between different variables in their dataset (Kam, 1995; Lo and Faber, 1997; Fung and Siu, 2000; Langlois and Kitchen, 2001; Bonaiuto *et al.*, 2003; Ogunseitan, 2005). While some of these studies were conducted in a RS/GIS environment to understand the physical structure of urban places, the others attempted to correlate socio-economic and demographic characteristics of the community.

As Johnston (2000) states, PCA is a statistical procedure for transforming a data matrix so that variables in the new matrix are uncorrelated. The difference between Factor Analysis and PCA is that there are in the latter as many new variables (named as components) in the transformed as in the original matrix.

The components in PCA are extracted by an iterative averaging procedure. The first principal component occupies a position as close to all of the original variables as possible. The second is as close to as possible to the residual variation from the first, and so on until all have been extracted.

The output of a PCA has three broad types of information (Jolliffe, 2002; Cureton and D'Agostino, 1983; Gorsuch 1983):

1. *Eigenvalues:* they are measures of the relative importance of each component. If the eigenvalues are high, then the commonality between the original variables is also high,
2. *Component Loadings:* they show the correlations between the original variables and the new ones, thus identifying which groups of variables have common patterns,
3. *Component Scores:* they are values for the observations on each of the new variables.

PCA has been used by geographers both in statistical and RS/GIS environments:

a) to identify groups of inter-correlated variables,
b) to simplify a data set by removing redundant information resulting from inter-correlated variables,
c) to reorganize a data set by removing collinearity.

In remote sensing, extensive interband correlation is a problem frequently encountered in the analysis of multi-spectral image data. Images generated by digital data from various wavelength bands often appear similar and convey essentially the same information. Principal transformations are, therefore, designed to reduce such redundancy in multi-spectral data. These transformations may be applied either as an enhancement operation prior to visual interpretation of the data or as a pre-processing procedure prior to automated classification of the data. If employed in the latter context, PCA generally increases the computational efficiency of the classification process because it results in a reduction in the dimensionality of the original data set (Lillesand and Kiefer, 2000).

With the reasons explained above, PCA will be applied in this thesis since a large set of data, both social and physical, is used to analyze QOP in Montréal and to understand the links between variables.

Spatial Analysis:

The literature review in the previous section shows that some methods of spatial analysis in GIS have commonly been used to understand the different components of QOL and QOP in the RS/GIS field. While some authors use spatial analysis to understand the social structure (Martin, 1989; Bassam *et al.*, 2000), others apply it to understand the physical structure of the cities such as the distribution of green areas, transportation network or accessibility to public services (Wang and Stauffer, 1996; Fung and Siu, 2000; Liu and Zhu, 2004; Tsou *et al.*, 2005).

Spatial analysis is defined as the study of spatial relationships between geographic features by using the processes of modeling, examination and interpreting, for the purpose of evaluating, estimating, predicting and understanding these relationships (Longley *et al.*, 2002). It is considered as one of the most important capabilities of GIS since it includes all of the transformations, data manipulations and methods that can be applied to geographical data to add value to them, to support decisions and to reveal patterns and anomalies. Early studies using spatial analysis were conducted even before GIS was developed where many researchers applied methods manually or with the help of other tools.

In GIS, there are mainly six types of spatial analysis methods: queries and reasoning, measurements, transformations, descriptive summaries, optimization and hypothesis testing. Longley *et al.* (2002) have summarized these methods as follows:

Queries and reasoning are the basic spatial analysis types where simple queries are handled in GIS. The essential point is that, the data don't change and no new data is produced as a result (like the query of "closest school in the neighbourhood"). Measurements are simple numerical values that describe aspects of geographic data (like length or area).

In addition, transformations are simple methods of spatial analysis that result in the change of datasets combining or comparing them. They usually apply geometric, arithmetic or logical rules including the transformation from raster to vector format or vice versa (Longley *et al.*, 2002). Moreover, descriptive summaries use descriptive statistics to capture the major characteristics of a datasets in terms of one or two numerical values (like the mean or standard deviation). Optimization techniques attempt to select ideal locations for objects given certain criteria (like location selection of a new shopping mall). Finally, hypothesis testing, works on the process of reasoning from the results of a limited sample to make generalizations about an entire population.

Since a key benefit of GIS is the ability to apply spatial operators to data to derive new information, many tools have been used for analysis and modelling which form the foundation of all spatial modelling and geoprocessing. Being one of the three types of GIS data (vector, raster and tin), the raster data structure provides the richest modeling environment and operators for spatial analysis. Modelling, in general terms, is a representation of reality which helps decision makers, planners or policy makers to understand, describe or predict how things work in the real world. There are two main types of models:

1. Representation models,
2. Process models.

The first type of modelling attempts to represent the objects in the landscape such as buildings, streams or forests. The way representation models are created in GIS is through a set of layers. In the spatial analyst toolbox in ArcGIS software (which is used in this thesis), these data layers are either raster or feature data. Raster layers are represented by a rectangular mesh or grid, and each location in each layer is represented by a grid cell, which has a value. Cells from various layers stack on top of each other, describing many attributes of each location (Figure 2.1).

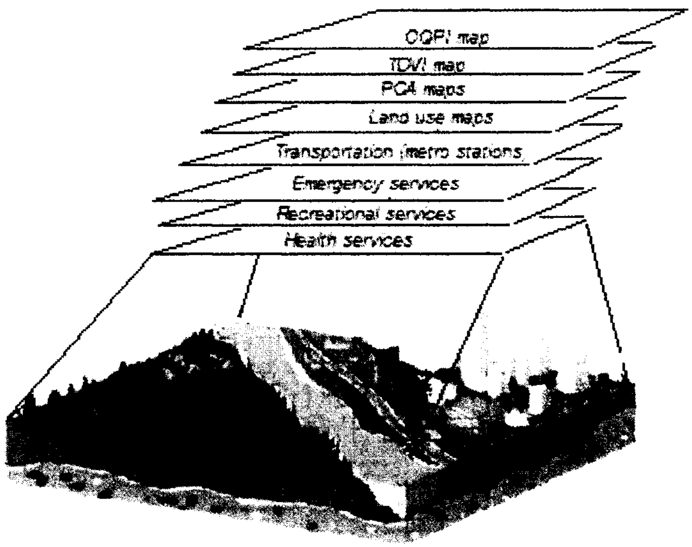


Figure 2.1: The representation model in spatial analysis *(adopted from ArcGIS)*

The representation model attempts to capture the spatial relationships within an object (the shape of a building) and between the other objects in the landscape (the distribution of buildings). Along with establishing the spatial relationships, the GIS representation model is also able to model the attributes of the objects (e.g. who owns each building). These models are sometimes referred to as data model and are considered descriptive models (ArcGIS, 2005).

The second type of modeling, process modeling, is much more interested in describing the interaction of the objects that are modeled in the representation model. The relationships are modeled using spatial analysis tools. This type of modeling is sometimes referred to cartographic modeling. Although process models can be used to describe processes, they are often used to predict what will happen if some action occurs. Each spatial analyst operation and function available in ArcGIS software can be considered as a process model while some are simple (like adding rasters together) and some are more complex (like adding logic or special functions).

There are many types of process models to solve a wide variety of problems. Some include:

- Suitability modeling: Most spatial models involve finding optimum locations such as finding the best location to build a new school, a landfill or a resettlement site.
- Distance modeling: What is the distance from the closest fire station to a historic building?
- Hydrologic modeling: Where will the water flow to?
- Surface modeling: What is the pollution level for various locations in a county?

For the purpose of the QOP study that is conducted in the thesis, most of the promising capabilities of spatial analysis methods, like linear distance calculation to public services and zonal statistics, are applied in chapter 5.

2.5. Problem definition based on the literature review

Based on the preceding both conceptual and technical literature review, two problems are identified on which the research problem definition is built. The first problem arises from the lack of consistency between the definitions of "QOL", "Well-being" and "QOP". As it is discussed in the literature survey, these terms differ from each other. The lack of such a differentiation has led to misunderstanding of the concept of QOP and hence, many studies show limited results to express urban quality of place. Therefore, one can conclude that an important problem in QOL/well-being/QOP studies is the clarification of the terminologies as Langlois and Anderson (2002) have pointed out.

Another problem is linked to the operational definition of QOP. As it is shown in the literature review, objective and subjective indicators are used to measure QOL/well-being/QOP. However, there are not many studies that try to integrate these two different aspects. In addition, some special considerations should be taken into account for both objective and subjective dimensions. For instance, the followings can be regarded as important key elements in the objective dimension:

1) The selection of indicators: The indicators should provide government or other actors such as environmental scientists, non-governmental and community groups, stake holders, real estate developers and residents with useful information of the sort that could aid decisions on the allocation of finance or make public policies.
2) The aggregation of indicators to one element: A major decision has to be taken on how to aggregate many different measurements to form a general indicator of QOP.
3) The weighting or non-weighting of the indicators: Many attempts to develop social indicators without employing a personal survey have simply applied equal weightings to all the components of life quality in deriving an aggregate measure. This can be criticized that weighting all the measures equally could be misleading.

For subjective measurements, the followings have been regarded as problems:

1) Validity: It is sometimes not practicable to obtain good measures of how people evaluate their lives and its various components.
2) Interpretation: The person who evaluates the survey data might not be well qualified or be influenced by different actors (because each person is unique and has different criteria for evaluation).
3) Completeness: Infinite range of possible human concerns.

There are also some problems attached to the measurement methods of QOP, both in statistical and RS and GIS techniques. The advantages and disadvantages of the studies introduced in this literature review can be summarized as follows:

- The studies of the 1960s proved that socio-economic data related to urban systems have high correlations with physical data, which is extracted from remotely sensed data. Moreover, the variables for detecting QOL/QOP can be similar, but the meanings attached to those variables have altered, therefore those variables should be updated according to the needs of today. Furthermore, the data used to make such an assessment are incapable of monitoring a rapidly changing urban environment. High-resolution satellite image data obtained from new sensors (SPOT-HRS, Quickbird, IRS or IKONOS) is useful for these purposes. However, economically speaking, these images cost more and cover a small territory.

- Secondly, when the studies that used such satellite imagery (Landsat MSS and Landsat TM from the 1972 and 1980s respectively), have been conducted, it was concluded that they were usually incapable of bringing new dimensions to the QOP assessment. Although the data used for the studies were new like Landsat-ETM+ or SPOT-HRV images, the methods were not efficient to point to the changing meaning of the variables. For example the indices as housing index or NDVI components derived for urban quality of life assessment using remotely sensed data can not be considered alone for a comprehensive evaluation. For example "greenness" cannot be the only criterion as a physical variable that has a relationship with socio-economic variables.
- Therefore, new physical variables, other than housing conditions and greenness, should be derived for such analyses. The suggestions can be, for example, the accessibility to emergency services, education, commercial and governmental usages or metro stations, which directly affects every citizen's life every day and hence an indicator of a place's attractiveness in terms of QOP.
- Furthermore, it has also been suggested to use the integration of GIS and remotely sensed data to increase capabilities. However, the integration of different types of data (census data, remotely sensed data and ancillary data stored in GIS) is not an easy task due to the nature of the data. There are several issues related to scale and resolution problems like the ecological fallacy problem (Alker, 1969), modifiable areal unit problem (MAUP) (Openshaw, 1984), the selection of imagery with the optimum scale and resolution, etc.

Being one of these problems, MAUP was first discovered in a study by Gehlke and Biehl (1934). They observed in their study that, the data of male juvenile delinquency were correlated with median equivalent monthly rental for aggregations of 252 census tracts. But as the number of regions was decreased from 252 to 25 by aggregation, it was observed that the correlation coefficient was increased. Openshaw (1984) has analyzed this situation again, and he has suggested the terminology MAUP to account for the observed phenomenon. According to him, this problem is due to a scale and an aggregation problem, both which are inextricably linked. The first refers to the variation in the results when areal units are progressively aggregated into fewer and larger units for analysis. The second refers to variation in results due to the use of alternative aggregation schemes at equal or similar scales (spatial resolutions). The scale problem is observed when there is uncertainty about the zones most appropriate for the study and the aggregation problem occurs because of the uncertainty about how the data are to be aggregated to form a given number of zones. Fotheringham and Wong (1991) have also identified this problem as the extent of the spatial bias in a multivariate regression analysis and Fotheringham *et al.* (1995) carried out similar research. Furthermore, Marceau (1994) was the first to illustrate that remotely sensed data represent a particular case of the MAUP.

For a solution to the MAUP problem, Longley *et al.* (2002) have introduced a study of Openshaw and Alvanides (1999), which is a reformulation of the MAUP into a geo-computational approach to zone design forms. They develop a geo-computational pattern in GIS to interpret the effects of zone measurement upon spatial analysis since GIS will allow users to identify their own customized zonal representations. However, with this approach, MAUP will disappear if only GIS analysts understand the particular areal units that they wish to study. According to Longley *et al.* (2002): *"There is a sense in which sensitivity analysis of the effects of zones upon the calculation of spatial measures implies recognition of the importance, not just of the objective spatial structure of space but also its particular qualitative character. There is also a practical recognition here that the areal objects of study are ever-changing, and our perceptions of what constitutes their appropriate definition will change"*. Another solution to this problem has come from Hay *et al.*

(2001). They have proposed a new analytical and upscaling framework based on the spatial influence of the dominant objects composing a remotely sensed imagery.

Besides, Dudley (1991) indicates that the modifiable areal unit problem is also highly related with ecological fallacy. "*...in socio-economic and environmental applications, the measurement of geographic individuals is unlikely to be determined with the endpoint of particular spatial analysis applications in mind. As a consequence, we cannot be certain in ascribing even dominant characteristics of areas to true individuals or point locations in those areas. This source of uncertainty is known as the ecological fallacy*" (Longley *et al.*, 2002).

Because of the reasons explained above, the next chapter will be devoted to the elaboration of a new conceptual framework that tries to solve the first problem, which is an effort in solving the problem of confusing terminologies between QOL, well-being and QOP. The goal is to make a new definition of urban QOP and build its relationship with QOL and well-being. Then, the methodological framework that will be introduced will need to find a solution to the second problem, which arises from the operational definitions. In this case, the goal is to find a new way to measure both objective and subjective dimensions of QOP with different sources of data using information technologies.

2.6. Conclusions

The arguments about the definition and the indicators of QOP showed that a more useful way of utilizing both the objective and subjective indicators is highly demanded. Since both have many advantages and disadvantages, a model based on an empirical study should be developed and tested. Such a theory should be able to examine the measurement, reliability and validity problems. Moreover, the selection of indicators and weighting of major life concerns and appropriate geographic scale are the important concepts that should be considered.

Although QOL, well-being and QOP studies are based on the fields of sociology and psychology, the "spatial dimension" has also been introduced by the geographer's contribution. This is due to the increase in the interest of territorial social inequalities in many societies. According to many geographers and urban planners, the distribution of resources can be more equal if it is proportional to the needs of the area which is far from being the case most of the time. The aggregate satisfaction level in an area doesn't always define the level of the individual.

Finally, the technical literature review also supported the necessity of developing a new methodological framework where both objective and subjective dimensions of QOP will be analyzed with different sources of data through the contribution of information technologies.

3 Conceptual and Methodological Framework

"No one is an artist unless he carries his picture in his head before painting it, and is sure of his method and composition."[4]

3.1. Introduction

In this chapter, a new conceptual framework will be defined based on the literature survey made in chapter 2. The main objective is to identify the relationships among QOL, QOP and well being; differences and similarities and the usefulness of QOP from a geographical perspective.

Following the conceptual model, a new methodological framework will be introduced for the study. The goal here is to measure QOP in both objective and subjective dimensions and explore the strength of their relationship. This will be performed through the integration of different sources of data with the help of RS and GIS technologies.

3.2. Proposed conceptual framework

The literature survey made in the previous chapter showed that problems arise in QOL studies from two dimensions: first is the lack of common understanding of the terms "QOL", "well-being" and "QOP". Secondly, the measurement techniques do not yield successful results that are capable of showing different aspects of QOP. Therefore, this thesis will make a significant contribution to QOP literature by introducing a new conceptual framework that integrates these dimensions through GIS and RS.

[4] Claude Monet, also known as Oscar-Claude Monet (November 14, 1840 – December 5, 1926) was a French impressionist painter.

The research questions in formulating the new conceptual framework for QOP in this study are as follows:

1. What is the role of place in determining one's QOL and well-being? Is it possible to link QOP with QOL and well-being?
2. What are the components of a place that determines its quality? How are these components located in the objective and subjective domains? And what is the relationship between those two domains?
3. Given the same physical environmental characteristics (in the objective domain), how do the evaluation and perceptions of individuals living in the same neighbourhood differ from each other (in the subjective domain)? Is there a difference in their evaluation in terms of "importance" and "satisfaction" levels? If so, how can be these two levels measured?
4. Is there a way to integrate the objective and subjective domains of QOP and how can it be measured?

A number of key themes emerge from the literature review as being crucial in answering the research questions raised above towards a new conceptual framework for QOP. As the starting point, the first attempt is to underline the role of place in determining one's QOL and well-being. QOP is concerned with both the living and natural environment. In other words, many factors that affect every citizen's daily life such as services, facilities, amenities, water and air quality, amount of green areas or economic vitality and social equity are embedded within the concept of QOP. These QOP factors, that are within the objective dimension, contribute to and are part of QOL evaluations. However, place is also construed through a repository of shared memories, feelings and traditions (Corcoran, 2002). Thus, feelings of place attachment are significant markers of QOP. This is particularly relevant in the context of the individual's own evaluations about the place. The ability of adaptation to that place through one's own aspirations and experience determine the level of satisfaction of that place, which in turn together with other factors determines personal well-being. Hence, QOP is linked to well-being in the subjective dimension.

In exploring the concept of QOP in more detail, "built and natural environment" and "individuals" are defined as the two components of place in this thesis. Being one component, environment (both natural and constructed) come to be inscribed in one's place consciousness. With the existence of natural resources for basic needs such as food or shelter; for enjoyment needs such as availability of natural environmental beauty or accessibility to public services which can dramatically alter the quality of a place and social capital developed from such environment. On the other hand, unique human responses to places and the associations they carry in terms of the human capital they hold to and their own evaluations form the other component of QOP. This latter component will be named as individuals in the conceptual framework.

Figure 3.1 shows the proposed conceptual framework. It differentiates the terms "QOL", "well-being" and "QOP" and makes the linkage between them. For this purpose, the model proposed by Langlois and Anderson (2002) has been used as a basis and has been modified. The model they propose has an objective and a subjective sphere that take into account both the environment and the individual. QOL is part of the objective sphere, and is assessed by the ability of the environment to meet the needs of the individuals. Well-being, on the other hand, resides in the subjective sphere, and emerges from the assessments individuals make of the social and physical circumstances of their lives. Well-being is based on QOL, but is an extension and elaboration of it.

Since Langlois and Anderson (2002) started a discussion towards an integrated model of QOL and well-being, the new approach proposed for this thesis will therefore include QQP in the model as an integrative component. According to Figure 3.1, QOP has been placed at the intersection of objective and subjective spheres. The reason by assigning QOP to the subjective sphere stems from the fact that its variation, with respect to different geographical locations, depends on the evaluation of different socio-economic and cultural characteristics of individuals. Therefore, subjective indicators may be used to measure QOP. However, it can also be assigned to the objective sphere since physical characteristics of the environment determines the degree of QOP which may be achieved through objective indicators such as the amount of greenness in the area or accessibility to public services etc. So, while QOL tries to explain all life domains in an objective dimension (for instance, a spatial analysis of aggregate levels of income, education, health distributions), QOP

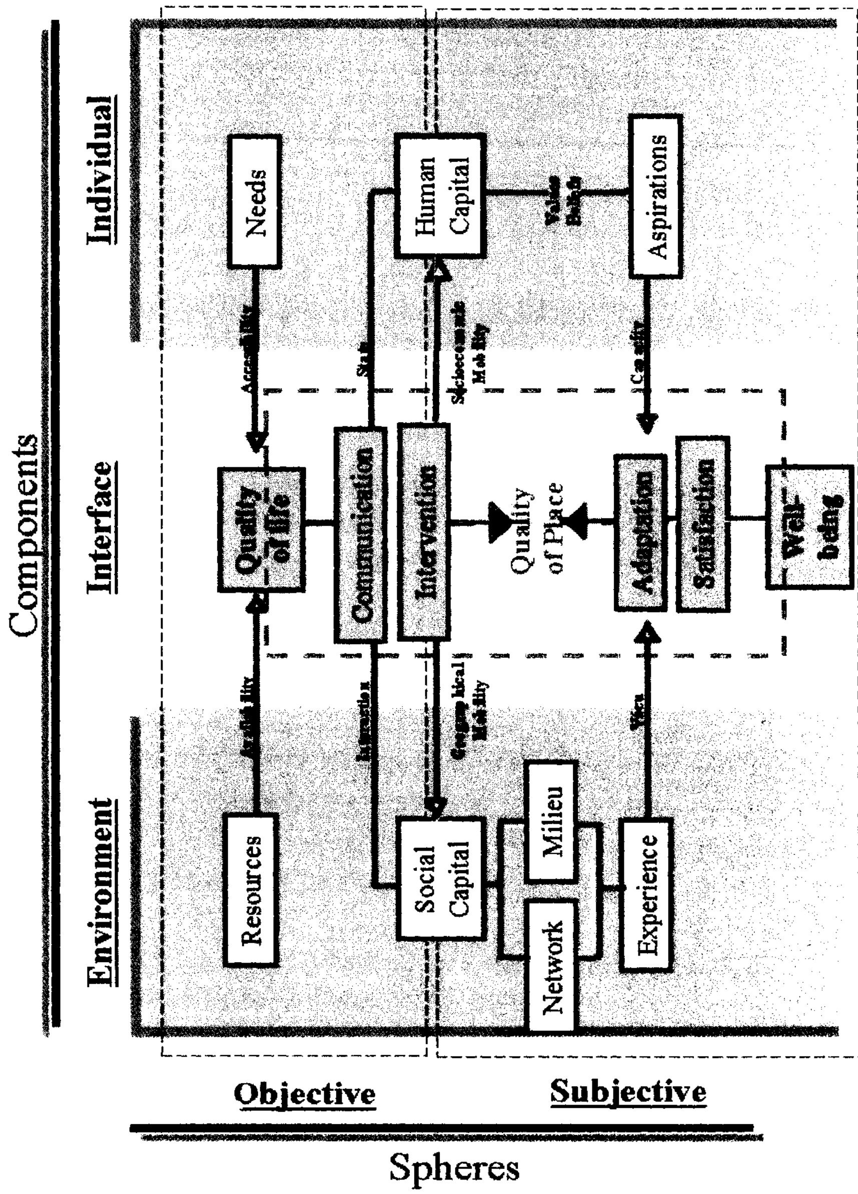


Figure 3.1: The new conceptual framework (based on Langlois and Anderson, 2002).

would tell how individuals in a specific area would perceive their living and natural environment as a liveable place while taking into account the special characteristics considerations of that area. Therefore, the new definition for QOP has been updated in this thesis as:

> *"QOP is an integrated measure of the objective and subjective factors that an individual is satisfied with his/her living and natural environment".*

With this new definition of QOP, an attempt has been made to introduce the "spatial dimension" into the QOL and well-being model that was proposed by Langlois and Anderson (2002) as a missing part of the puzzle. Furthermore, a special effort has been given to integrate both the objective and subjective dimensions in the same model. The reason is that, as indicated in chapter 2, many research projects have been based on either objective or subjective indicators. A limited number of studies have been conducted using both of the indicators; however, today, the trend is to base it on both.

Since many factors intervene between the objective world and an individual's evaluation of it, one can assume that there is a relation between objective and subjective indicators. The factors that affect the importance of this relation are summarized as follows:

1) Individual experience: Some experiences might affect an individual's perception of quality of life for specific criteria.
2) Aspiration level of the individual's expectations: The satisfaction level of an individual might be different from another person within different objective situations.
3) Accommodation: In a fixed situation, an individual's satisfaction with a condition may increase over time by accommodation to that situation.
4) Individual's cultural background: This produces the standard of comparison against which objective conditions are measured. The effect of this factor can be observed in different spatial scales like international, national, regional or even within city itself.
5) Scale discordance: While objective social indicators are collected for well defined territorial units it is unlikely that the territorial base of an individual's perception will coincide exactly with the boundaries of the administrative unit used for the collection of objective data.

3.3. Proposed methodological framework

Research methods can be classified in various ways; however, one of the most common distinctions is between qualitative and quantitative research methods. Quantitative methods were originally developed in the natural sciences to study natural phenomena. Examples of quantitative methods now well accepted in the social sciences include survey methods, laboratory experiments, formal methods (e.g. econometrics) and numerical methods such as mathematical modelling. Qualitative research, on the other hand, is described as the non-numerical examination and interpretation of observations for the purpose of discovering underlying meanings and patterns of relationships (Babbie, 1992). These methods were developed in social sciences to enable researchers to study social and cultural phenomena. Examples of qualitative methods are action research, case study research and ethnography. Qualitative data sources include observation and participant observation (fieldwork), interviews and questionnaires, documents and tests and the researcher's impressions and reactions.

Unfortunately, the ability to combine research expertise across traditional methodological boundaries is often thwarted. Qualitative and quantitative researchers often operate with a different set of assumptions about the world and ways of learning about it. These assumptions may be seen as mutually and inevitably irreconcilable. Researchers are often thought to master only one type of method and, so, become comfortable with their expertise in handling either quantitative or qualitative analysis, but not both (Casebeer and Verhoef, 1997). The result is that the two major approaches are seldom combined and their respective strengths are ignored. Instead of either ignoring or defending a particular research paradigm, it is possible and more instructive to see qualitative and quantitative methods as a part of a continuum of research techniques. The point here is not to understand the specific differences of these techniques, but to highlight the existence of a range of options in both methods.

> *"Both qualitative and quantitative methods may be used appropriately with any research paradigm. Questions of method are secondary to questions of paradigm, which we define as the basic belief system or world view that guides the investigator"* (Guba and Lincoln, 1989).

Within the discussion of which method is best, there are a few but important moves toward more collaborative use of both types of research methods in urban geography, particularly in relation to the study of QOL and QOP as indicated in the literature survey in chapter 2. Thus, the need to recognize that both methodological schools as equally respectable will be the main focus of the new methodological framework proposed in this thesis. The goal here, is to measure QOP in both objective and subjective dimensions through a combination of qualitative and quantitative research techniques and prove whether there is a link between them or not. This will be performed through the integration of different sources of data with the help of RS and GIS technologies.

The proposed methodological framework is given in Figure 3.2. Generally, three types of information explaining QOP will be gathered in statistical, RS and GIS environments. The three types of information (based on study of Townshend, 2001) are as follows:

1. Social structural information (objective dimension).
2. Physical structural information (objective dimension).
3. Experiential community structural information (subjective dimension).

3.3.1. Objective dimension

This dimension of QOP explains both the social and the physical structural information which is measured objectively. Social structural information is derived from census-based variables like income, ethnicity, family status or education level whereas physical structural information helps to analyze the "place" in terms of accessibility to public services and the characteristics of the urban land use.

3.3.1.1. Social structural information

First, from 2001 census data, the selected variables (as will be defined in chapter 4) for all the census tracts (CTs) in Montréal will be exported from the Beyond 2020 program to Excel, to give labels for each variable. Then, the file is exported to SPSS, a statistical program which enables the user to do statistical analysis and later provides an opportunity to save the resulting tables in ".dbf" format to use in the Arcview system for GIS applications. The next step, is to calculate the percentages for each variable (this is necessary since the values of each variable are different, like income level, education or household size, etc.).

Statistical methods are the ones that have been commonly used to understand the community structure of the cities and the relation among different variables of this structure. Since large sets of data have commonly been used for such analysis, being one of these statistical methods, PCA have become a very popular method and it will be used in this study (see chapter 2 for technical background on PCA).

At this stage PCA will be used to see the relation between different types of census data and to analyze the spatial differentiations of neighbourhoods in Montréal through the help of resulting components (C_i, where i=1,2,3,...,N). These components will also be used, later, to determine three neighbourhoods where the questionnaires were distributed.

After obtaining the components, a QOP index (QOP_{cs}) is derived by linear weighted summation at CT level. The eigenvalues will be used for giving weights to each component.

$$QOP_{cs} = (\sum_{i=1}^{N} e_i.C_i) / N \tag{3.1}$$

Finally the index scores will be mapped at CT level and this final map will be rasterized in order to use in the Multi-Criteria Evaluation (MCE) algorithm at the final steps.

3.3.1.2. Physical structural information

At this stage, remote sensing data and other urban data layers (hospitals and other emergency services, transportation modes, education services and land use) will be used to obtain the physical structural information which is a component of objective QOP. From remotely sensed data, vegetation cover and land use information will be gathered through "Transformed Difference Vegetation Index (TDVI)", PCA_{rs} and Parallelepiped Classification procedures. The value of TDVI varies from 0 to 1 as greenness increases. For integration with social data, the TDVI values have to be aggregated into CTs. The TDVI values of pixels found within the boundaries of each CT, hence, will be averaged to give one value.

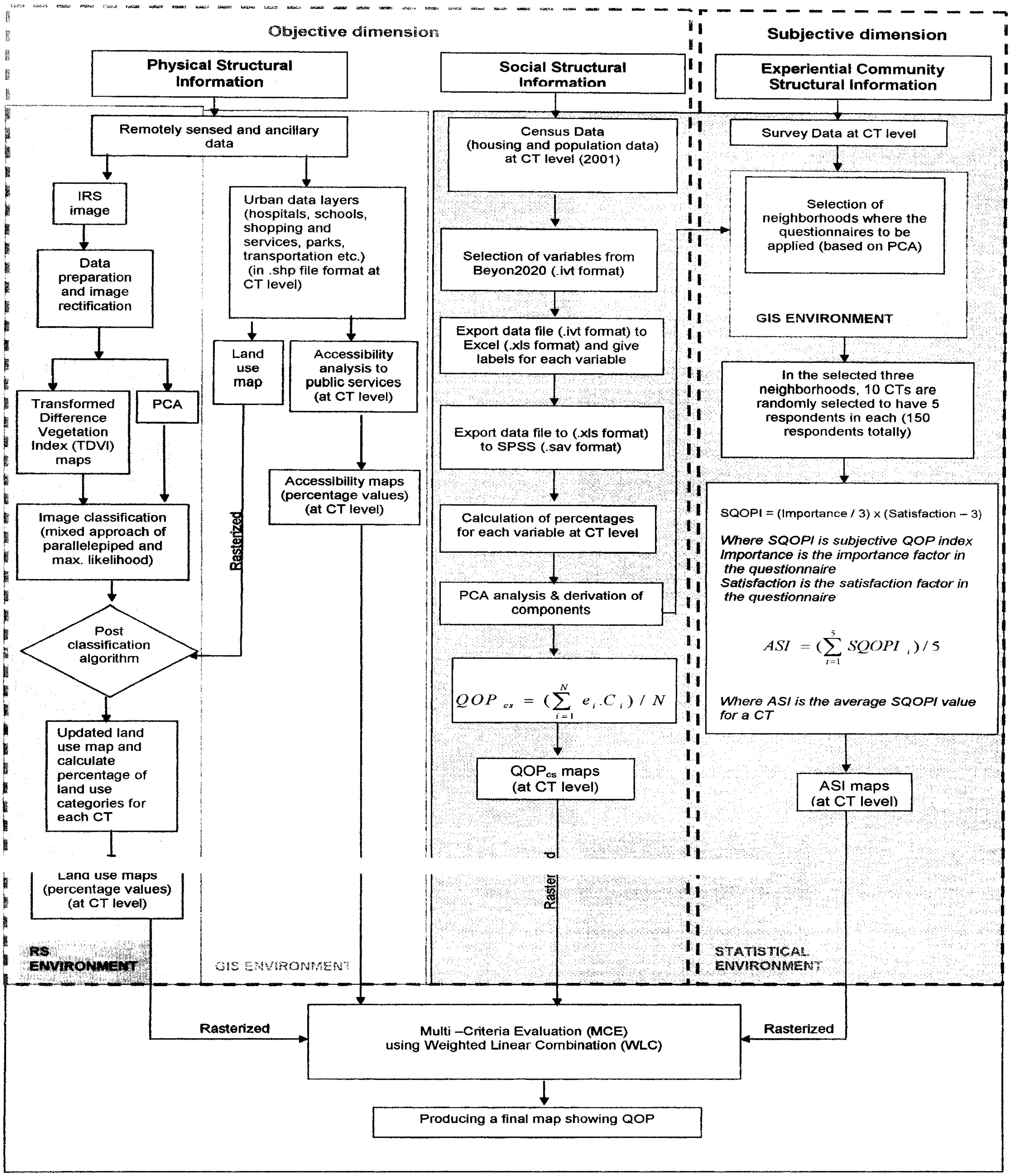


Figure 3.2: The proposed methodological framework for QOP

Moreover, a land use classification map will also be obtained from IRS-1D image. For this purpose, the classification procedure will use the integration of GIS and RS techniques together with the help of a post-classification algorithm. As a first step, PCA_{rs} will be applied to the four channels of image data. The resulting components and the TDVI will be subjected to a mixed approach of parallelepiped and maximum likelihood classification procedures since conventional image processing techniques based on spectral observation are often not sufficiently accurate for urban studies. The problem is that one spectral class may often represent subsets of more than one object class. Besides, the land use information obtained from an image does not provide any knowledge about how that land is used like commercial, governmental or industrial. While GIS stored urban land use data has the advantage of providing such information, on the other hand, it has the disadvantage of giving a static model of the urban environment and less detailed information on the vegetation cover. To overcome these problems, a post-classification modification algorithm that contains a set of decision rules will be applied. For this purpose, first, the land use map stored in GIS will be transferred to raster format for each land cover/use category within a range of 1-10. Then the post-classification process will be applied which enables comparison of each pixel assigned to a land use class in the IRS image with the one in rasterized GIS based land use map. After obtaining the final land use map, the percentage for each land use category will be computed since the number of pixels falling in a CT will be known.

The information on the accessibility to public services like emergency, health, education and transportation will be obtained using ancillary data in vector format. With ArcView Spatial Analyst, the accessibility of each CT for a public service will be calculated using the "straight distance" algorithm. The results of these analyses will be the layers for accessibility to each public service and in raster format to be used in further steps of the study in Multi-Criteria Evaluation (MCE).

3.3.2. Subjective dimension

As it has been discussed in the proposed conceptual framework, place is also an aggregation of shared memories, feelings and traditions. Thus, feelings of place attachment are significant markers of QOP. This is particularly relevant in the context of an individual's own evaluations about the place. Both social and human capital and the ability of adaptation to that place determine the level of satisfaction of that place. Hence, QOP is linked to well-being in the subjective dimension.

This dimension will not only contribute to understanding the differentiation among the perceptions of the individuals for their QOP, but also to see the link between the objective and subjective indicators. The following section will summarize the steps that will be used to analyze the survey data within the subjective dimension of QOP named as: "experiential structural information".

3.3.2.1. Experiential community structural information

To extract experiential community structural information at the individual level, questionnaires were distributed in selected neighbourhoods of Montréal. For each CT, a subjective QOP index was computed based on a study of Raphel *et al.* (1996) as explained in chapter 2. These authors were interested in developing a broader conceptualization of QOL of the elderly than had been used in previous studies. The conceptual framework they proposed had three life domains: being (who one is), belonging (one's fit with one's environment) and becoming (one's purposeful activities in life). These life domains are all shaped by two factors: importance and enjoyment, such that QOL results from the individual's own perceptions and evaluations. The questionnaire they developed consisted of 111 items applied to elderly people based on a score for both factors (importance and enjoyment) on a scale of 0-5. In this thesis, the questionnaire used to analyze QOP in the neighborhoods of Montréal contains 97 variables. Equation (2.1) is adopted and modified to calculate a "subjective QOP index (SQOPI)" as follows:

$$\text{SQOPI} = (\text{Importance} / 3) \times (\text{Satisfaction} - 3) \qquad (3.2)$$

In this calculation, "importance" scores are considered as weights for converting "satisfaction" scores into SQOPI values. The items in the questionnaire rated as "very important" produce "very high" SQOPI scores for items where high satisfaction is indicated by the respondent. Furthermore, items rated as "very important" produce "very low" SQOPI scores where lack of satisfaction is indicated. Items rated as being less important produce more moderate SQOPI scores.

SQOPI values range from -3.33 (which means "not at all satisfied with very important items") to +3.33 (which means "very satisfied with very important items"). If the value of the SQOPI is above "0", then it can be considered that the respondent has a positive QOP perception, but if it has a value of below "0" then the QOP is negative for that individual.

While dividing importance scores by 3 merely restricts the range of QOP scores, it also makes explicit that a rating of 3 for importance (leading to a weight of 1) is associated with QOP score being equal to the unweighted satisfaction score. The subtraction of 3 from satisfaction scores serves to set the range of satisfaction scores from +2 to -2 and allows higher importance scores to increase the magnitude of QOP scores.

Since there are five respondents in each CT, an average value of SQOPI index (ASI) will be computed in order to use in the MCE stage as follows:

$$ASI = \left(\sum_{i=1}^{5} SQOPI_i\right) / 5 \qquad (3.3)$$

3.3.3. Integration of the objective and subjective dimensions

To integrate all different sources of data, MCE technique will be used. This technique is chosen since it allows the user to join several criteria at the same time which is the goal of many urban applications (Voogd, 1983). According to Eastman (1999), this technique uses one of the following procedures: "Boolean overlay" whereby all criteria are reduced to logical statements of suitability and then combined by means of one or more logical operators such as intersection (AND) and union (OR).

The second is known as "weighted linear combination (WLC)" wherein continuous criteria (factors) are standardized to a common numeric range, and then combined by means of a weighted average. The result is a continuous mapping of suitability that may then be masked by one or more Boolean constraints to accommodate qualitative criteria, and finally threshold to yield a final decision. Eastman (1999) also argues that the Boolean strategy dominates vector approaches to MCE, while WLC dominates solutions in raster systems.

The study proposed in this thesis will use the second method of MCE since all the layers will be in raster format at CT level. Therefore, the resulting QOP map will be a continuous mapping style showing which sectors are good for the selected criteria of QOP or vice versa.

3.4. Conclusions

In this chapter, a new conceptual framework has been proposed for QOP to differentiate it from the other two concepts of QOL and well-being. The proposed model defined QOP not only at the intersection of QOL and well-being but also in two dimensions: objective and subjective. The links between the QOP, QOL and well-being indicated that while QOL tries to explain all life domains in an objective dimension, QOP tells how individuals in a specific area perceive their physical environment as a liveable place while taking the special characteristics into consideration in that area.

Moreover, the new methodological approach presented in this chapter not only enables users to understand both objective and the subjective dimensions of QOP, but also shows how the integration of RS and GIS can assist for measuring those dimensions. With the help of many different data sources (census, survey, remotely sensed and GIS data), it is hypothesized that the full picture of QOP will be provided in better ways and the spatial differentiations among the neighborhoods will be analyzed.

Another expectation from this methodology is that to obtain the link between the two dimensions, objective and subjective, and to show whether one can be explained in terms of the other or not. Since there are many variables from different sources of data included within the new model, it is assumed that some correlations would yield better understanding of the QOP, while others might not be very clear to understand. For instance, while the QOP for the young and elderly population might differ, there might be slight differences among different genders although the objective QOP index would be same for all.

4 Case Study and Data Sources

> "The sense of 'liveability' in Montréal derives perhaps most of all from the city's unique kind of urbanity, embodying a European flavor but one that has been transplanted to a resolutely North American context where culture seems much more fluid than in the Old World"[5]

4.1. Introduction

The conceptual and methodological framework proposed in chapter 3 will be tested in Montréal. The reasons why this city was chosen will be underlined and the sources of data and the variables will be explained in this chapter. The analysis of demographic, economic, linguistic characteristics and the social upgrading/gentrification process in Montréal will not only help to understand the urban dynamics within the city but also highlight the effects of the two components on QOP, environmental and individual, as introduced in the conceptual framework.

4.2. Study area: Montréal

Much of the research on urban social problems in Canada has focused on the central areas of the largest cities in Canada including Toronto, Montréal and Vancouver. The central city includes the core area and the inner city. According to Langlois and Kitchen (2001), the central city can be defined as the largest place or municipality in a census metropolitan area (CMA). It has the largest population and is usually the oldest place in a metropolitan area. On the other hand, they also argue that there is a lack of consensus on what constitutes the inner city in Canada. However, as Ley (1991) argues, the inner city can be defined as the area including the central business district (CBD), as

[5] Rose D. and Germain A., (2000), *Montréal: the Quest for a Metropolis*, Chichester, West Sussex ; New York : Wiley, p.5

well as the surrounding areas of mixed land uses and high-density residential development.

For this study, Montréal's inner city will be analyzed because of the significant problems and changes that have occurred in the city over the past two decades. As Langlois and Kitchen (2001) argue, these include the substantial loss of manufacturing activity and employment, the out-migration of businesses and residents from core areas to the suburbs (and to other parts of Canada, particularly the non-Francophone population) and a growing concentration of social and economic problems in the central city. Selected economic characteristics for the major Canadian cities show that Montréal is among the most distressed cities (Tables 4.1 and 4.2). The census data show that the CMA had the highest rates of unemployment in 1991, 1996, 2001 and 2005. According to Table 4.2, Montréal had the lowest median family incomes in 1991 and 1996 and the highest percentages of low- income families. According to Statistics of Canada, in 1996, more than one third of all families in the City of Montréal were low-income (34.1 %). In 2001, the CMA had still the lowest percentage of low-income among the other CMAs in Canada (22.2%).

Table 4.1: Unemployment rates for the major Canadian Census Metropolitan Areas (CMAs)

CMAs	Unemployment rate (%)								
	1991	**1996**	**% change** (1996-91)	**2001**	**% change** (2001-1996)	**2005**	**% change** (2005-01)	**2006**	**% change** (2006-05)
Toronto	8.5	9.1	0.6	5.9	-3.2	7.3	1.4	6.4	-0.9
Montréal	**11.7**	**11.2**	-0.5	**7.5**	-3.7	**8.4**	0.9	**9.4**	1
Vancouver	9.2	8.6	-0.6	7.2	-1.4	6.3	-0.9	4.3	-2
Ottawa	7.3	8.8	1.5	5.6	-3.2	6.9	1.3	4.9	-2
Edmonton	8.3	8.2	-0.1	5.5	-2.7	4.6	-0.9	3.9	-0.7
Calgary	8.0	6.6	-1.4	4.9	-1.7	3.7	-1.2	2.9	-0.8
Quebec	9.1	10.4	1.3	6.9	-3.5	6.4	-0.5	5.8	-0.6
Winnipeg	8.6	7.9	-0.7	5.6	-2.3	5.1	-0.5	5.1	0
Hamilton	8.9	8.1	-0.8	5.7	-2.4	5.6	-0.1	5.9	0.3
London	8.5	9.3	0.8	6.7	-2.6	6.9	0.2	6.3	-0.6

(*Source: based on Langlois and Kitchen, 2001 and Statistics of Canada, 2006*)

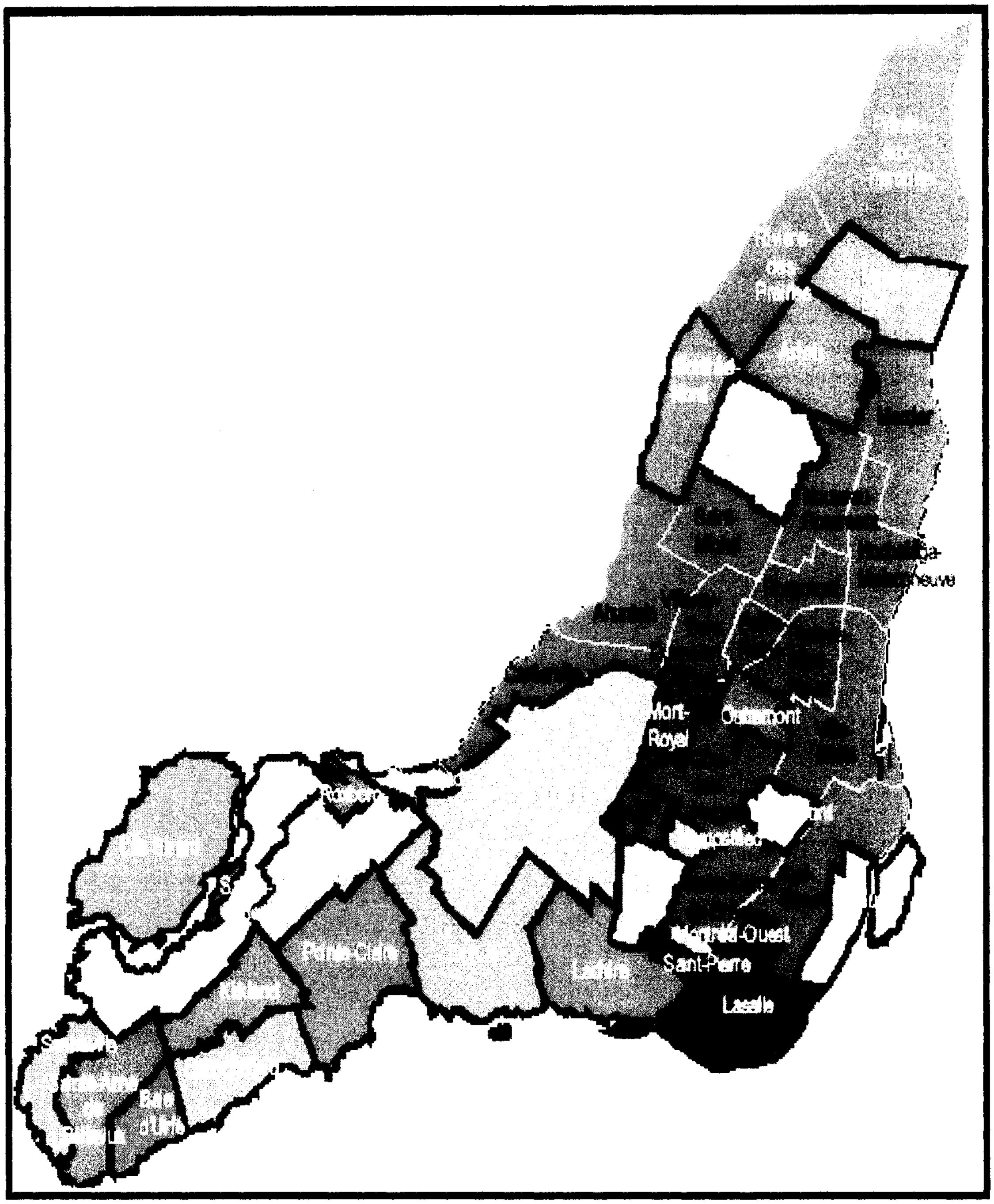
Table 4.2: Selected economic characteristics for the major Canadian Census Metropolitan Areas (CMAs)

CMAs	**Median family income (CAD)**				**Percentage of low-income**				
	1991	**1996**	**% change** (1996-91)	**2001***	**1991**	**1996**	**% change** (1996-91)	**2001**	**% change** (2001-1996)
Toronto	54 661	52 959	-3.1	83 863	12.4	18.6	6.2	16.7	-1.9
Montréal	**44 196**	**45 142**	**2.1**	72 175	**18.5**	**22.6**	4.1	**22.2**	-0.4
Vancouver	49 530	51 281	3.5	77 005	13.6	18.7	5.1	20.8	2.1
Ottawa	55 876	57 386	2.7	87 920	11.5	15.2	3.7	15	-0.2
Edmonton	47 879	49 483	3.3	76 238	15.9	17.4	1.5	16.2	-1.2
Calgary	50 480	53 134	5.3	79 098	14.1	15.7	1.6	14.1	-1.6
Quebec	44 874	47 074	4.9	69 180	15.6	18.6	3.0	18.9	0.3
Winnipeg	44 164	47 307	7.1	69 837	16.7	18.4	1.7	13.2	-5.2
Hamilton	50 319	53 884	7.1	82 089	12.7	15.9	3.2	16.7	0.8
London	47 991	51 079	6.4	70 775	10.7	13.6	2.9	15.1	1.5

**2001 census data includes all census families and both spouses or partners with earnings.*

(Source: based on Langlois and Kitchen, 2001 and Statistics of Canada, 2006)

The city of Montréal, like the other cities of Québec, underwent a significant redefinition of its territory since 2001. Before the municipal regrouping of 2001, the city of Montréal was composed of 16 neighborhoods occupying the Island of Montréal with 28 other municipalities (Figure 4.1). The city of Montréal as such was divided into two, with a completely detached part of the city in the north-east of the island made up of the neighborhoods of Pointe-aux-Trembles and Riviere-des-Prairies. Since the regrouping of 2001, the city has occupied the whole of the Island of Montréal. The new city had 1,812,715 residents (based on the 2001 census) divided in 27 neighborhoods (Figure 4.2). In general, the former municipalities of the Island and the municipal neighborhoods have all become, with certain regroupings, the new administrative districts. Only the former municipality of Montréal-Est has disappeared as an administrative unit. However, in January 2006, the city underwent another municipal territory change where a new municipal organization was also introduced. The new city now comprises 19 neighborhoods (Figure 4.3) and continues to offer services throughout the territory of the



not to the scale

Figure 4.1: The municipal boundaries of Montréal before regrouping in 2001
(*Source: Marois and Langlois, 2003*)

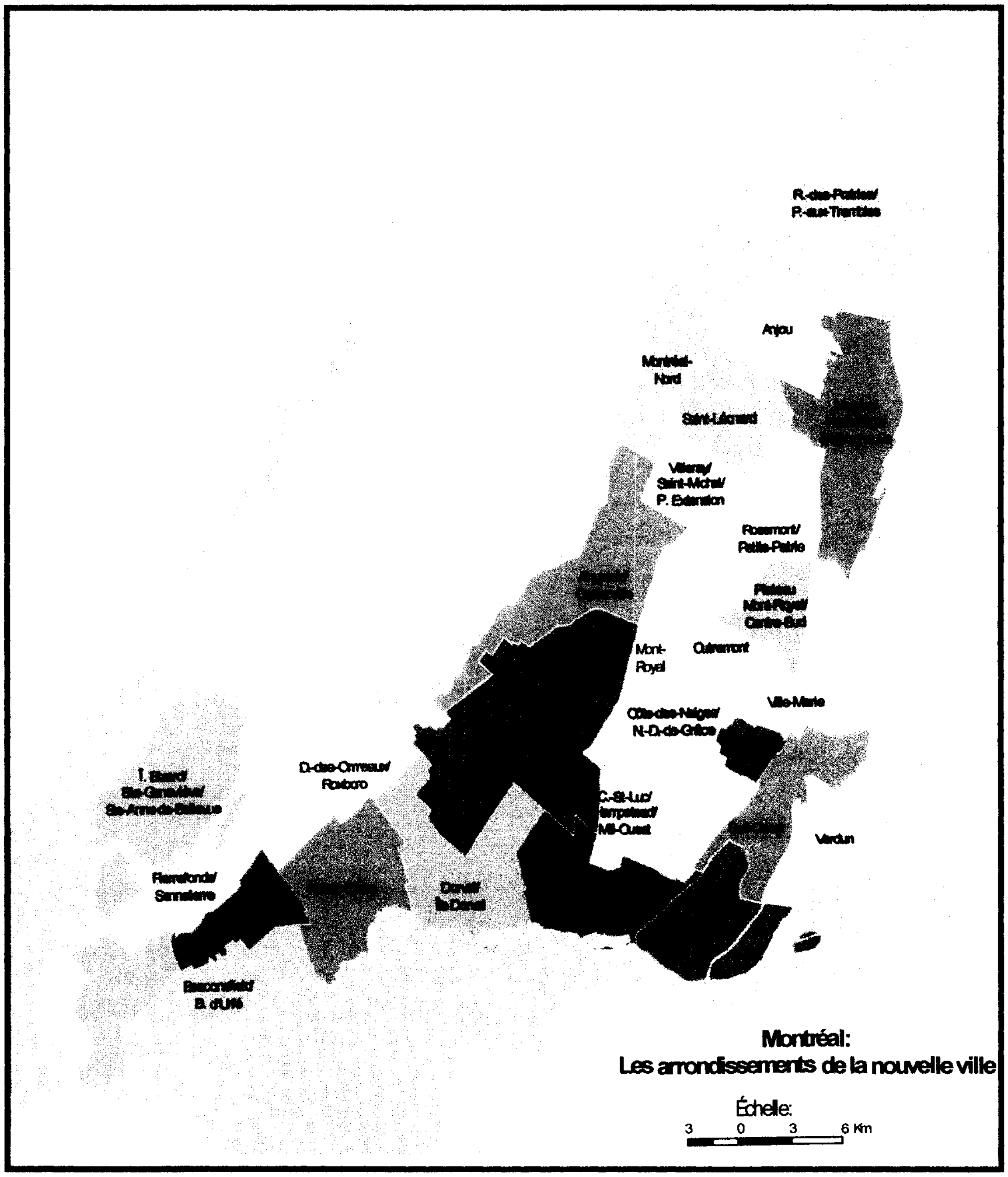
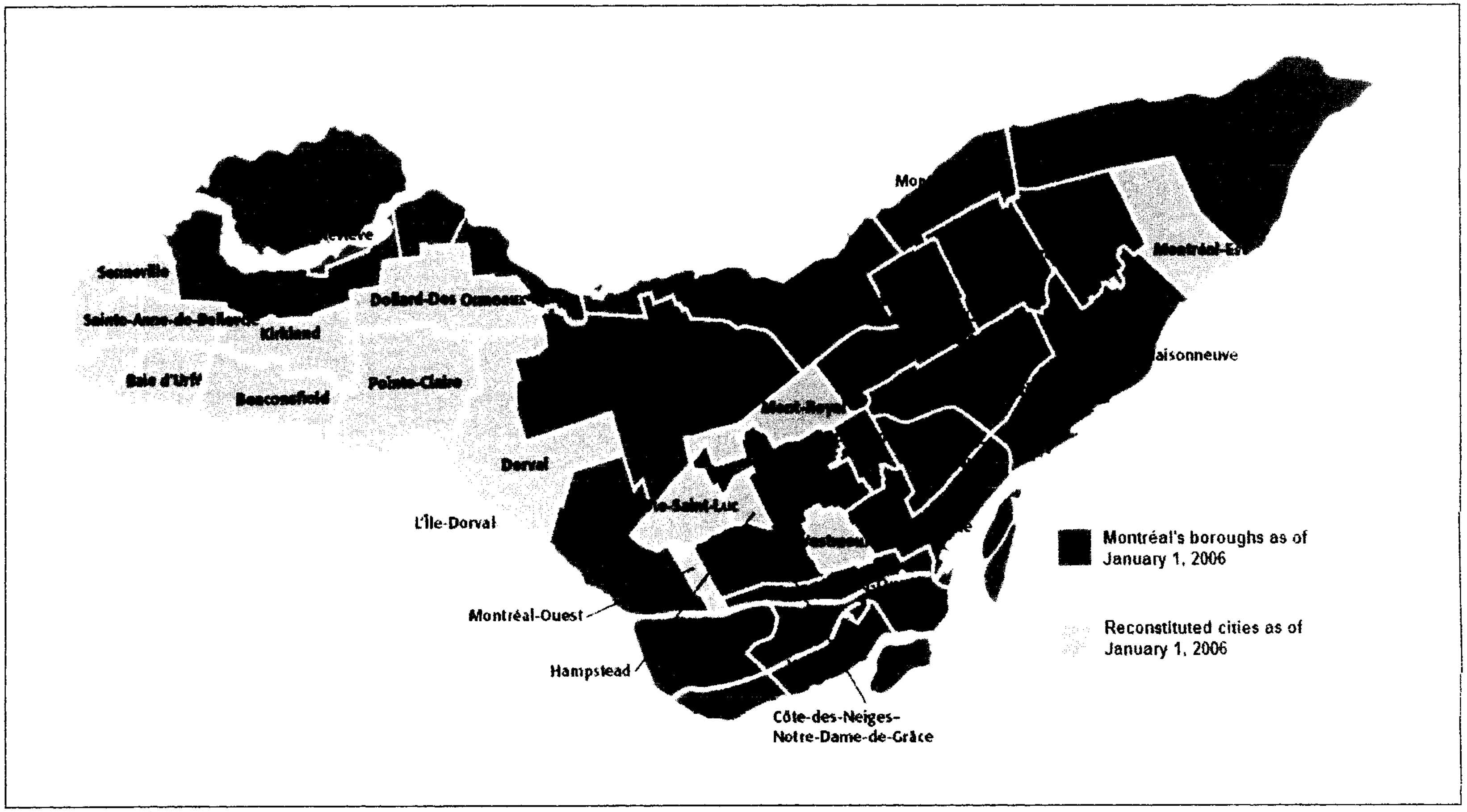


Figure 4.2: The district boundaries of the city of Montréal after regrouping in 2001 (*Source: Marois and Langlois, 2003*)



*not to the scale

Figure 4.3: The district boundaries of new city of Montréal as of January 1, 2006

(*Source: Ville de Montréal, 2006*)

island of Montréal, including the 15 reconstituted cities (Table 4.3). A new political entity, the agglomeration council, will be created at the time of this thesis is written.

Table 4.4 gives the list of the administrative districts with their respective population in 1996 and 2001. As seen from this table, for 1996, the districts differ widely in terms of their population, varying between 17 572 (Dorval/L'Île-de-Dorval) and 157 541 (Côte-des-Neiges/Notre-Dame-de-Grâce). These are the former central neighborhoods (before the regrouping in 2001) that generally constitute the most populous whereas certain former districts from the west of the island are among the least populous. With the recent amalgamation in 2006, the population range between 23 239 (Outremont) and 163 110 (Côte-des-Neiges/Notre-Dame-de-Grâce). From these numbers, it is observed that Côte-des-Neiges/Notre-Dame-de-Grâce has always been the most populous neighbourhood.

Table 4.3: Montréal's new districts and the reconstituted cities as of January 2006

Montréal's boroughs as of January 1, 2006	Reconstituted cities as of January 1, 2006
Ahuntsic-Cartierville	Beaconsfield
Anjou	Baie d'Urfé
Côte-des-Neiges—Notre-Dame-de-Grâce	Côte-Saint-Luc
Lachine	Hampstead
LaSalle	Dollard-Des Ormeaux
Le Plateau-Mont-Royal	Dorval
Le Sud-Ouest	Kirkland
L'Île-Bizard—Sainte-Geneviève	L'Île-Dorval
Mercier—Hochelaga-Maisonneuve	Montréal East
Montréal-Nord	Montréal West
Outremont	Mount Royal
Pierrefonds-Roxboro	Pointe-Claire
Rivière-des-Prairies—Pointe-aux-Trembles	Sainte-Anne-de-Bellevue
Rosemont—La Petite-Patrie	Senneville
Saint-Laurent	Westmount
Saint-Léonard	
Verdun	
Ville-Marie	
Villeray—Saint-Michel—Parc-Extension	

(*Source: Ville de Montréal, 2006*)

Table 4.4: Population of districts in the city of Montréal in 1996 and 2001

Districts	Population 1996	Population 2001
1. Ahuntsic / Cartierville	123 461	125 160
2. Anjou	37 308	38 015
3. Beaconsfield / Baie d'Urfé	23 188	N/A
4. Côte-des-Neiges / Notre-Dame-de-Grâce	157 541	163 110
5. Côte-Saint-Luc / Hampstead / Montréal Ouest	41 605	N/A
6. Dollard-des-Ormeaux / Roxboro*	53 776	N/A
7. Dorval / L'Île-Dorval	17 572	N/A
8. Kirkland	18 678	N/A
9. L'Île-Bizard / Sainte-Geneviève /Sainte-Anne-de-Bellevue	21 077	N/A
10. Lachine	39 910	40 077
11. Lasalle	72 029	73 457
12. Mercier/Hochelaga-Maisonneuve	125 519	128 440
13. Montréal-Nord	81 581	83 600
14. Mont-Royal	19 671	N/A
15. Outremont	22 571	23 239
16. Pierrefonds */ Senneville	53 892	65 156
17. Plateau-Mont-Royal	99 575	101 364
18. Pointe-Claire	28 435	N/A
19. Rivière-des-Prairies / Pointe-aux-Trembles / Montréal-Est	103 135	102 457
20. Rosemont / Petite-Patrie	129 417	131 318
21. Saint-Laurent	74 240	76 500
22. Saint-Léonard	71 327	69 604
23. Sud-Ouest	66 434	69 604
24. Verdun	59 714	60 564
25. Ville-Marie	72 049	75 880
26. Villeray / Saint-Michel / Parc-Extension	141 663	145 000
27. Westmount	20 420	N/A

N/A refers the records that are no longer within the city of Montreal as of January 2006.

* as of January 2006, Pierrefonds and Roxboro are amalgamated.

(Source: Marois and Langlois, 2003 and Ville de Montréal, 2006)

4.2.1. Social profile of Montréal

As it was analyzed in the literature review, economic factors such as employment opportunities and unemployment rates are key factors that determine local QOP. To put in other words, QOP serves to attract and retain the high-skilled employees, the worker who generates the ideas, creativity and imagination for knowledge-intensive production; those regarded as important actors for success in the "new economy". The major characteristics of these workers are high mobility, attracted to cities that offer certain attributes (hence a better QOP) in terms of economic opportunity and diversity. Similarly, demographic characteristics are also relevant factors that determine one's satisfaction with the neighbourhood and also the city. For example, expectations of a young adult population for a place would be very different than those of elderly people in the same neighbourhood. While the first group would be in demand of a district where entertainment and more diversified interests are dominant, the latter on the other hand, would be more interested in accessibility to health and social services. It is therefore an objective of the following sections to understand these characteristics of "human capital", which was a component in the proposed conceptual framework, through a social profile of the city of Montréal.

Furthermore, language characteristics are other indicators that affect QOP since they help to shape the social space. For the case of Montréal, being bilingual is a significant factor which influences networks of individuals. It is through the language that one can enjoy and increase adaptability to a place. To analyze this interaction, referred to "social capital" in the conceptual model, an effort will also be made to understand the language characteristics of the city.

4.2.1.1. Demographic characteristics and the household structure

Between 1981 and 1996, the population continued to decline in Montréal; however, there has been an increase in population in the downtown area due to the young recent immigrant families. When it is compared with the rest of the metropolitan area, the city differs in the age composition of the population. There are proportionately fewer children and more elderly people within the city and young adults have the greater share of the city's population that indicates its regional importance as a place to study (Rose and Germain, 2000).

The results of Rose and Germain (2000) have been updated in this thesis using 2001 census data to compare the age structure between the Census Metropolitan Area (CMA) and the City of Montréal. Table 4.5 shows that the percentage of young population is less than that of in the metropolitan area. However, the percentages of both old and the adult population are greater within the city than the CMA.

Table 4.5: Comparison of the age structure of Montréal CMA and the City of Montréal (2001 Census Data)

	total population	total young population (0-14)	% young population (0-14)	total adult population (15-44)	% adult population (15-44)	total elderly population (60 and over)	% elderly population (60 and over)
Montréal CMA	3 426 350	618 855	18.06	1 521 560	44.40	592 075	17.28
City of Montréal	1 812 715	290 475	16.02	813 750	44.89	357 685	19.73

Rose and Germain (2000) have also indicated that there are noticeable differences among the neighbourhoods within the city in terms of age structure. Being one the neighbourhoods of Montréal which will be under study, Plateau Mont-Royal attracts a large proportion of the young adult population between 15-44 age group while a more youthful age structure exists within the neighbourhoods having large immigrant population like Côte-des-Neiges and St-Michel. The highest proportion of elderly is to be found in Rosemont where there is little immigration and it is mostly traditionally francophone.

"The number of households in the city has continued to grow even in those districts where population has declined; this is indicative of decreasing household size and in particular, the increasing concentration of non-family households in inner-city neighbourhoods" (Rose and Germain, 2000). This structure also indicates that the increase in home-ownership rates during the 1980s and early 1990s was significant especially when contrasted with the trend in the rest of urban Canada.

4.2.1.2. Gentrification and economic characteristics

In this section, "social upgrading and gentrification" will be analyzed to understand the effects of this process on QOP of the neighbourhoods of Montréal. By definition, gentrification is "a process of neighborhood regeneration by relatively affluent incomers, who displace lower-income groups and invest substantially in improvements to homes the quality of which has deteriorated" (Johnston *et al.,* 1994). As Bourne and Bunting (1993) argue, neighborhoods may change for many reasons, either new neighborhoods may be added in the suburbs or redevelopment may occur with the re-entrance of elite classes to old neighborhoods. Gentrification often brings about a number of positive effects, including cultural revival in the inner city, the protection and preservation of historical properties, and the enhancement of the quality of life of residents, as well as a rise in property, income, and sales tax revenues for local governments. Gentrification also tends to increase the safety of an area and its desirability as a tourist location but it is, still, not without negative effects. The most important of these is the effect on the individuals who lived or worked in the neighbourhood before gentrification began. Many of these individuals find that their rent or property taxes rise above a level that they can afford and are thus forced out.

In some urban areas, these individuals face an increasingly difficult task as they try to find affordable new housing. They are often crowded into less desirable neighbourhoods or new, characterless public housing projects. Consequently, the effort of measuring the QOP in the inner city could not be handled without an understanding of urban gentrification

When we analyze the literature on the gentrification process in the Canadian urban context, we observe that the urban neighborhoods have experienced different gentrification processes in different time periods. For instance, between 1971 and 1981, Ley (1985) conducted a study where four major hypotheses below are gathered to account for inner city gentrification for 22 Canadian metropolitan areas:

1. The effects of demographic change,
2. Local housing market conditions,
3. The level of urban amenity or the quality of life,
4. The nature of environment.

These hypotheses were operationalized in a statistical model with 35 independent variables. From all four hypotheses, these variables correlated significantly with the gentrification index, which measured the increase in socio-economic status in 22 metropolitan inner cities (Ley, 1985). It is interesting that the strongest associations occurred against the economic and quality of life variables. In this study, the gentrification index was mapped and a profile of gentrifiers was presented. Between 1971-1980, his study showed that in Canada, gentrifiers tend to be young, childless, middle-class professionals who have previously lived in the inner city. For Montréal, the greatest increases in social status which is an indicator of gentrification, occur in tracts adjacent to existing upper and middle-class districts (Westmount, Outremont, parts of Notre-Dame-de-Grâce which will be under study) and close to environmental amenities (Mount Royal and Lafontaine Park). The earliest gentrification in the city involved large, formerly bourgeois Victorian townhouses on the downtown fringes with exceptional architecture that had deteriorated and were 'reclaimed' in the 1970s by professionals (Rose and Germain, 2000).

Canadian research indicates that an early wave of gentrifiers do not radically affect price levels in neighborhood housing markets. However, with the local market, later middle class arrivals confront and contribute to higher prices. As a result, many Canadians were displaced by middle class reinvestment in the inner city and therefore gentrification has been considered as a major contributor to the crisis of affordable rental housing in many large Canadian cities like Toronto, Montreal and Vancouver (Ley, 1985). However, this was the situation of the 1970s. With the changing economic conditions, especially in global cities like New York and London, a new pattern of gentrification was observed, named as "super-gentrification" by Lees (2000). "In neighborhoods that gentrified early, many first-stage gentrifiers have sold their property to new, who are regentrifying property in the neighborhood at this time" (Lees, 2000). Therefore, being a social process, gentrification has become more chaotic and its spatial expression has been more complex since the beginnings of the 1980s. "*No longer is an upgraded inner-city residence limited to the submarket of the young urban professional, the quintessential gentrifier of the 1970s. Increasingly, professional nuclear families with children are an important subgroup*" (Ley, 1993, p.252). To understand the present situation of gentrification in Montréal, it is essential to analyze the structure of the economic sectors and the residential location of the workforce in these sectors.

Today's Montréal metropolitan region's economy has important concentrations of both labour-intensive and high-technology manufacturing production. As Rose and Germain (2000) emphasize that while the city's central core has maintained employment in 'knowledge-based' sectors, the north-central and north-east parts have been dominated by labour-intensive industries and the suburbs with capital-intensive sectors. Residential location of the work force has also followed the same trends like the location behaviour of these different economic sectors. North-central and north-east neighbourhoods have a concentration of workers in labour-intensive sectors where such industries are located. People working in capital-intensive manufacturing tend to reside in North Shore and some South Shore suburbs whereas workers in public administration and finance prefer mostly West Island and South Shore suburbs. The traditional elite and middle-class neighbourhoods have a high concentration of workers in education, health and social services while neighbourhoods like Plateau Mont-Royal have more workers in cultural, communication and personal service sectors. Rose and Germain (2000) indicate that these tendencies of the workers show the link between the concentration of advanced tertiary jobs in the downtown core and a strong residential presence of 'knowledge workers' in the surrounding residential neighbourhoods. Although intense existence of the advanced tertiary jobs in the central city can be considered as a sufficient condition for "gentrification", in the literature, other factors have also gained some importance like public policies (Ley, 1996; Rose, 1999). For instance, some housing and neighbourhood policies of the City of Montréal have encouraged the "knowledge workers' to maintain their residence in the inner city.

4.2.1.3. Linguistic characteristics

According to 2001 census data, the 1.8 million people who presently reside on the Island of Montréal make up a diverse cultural and linguistic mosaic: 70% of all immigrants to Quebec settle on the Island of Montréal. The population of Montréal differs from the rest of Quebec by having a higher proportion of people with ethnic origins other than Canadian (French or British Canadian). While 34.7% of the total population is Canadian, 65.3% has a different origin. When the knowledge of "language spoken at home" is analyzed, it is observed that 63.7% speak French at home, 22.5% speak English and 13.8% use other languages: Italian and Spanish top the list, while three other languages, Arabic, Chinese and Greek, and are on the rise. 27% are allophones, of whom 2% speak neither French nor English. The 10 languages spoken by 70% of allophones, in order of importance, are: Italian, Spanish, Arabic, Chinese, Greek, Creole, Portuguese, Polish, Vietnamese and German.

The effect of the linguistic characteristics on urban space of Montréal is an important component in understanding the differentiations among QOP. According to Rose and Germain (2000), Montréal's social space has been shaped by a spatial divide between the two distinct communities, anglophone and francophone communities. However, since the 1960s with the immigration waves, major transformations have taken place in the socio-cultural space of Montréal. The dominant linguistic image of anglophones and francophones has started to substitute with a new one which results in the social space as "multi-cultural" reflections. Some studies show that the spatial divide observed between the anglophone-francophone districts is no longer clear-cut but instead, there is a social and ethnocultural mix (Langlois, 1985; Marois, 1989). Moreover, as Rose and Germain (2000) emphasize that this ethnocultural heterogeneity is an increasing trend due to the decline of Montréal's anglophone population, the diversification of immigration and the spatial patterning has never been static.

Besides the decline of the anglophone population, it is also necessary to point out that French language is also no longer spoken only by French Canadians. Many immigrants from Latin America or other countries use French as an everyday language. However, francophones, within and outside Québec, still constitute less than a quarter of Canada's total population, whereas at the time of Confederation half the population was French Canadian.

4.3. Data sources and variable types

For this thesis, four different types of data will be used. These data, their characteristics and name of the institutions providing them are listed in Table 4.6 as follows.

Table 4.6: The data types that will be used in the study

Data type	Characteristics	Provided by
2001 Census data	Population and housing data at census tract (CT) level	Map Library of University of Ottawa
Survey data (applied on July 2002)	A questionnaire of 150 items for three selected neighborhoods of Montréal (at CT level)	University of Ottawa/ Department of Geography
Remotely sensed data	IRS –1D image with 4 channels, visible and NIR (20 meters nominal spatial resolution)	University of Ottawa/ Department of Geography, Remote Sensing and Geomatics of Environment Laboratory
GIS based ancillary data	Urban data (e.g. land use, roads, infrastructure, emergency and cultural etc.)	Map Library of University of Ottawa

4.3.1. Census data

For the objective dimension of the model, 2001 census data of Montréal is used which is provided by Statistics of Canada through the Beyond 2020 Program. A selection among all these variables has been made for QOP assessment (Table 4.7). The variables related with QOP were selected with reference to the literature review (Smith, 1973; Lo and Faber, 1997; Townshend, 2001; Williams *et al.,* 2001).

Table 4.7: The selected variables from 2001 housing and population census data for QOP assessment in Montréal.

No	Variable name	Variable description
1	TOTPOP	Total population by sex and age groups
2	TOTYOU	Total young population (0-14)
3	TOTOLD	Total old population (65 and over)
4	TOTMAR	Total population 15 years and over by legal marital status
5	WTOSPO	People who are not living with a spouse (never married, separated, divorced or widowed)
6	TOTDWE	Total number of occupied private dwellings
7	AVGROOM	Average number of rooms per dwelling
8	MAJRPR	Major repairs
9	OLDDWE	Old buildings (1946-1960)
10	NEWDWE	New buildings (1991-1995)
11	TOTOFL	Total population by knowledge of official languages - 20% Sample data
12	ENGFR	Total population by knowledge of official languages - 20% Sample data: English and French
13	NENGFR	Total population by knowledge of official languages - 20% Sample data: Neither English nor French
14	TOTHEDU	Total population 20 years and over by highest level of schooling - 20% Sample data
15	LESSGR9	Total population 20 years and over by highest level of schooling - 20% Sample data: Less than grade 9
16	UNIVER	Total population 20 years and over by highest level of schooling - 20% Sample data: University (With bachelor degree or higher)
17	TOTAVIN	Average total income
18	LOWINC	Incidence of low income of population in private households
19	HOUAVIN	Average household income
20	VALAVDW	Average value of dwelling
21	TOTUNEM	Unemployment rate of total population
22	UNEMPM	Unemployment rate of male 15 years and over
23	UNEMPFE	Unemployment rate of female 15 years and over
24	TOTPWST	Total employed labour force 15 years and over by place of work status

Table 4.7 (continue)

25	PWCSDM	Total employed labour force 15 years and over by place of work status: In CSD[6] of residence, males
26	PWHOMM	Total employed labour force 15 years and over by place of work status: At home, males
27	PWCSDF	Total employed labour force 15 years and over by place of work status: In CSD of residence, females
28	PWHOMF	Total employed labour force 15 years and over by place of work status: At home, females
29	MODTRAN	Total employed labour force 15 years and over by mode of transportation - 20% Sample data
30	WALKBIC	Total employed labour force 15 years and over by mode of transportation - 20% Sample data: Walked or bicycle

4.3.2. Survey data

For the subjective dimension of the model, a questionnaire was distributed in three selected neighborhoods of Montréal. The selection of the neighborhoods was made according to the results of PCA applied to the 1996 housing and population census data for a project conducted by Marois and Langlois (2003). Since the previous sections of this chapter demonstrated that these neighborhoods have different characteristics in terms of urban gentrification, linguistic characteristics and immigrant profile, it was decided to keep the same neighborhoods for this study. According to the results of PCA, the three neighbourhoods showed very different characteristics from each other (Figures 4.4, 4.5 and 4.6) (similar PCA results have also been obtained for 2001 census data which will be explained in chapter 5):

- Côte-des-Neiges and Notre-Dame-de-Grâce,
- Hochelaga Maisonneuve,
- Plateau Mont-Royal.

According to a publication of Ville de Montréal (2001), the district of Côte-des-Neiges and Notre-Dame-de-Grâce has just over 150 000 residents. This neighborhood has a sizable proportion of small households (40% are one person households). The average

[6] Area that is a municipality or an area that is deemed to be equivalent to a municipality for statistical reporting purposes

household income is 37 802 CAD, perhaps explaining why only 22% of the population is home owners. One of the defining characteristics of the district is the ethnic presence: immigrants and particularly recent immigrants represent 44% and 35% respectively of the district population.

The district of Hochelaga-Maisonneuve has 125 000 residents. 39% of households are single person households, and again the level of home ownership is relatively low at 28%. This neighborhood has one of the lowest average household incomes at 33 347 CAD, and a low socio-economic status generally, particularly in the sectors near the city center.

The district of Plateau-Mont-Royal has almost 100 000 residents the majority of whom (52%) live in single person households; 18% of the population are home owners. Average household income is relatively low (31 885 CAD) and population is primarily francophone.

The questionnaire prepared for this thesis was distributed to the three neighborhoods in the summer 2002 in two versions: French and English (See Appendix A and B for both versions). The questionnaire includes 97 items in four sections (Table 4.8). These four sections are as follows:

1. Basic information about the responder:
   Age, sex, marital status, etc.
2. Socio-economic profile:
   Education level, income level, etc.
3. Place of residence and mobility:
   Type of residence, construction period, etc.
4. Needs and satisfaction in the neighborhood:
   Environment, public services, etc.

Figure 4.4: Côte-des-Neiges

(*Source: Marois and Langlois, 2003*)

Figure 4.5: Hochelega Maisonneuve

(Source: Marois and Langlois, 2003)

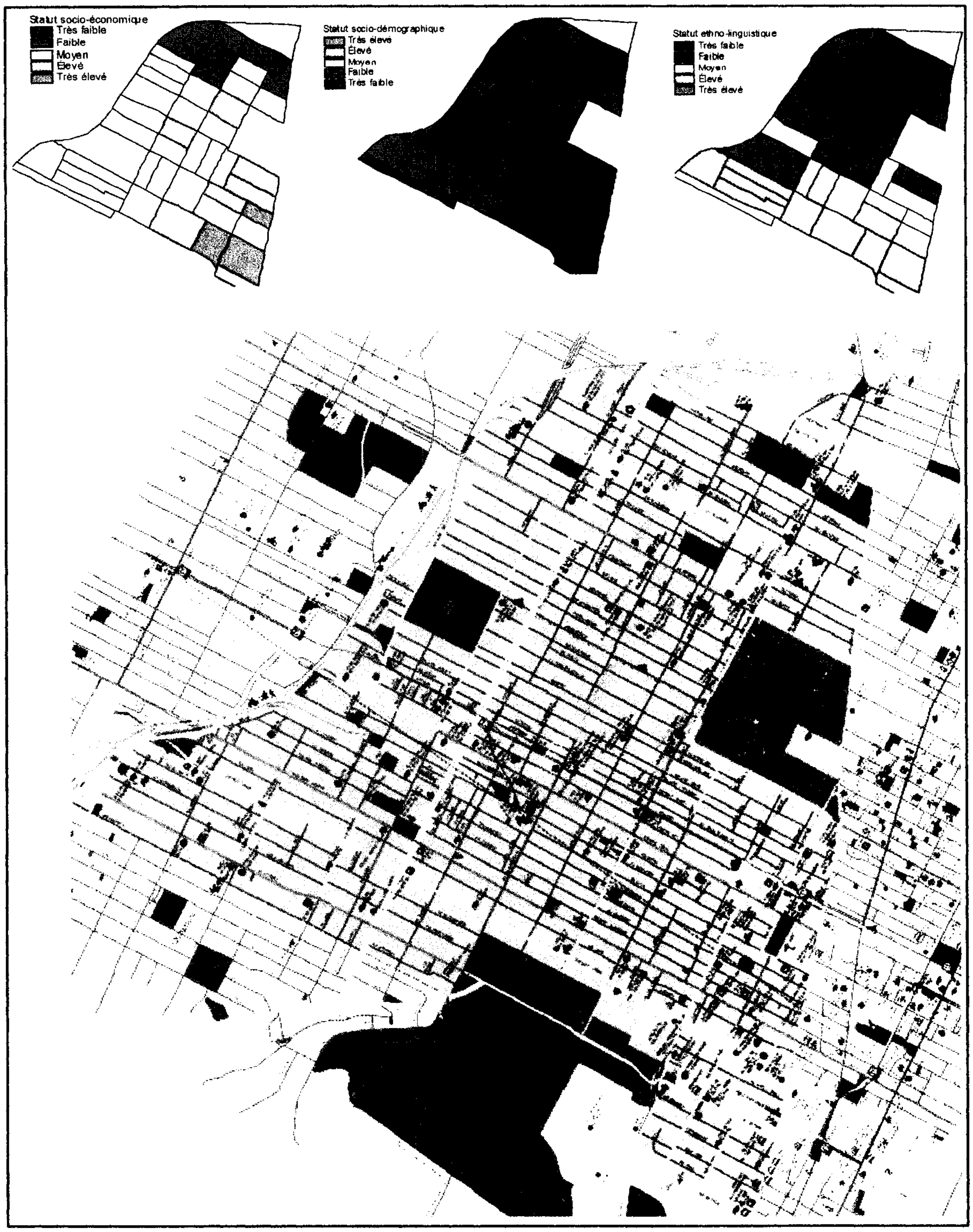


Figure 4.6: Plateau-Mont-Royal

(*Source: Marois and Langlois, 2003*)

Table 4.8: List of items in the questionnaire

No	Variable	Definition	Section
1	no	Questionnaire no	Basic information
2	burrough	Name of the neighbourhood	
3	sex	Sex	
4	age	Age group	
5	mtongue	Mother tongue	
6	mstatus	Marital Status	
7	hsize	Household size	
8	wstatus	Worker status	Socio-economic status
9	plofwrk	Place of work	
10	educ	Education level	
11	income	Income	
12	typres	Type of residence	Place of residence and mobility
13	occstatu	Type of tenure	
14	cperiod	Construction period	
15	lghtrpl	Length of residency at the residence	
16	lghtrn	Length of residency in the neighbourhood	
17	pplres	Preceding place of residence	
18	mtrsp	Mode of transportation	
19	ssize	Residence: size (satisfaction)	**Needs and satisfaction:** Evaluation of the neighbourhood as a place to live
20	isize	Residence: size (importance)	
21	scond	Residence: condition (satisfaction)	
22	icond	Residence:condition (importance)	
23	smaint	Residence: maintenance (satisfaction)	
24	imaint	Residence: maintenance (importance)	
25	scomf	Residence: comfort (satisfaction)	
26	icomf	Residence: comfort (importance)	
27	sgreen	Environment: green spaces (satisfaction)	
28	igreen	Environment: green spaces (importance)	
29	squiet	Environment: Quietness (satisfaction)	
30	iquiet	Environment: Quietness (importance)	
31	ssafety	Environment: Safety (satisfaction)	
32	isafety	Environment: Safety (importance)	
33	supkeep	Environment: upkeep (satisfaction)	
34	iupkeep	Environment: upkeep (importance)	
35	sairq	Environment: air quality (satisfaction)	
36	iairq	Environment: air quality (importance)	
37	sfire	Public service: fire fighter (satisfaction)	
38	ifire	Public service: fire fighter (importance)	
39	spolice	Public service: police (satisfaction)	
40	ipolice	Public service: police (importance)	
41	sgarb	Public service: garbage (satisfaction)	
42	igarb	Public service: garbage (importance)	
43	sroad	Public service: road upkeep (satisfaction)	
44	iroad	Public service: road upkeep (importance)	

Table 4.8 (continue)

No	Variable	Definition	Section
45	ssnow	Public service: snow removal (satisfaction)	**Needs and satisfaction:** Evaluation of the neighbourhood as a place to live
46	isnow	Public service: snow removal (importance)	
47	shealth	Public service: emergency health (satisfaction)	
48	ihealth	Public service: emergency health (importance)	
49	sqwater	Public service: quality of water (satisfaction)	
50	iqwater	Public service: quality of water (importance)	
51	spubtrsp	Public service: public transportation (satisfaction)	
52	ipubtrsp	Public service: public transportation (importance)	
53	scomm	Involvement: community life (satisfaction)	
54	icomm	Involvement: community life (importance)	
55	spol	Involvement: political life (satisfaction)	
56	ipol	Involvement: political life (importance)	
57	secon	Involvement: economic life (satisfaction)	
58	iecon	Involvement: economic life (importance)	
59	ssocio	Involvement: socio-cultural life (satisfaction)	
60	isocio	Involvement: socio-cultural life (importance)	
61	neighev1	Overall evaluation of the neighbourhood (satisfaction)	
62	neighev2	Overall evaluation of the neighbourhood (importance)	
63	icstore	Access: corner store (importance)	**Needs and satisfaction:** Access to goods and services
64	scstore	Access: corner store (satisfaction)	
65	ismark	Access: supermarket (importance)	
66	ssmark	Access: supermarket (satisfaction)	
67	idrugstr	Access: drugstore (importance)	
68	sdrugstr	Access: drugstore (satisfaction)	
69	ihrdwr	Access: hardware (importance)	
70	shrdwr	Access: hardware (satisfaction)	
71	ibank	Access: bank (importance)	
72	sbank	Access: bank (satisfaction)	
73	irest	Access: restaurant (importance)	
74	srest	Access: restaurant (satisfaction)	
75	ibtq	Access: boutiques (importance)	
76	sbtq	Access:boutiques (satisfaction)	
77	iclsc	Access: clsc (importance)	
78	sclsc	Access: clsc (satisfaction)	
79	ihptl	Access: hospital (importance)	
80	shptl	Access: hospital (satisfaction)	
81	ischool	Access: schools (importance)	
82	sschool	Access: schools (satisfaction)	
83	iptrsp	Access: public transportation (importance)	
84	sptrsp	Access: public transportation (satisfaction)	
85	ipark	Access: parks (importance)	
86	spark	Access: parks (satisfaction)	
87	isocioc	Access: socio-cultural activities (importance)	
88	ssocioc	Access: sociocultural activities (satisfaction)	

Table 4.8 (continue)

No	Variable	Definition	Section
89	isports	Access: sportive activities (importance)	**Needs and satisfaction:** Access to goods and services
90	ssports	Access: sportive activities (satisfaction)	
91	ileisr	Access: Leisure activities (importance)	
92	sleisr	Access: Leisure activities (satisfaction)	
93	acceval1	Access: Overall evaluation of accessibility (importance)	
94	acceval2	Access: Overall evaluation of accessibility (satisfaction)	
95	today	Overall evaluation of quality of life: today	
96	yestrd	Overall evaluation of quality of life: 10 years ago	
97	in10yrs	Overall evaluation of quality of life: in 10 years	

In part 4 of the questionnaire, the respondents are asked to evaluate their neighbourhoods as a place to live, accessibility to public services etc. on two levels: satisfaction and importance. This section is based on a study of Raphael *et al.* (1996), "Quality of Life Research Unit" of University of Toronto, where they have used "importance" and "enjoyment" rankings for the three life domains (being, belonging, becoming) and their sub items to understand how elder people regard their quality of life. They used a scale of 1-5 to rank both items. The similar ranking system is used for the questionnaire applied in the three neighbourhoods of Montréal for this thesis. The sampling procedure to select the individuals is conducted at two levels. First, 10 census tracts (CTs)[7] are randomly selected by using a table of random numbers generated by function "RAND" of the Excel software of Microsoft. The result of this procedure is shown in Figure 4.7 where 30 CTs are shown in yellow. Secondly, in each CT, 5 people are randomly selected. The method of selection, within the boundaries of CTs, consisted of choosing by chance an individual, either at home or on the street. On the whole, 150 people agreed to answer the questionnaire.

[7] Census tracts (CTs) are small, relatively stable geographic areas that usually have a population of 2 500 to 8 000. They are located in census metropolitan areas and in census agglomerations with an urban core population of 50 000 or more in the previous census (2001 Census Dictionary, Statistics of Canada, p.246).

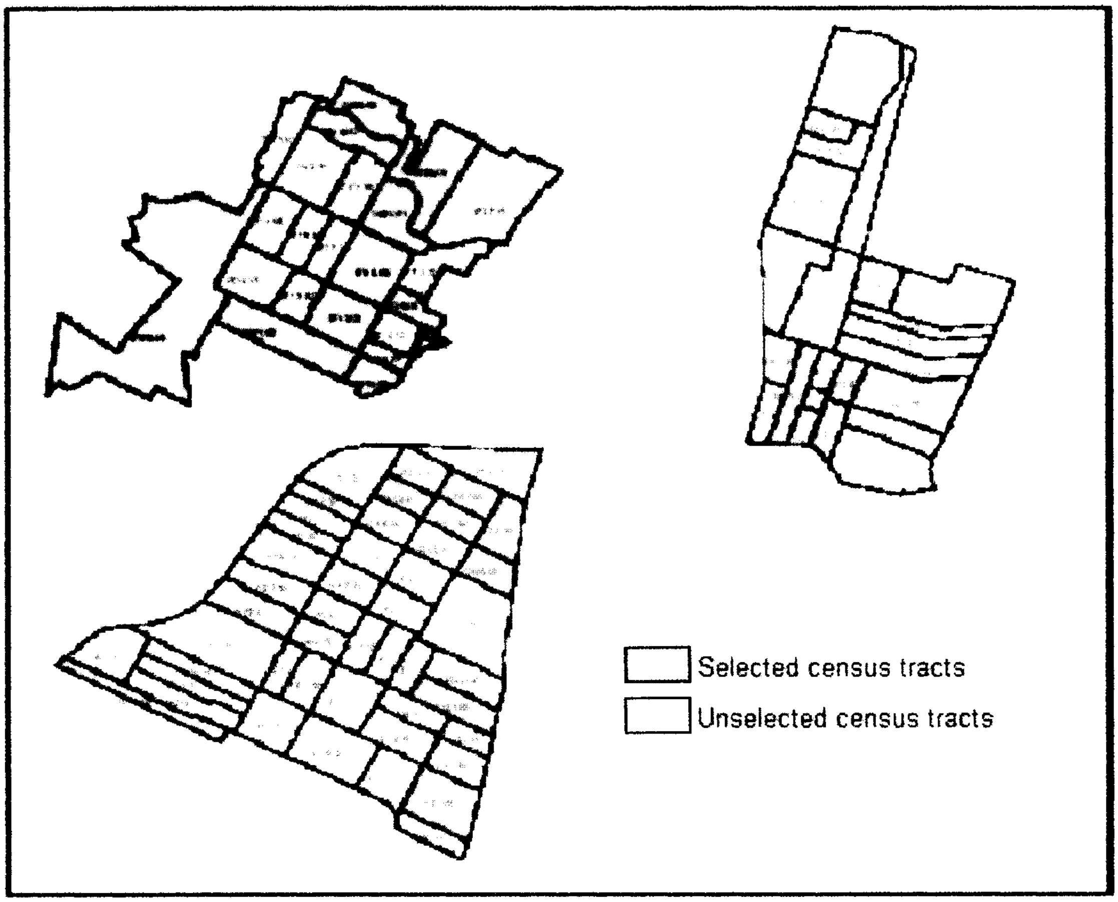


Figure 4.7: The selected census tracts where the questionnaires were distributed

4.3.3. Remotely sensed and ancillary data

The remotely sensed data that used for the study is recorded by the Indian Remote Sensing Satellite (IRS-1D). The IRS-1D was launched in September 1997 with 3 sensors on board: the high resolution PAN-camera with 5.8 m pixel size, the Linear Self Scanning Camera (LISS-III) with 4 spectral bands and with a nominal spatial resolution of 20 meters, and the Wide Field Sensor WIFS with 188 m pixel size (Table 4.9). The image that covers the island of Montréal obtained for this study has 3 spectral bands and was acquired on the date of 13.08.1998 (Figure 4.8). This image is selected for two reasons: first, the spatial resolution is perfect to assess vegetation cover, roads and buildings, and secondly, the data acquisition date is the period of the year where the growing vegetation cover is in the maximum stage to analyze.

Table 4.9: The characteristics of IRS-1D image for the study

Sensor	**LISS-III**		
Spatial resolution	20 m (VIS and NIR) 70 m (SWIR)		
Swath-width	127 - 141 km		
Radiometric resolution, quantisation	7 bit		
Spectral coverage	Band 2	520-590 nm	Green
	Band 3	620-680 nm	Red
	Band 4	770-860 nm	NIR
	Band 5	1550-1700 nm	SWIR

In addition to the remotely sensed data, ancillary data which is in vector format was also used. The data is obtained in shape ".shp" format through ArcView system. Table 4.10 shows the names of all the layers and their descriptions. The data is provided in three different categories: P (point), L (polyline) and R (region). For instance, the "industrial and resources" layer is available as a *irl* (containing polylines), *irp* (containing points) and *irr* (containing regions) layers. It should also be noted that all these layers are in NAD83 datum and displayed as unprojected latitude and longitude. Those data are used both for the accessibility analysis and digital image land use post-classification.

Figure 4.8: Uncorrected IRS-1D image of Montréal (composite of the NIR, red, green bands displayed as red, green and blue, respectively)

Table 4.10: The list of all ancillary data provided for the study

Name of the file	Description
QCbfr.shp	Building footprints
QCral.shp	Recreation & amusement areas
QCrap.shp	Recreation & amusement areas
QCrpr.shp	Recreation & amusement areas
QClur.shp	Land use
QCrtl.shp	Rail transit
QCrtp.shp	Rail transit
QCrds.shp	Roads
QCrec.shp	Recreation & entertainment
CANwat.shp	Water
CANrmn.shp	Regional municipalities
Mtl.shp	Census tract boundaries

4.4. Conclusions

The discussion carried out in this chapter showed that Montréal is a relevant case study for testing the proposed conceptual and methodological framework for QOP introduced in chapter 3. Since many socio-economic, demographic and linguistic characteristics provide a range of differentiations among the intra-urban space of the city, the reliability of the analysis results is expected to be high in chapter 5.

5 Analysis of the Objective and Subjective Dimensions

> "I find that there are persistent problems in measuring QOP...The analytical community should therefore acknowledge that people hold diverse preferences, increase efforts to detect and model the consequences of policies, look across levels of decision making for influences on QOP, and build adaptive analytical capacity."[8]

5.1. Introduction

This chapter will provide the analysis results of both objective and subjective dimensions. The first step is to show the results of "principal component analysis" (PCA_{st}) and "quality of place index" (QOP_{cs}) derivation based on the census data in statistical and GIS environments. Next, the results for the urban land use extraction from remotely sensed data and the accessibility to public services using GIS and RS will be presented. This chapter will also introduce the application of a new vegetation index to the RS literature, the "Transformed Difference Vegetation Index" (TDVI), for measuring the greenness component in Montréal. Following the analysis in the objective dimension, statistical description of the survey data and the "subjective quality of place index" (SQOPI) derivation will be the final steps of this chapter.

5.2. Objective dimension

In this section, social structural information and accessibility to public services and land use will be analyzed through census, remotely sensed and GIS based ancillary data. Objective dimension of QOP explains how both the social and the physical structural information are measured objectively. Social structural information provides a general understanding and measuring the census-based variables like income, ethnicity, family status or education level whereas physical structural

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[8] Andrews C.J., (2001), "Analyzing quality of place", _Environment and Planning B: Planning and Design_, 28, p.201

information helps to analyze the "place" in terms of accessibility to public services and the characteristics of the urban land use.

5.2.1. Social structural information

As a starting point, the selected variables from 2001 census data (as defined in chapter 4) for all the census tracts (CTs) in Montréal are exported from the Beyond 2020 program to Excel, to create labels for each variable (Table 5.1). Then, the file is exported to SPSS, a statistical program which enables the user to do statistical analysis and later provides an opportunity to save the resulting tables in ".dbf" format to use in ArcGIS for GIS applications.

Next step, is to calculate the percentages for each variable (this is necessary since the values of each variable are different like income level, education or household size, etc.). Since large sets of data have been used for this analysis, after the percentage value calculations for each variable, PCA_{st} has been applied to the whole set of data (the technical background of this technique is provided in chapter 2). With the components derived from PCA_{st}, the last step is to understand the social structure, with the help of a "Quality of Place Index (QOP_{cs})" derivation. The index is based on a weighted linear combination of the components derived from PCA_{st}.

5.2.1.1. Principal component analysis

After having calculated the percentage values for each variable, at the next stage, PCA_{st} is used (see Appendix C for the "Syntax File" created in SPSS) to see the relation between different types of census data and to analyze the spatial differentiations of neighbourhoods in Montreal through the help of resulting components (C_i, where i = 1, 2, 3,..., N). These components are also used, later, to determine three neighbourhoods where the questionnaires to be distributed. In addition, the relation among the different variables and the derived QOP indices will also be analyzed with the help of this technique. The first step of PCA_{st} is to obtain the number of components (dimensions), which explain most of the data. To do this, the table of "Rotation sums of squared loadings" is used which is one of the resulting outputs of the PCA_{st} in SPSS (Table 5.2).

Table 5.1: Selected variables from census data

No	Variable name	Variable description	Labels for percentage calculation
1	TOTPOP	Total population by sex and age groups	
2	TOTYOU	Total young population (0-14)	pctyoun
3	TOTOLD	Total old population (65 and over)	pctold
4	TOTMAR	Total population 15 years and over by legal marital status	
5	WTOSPO	People who are not living with a spouse (never married, separated, divorced or widowed)	pctwspo
6	TOTDWE	Total number of occupied private dwellings	
7	AVGROOM	Average number of rooms per dwelling	
8	MAJRPR	Major repairs	pctmajr
9	OLDDWE	Old Buildings (1946-1960)	pctoldb
10	NEWDWE	New Buildings (1991-1995)	pctnewb
11	TOTOFL	Total population by knowledge of official languages - 20% Sample Data	
12	ENGFR	Total population by knowledge of official languages - 20% Sample Data: English and French	pctengfr
13	NENGFR	Total population by knowledge of official languages - 20% Sample Data: Neither English nor French	pctnenfr
14	TOTHEDU	Total population 20 years and over by highest level of schooling - 20% Sample Data	
15	LESSGR9	Total population 20 years and over by highest level of schooling - 20% Sample Data: Less than grade 9	pctlegr9
16	UNIVER	Total population 20 years and over by highest level of schooling - 20% Sample Data: University (With bachelor degree or higher)	pctuni
17	TOTAVIN	Average total income	
18	LOWINC	Incidence of low income of population in private households	
19	HOUAVIN	Average household income	
20	VALAVDW	Average value of dwelling	
21	TOTUNEM	Unemployment rate of total population	
22	UNEMPM	Unemployment rate of male 15 years and over	
23	UNEMPFE	Unemployment rate of female 15 years and over	
24	TOTPWST	Total employed labour force 15 years and over by place of work status	
25	PWCSDM	Total employed labour force 15 years and over by place of work status: In CSD of residence, males	pctmcsd
26	PWHOMM	Total employed labour force 15 years and over by place of work status: At home, males	pctmhom
27	PWCSDF	Total employed labour force 15 years and over by place of work status: In CSD of residence, females	pctfcsd
28	PWHOMF	Total employed labour force 15 years and over by place of work status: At home, females	pctfhom
29	MODTRAN	Total employed labour force 15 years and over by mode of transportation - 20% Sample Data	
30	WALKBIC	Total employed labour force 15 years and over by mode of transportation - 20% Sample Data: Walked or bicycle	pctwalbic

Table 5.2: Total variance explained in PCA_{st}

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**7.33**	31.86	31.86	7.33	31.86	31.86	5.08	22.09	**22.09**
2	**4.21**	18.31	50.17	4.21	18.31	50.17	4.21	18.31	**40.40**
3	**2.14**	9.30	59.47	2.14	9.30	59.47	3.44	14.94	**55.34**
4	**1.58**	6.86	66.34	1.58	6.86	66.34	1.86	8.07	**63.41**
5	**1.43**	6.21	72.55	1.43	6.21	72.55	1.69	7.34	**70.74**
6	1.12	4.87	77.41	1.12	4.87	77.41	1.53	6.67	77.41
7	0.89	3.87	81.29						
8	0.68	2.96	84.25						
9	0.58	2.51	86.75						
10	0.48	2.08	88.83						
11	0.41	1.77	90.60						
12	0.38	1.67	92.26						
13	0.34	1.50	93.76						
14	0.30	1.29	95.05						
15	0.28	1.24	96.29						
16	0.23	1.00	97.29						
17	0.18	0.76	98.05						
18	0.14	0.62	98.67						
19	0.11	0.47	99.14						
20	0.10	0.43	99.57						
21	0.07	0.32	99.89						
22	0.02	0.09	99.99						
23	0.00	0.01	100.00						

Extraction Method: Principal Component Analysis.

According to Table 5.2, if only one component is used, 22.09 % of the data is explained. If the number is increased to five, then 70.74 % of the data is represented. A "Scree Plot" (Figure 5.1) is also used to see how many components to retain. From this graph, it is easily observed that five components are enough to represent the whole range of data.

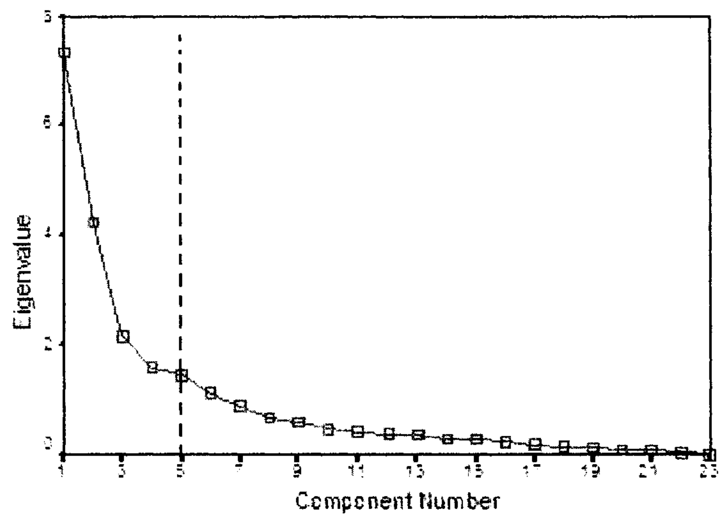


Figure 5.1: Scree plot of PCA_{st}

After deciding the number of components to retain, the next goal is to understand the meaning of these components and to analyze which variables are explained in different components. This helps to see the relation between different types of variables and which component describes a different dimension of QOP. To do that, "Rotated Component Matrix" is used (Table 5.3). According to this table, the variables "% people who can speak both English and French", "% with bachelor degree of higher", "% with education less than grade 9", "Average total income", "Average household income", "Average value of dwelling", "% females, place of work status at home" are highly related to each other and are represented in component 1. Rotated Component Matrix is also useful to understand the variables that are positive or negatively related within each component. Therefore, it is observed that the variables "% people who can speak both English and French", "% with bachelor degree or higher", "Average total income", "Average household income", "Average value of dwelling" and "% females, place of work status at home" are positively related while "% with education less than grade 9" is negatively related.

Table 5.3: Rotated Component Matrix[a]

Variables	Component					
	1	2	3	4	5	6
% total young population	-0.03	**-0.76**	-0.05	-0.02	-0.11	0.41
% total old population	0.02	0.02	-0.04	-0.09	-0.04	**-0.87**
% people who are not living with a spouse	-0.10	**0.85**	0.04	0.24	-0.04	0.08
Average number of rooms per dwelling	0.14	**-0.74**	-0.18	-0.11	0.05	0.23
% number of dwellings that need major repairs	0.04	0.27	0.10	**0.74**	-0.05	0.31
% old buildings	0.13	0.35	0.03	**0.74**	-0.03	0.19
% new buildings	0.02	0.00	-0.02	**-0.76**	-0.13	0.36
% people who can speak both English and French	**0.72**	-0.03	-0.39	-0.04	0.17	0.14
% people who can speak neither English nor French	-0.27	-0.20	0.44	0.09	0.55	-0.19
% with bachelor degree or higher	**0.85**	0.14	-0.19	0.12	0.25	0.15
% with education less than grade 9	**-0.72**	-0.05	0.34	0.04	-0.08	-0.24
Average total income	**0.88**	-0.19	-0.25	-0.01	-0.08	-0.11
Incidence of low income of population in private households	-0.43	0.39	**0.67**	0.11	0.18	0.05
Average household income	**0.83**	-0.33	-0.22	-0.03	-0.11	-0.13
Average value of dwelling	**0.83**	-0.22	0.04	0.06	-0.03	-0.19
Unemployment rate of total population	-0.23	0.18	**0.93**	0.05	-0.06	0.04
Unemployment rate of male 15 years and over	-0.24	0.25	**0.81**	0.10	-0.20	0.10
Unemployment rate of female 15 years and over	-0.17	0.03	**0.86**	-0.05	0.22	-0.05
% males, place of work status in CSD of residence	-0.14	**0.82**	0.17	0.11	0.10	0.17
% males, place of work status at home	0.40	0.12	-0.08	-0.01	**0.80**	0.08
% females, place of work status in CSD of residence	-0.21	**0.74**	0.09	0.17	-0.12	0.16
% females, place of work status at home	**0.68**	-0.03	-0.07	0.09	0.41	-0.01
% people walked or use bicycle	0.20	**0.65**	0.13	-0.03	0.53	0.13

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 9 iterations.

Component 2, on the other hand, keeps the variables "% total young population", "% people who are not living with a spouse", "Average number of rooms per dwelling", "% males, place of work status in CSD of residence", "% females, place of work status in CSD residence" and "% people walked or use bicycle". Among these, only "% total young population" and "Average number of rooms per dwelling" are negatively related with the other variables explained in component 2. The variables related with unemployment and low income are explained in the third component and related positively with each other (such as "unemployment rate of male 15 years and older"). Furthermore, component 4 keeps the variables related with the condition of the dwellings whereas component 5 keeps the variable "% males, place of work status at home".

With the help of these results, the five components can be linked to QOP with five different meanings, which are described as follows:

- Component 1 (Figure 5.2): Mostly explains about "socio-economic status", "education" and "linguistic",
- Component 2 (Figure 5.3): Keeps the "family status (single people)" and "transportation modes" information,
- Component 3 (Figure 5.4): Explains the "unemployment status",
- Component 4 (Figure 5.5): Explains the "housing conditions",
- Component 5 (Figure 5.6): Keeps the "gender differentiations for work place".

Figure 5.2 shows that positive values (blue and green colors) for component 1 are more observed in the southern parts of the Island while negative values (orange and red colors) exist dominantly on the north. Being one of the study areas for this thesis, Côte-des-Neiges is one of the most ethnically diverse neighborhoods of Montréal, and hence, component 1 shows that the linguistic and educational characteristics are more diverse in this neighbourhood. While some census tracts show more positive values, we can still observe negative values (orange colors) within the neighbourhood which indicates that some CTs may experience unsatisfactory QOP in terms of socio-economic status and linguistic characteristics. Côte-des-Neiges is also known as a working-class neighborhood. Therefore these results show a meaningful geographical distribution of component 1 for this neighborhood. However, less negative values (green colors) for component 1, are observed in Plateau-Mont-Royal where ethnicity is less diverse and more homogenous structure exist. The results of this component related with socio-economic status in Plateau-Mont-Royal, supports the socio-profile which is explained in chapter 4. Since this neighbourhood has more workers in cultural, communication and personal service sectors, it is expected to observe less negative values for component 1. On the other hand, Figure 5.2 also shows that more negative values (orange color) for component 1 are observed in Hochelaga-Maisonneuve where the majority of the residents speak French. As it has been discussed in chapter 4, linguistic characteristics are one of the most important factors of QOP. These negative results of component 1 in Hochelaga-Maisonneuve demonstrate that the adaptability of minority groups to the neighbourhood would relatively be less (and hence the QOP that they experience may not be satisfactory for them) in terms of language since the majority of people speak French.

Figure 5.3 shows the results of the component 2 which generally explains about the "life style" such as the family status (single people), transportation modes, etc. It is observed that positive values (blue color) are more dominant in the downtown of the Island while negative values (orange and red) exist on the west. Positive values illustrate that the "life style" component of QOP is relatively high in the downtown. This result is not surprising since accessibility to public transportation is easier in the central parts when we compare with the neighbourhoods in the north. Furthermore, this component has also interesting interpretations for family status in the downtown and outer neighbourhoods of the Island such as Pointe-Claire, Beaconsfield, Rivière-des-Prairies and Anjou. These latter neighbourhoods are the places where negative values are loaded for the second component while the downtown districts had positive values. This indicates that single people are willing to live more in the downtown where the place offers diversification for their life style whereas families with children relatively prefer outer neighbourhoods. This can also be explained by the gentrification process that was explained in chapter 4.

As it was analyzed in the literature review before, with the social upgrading and gentrification in the downtown neighbourhoods, more high-skilled knowledge workers, who are generally of a young age, preferred the central parts such as Plateau-

Mont-Royal or Ville-Marie. The results also support that QOP in terms of transportation is higher for these people in the downtown, since there is a positive relationship between "single family status" and "public transportation or bicycle use" as mode of transportation.

Another significant interpretation of Figure 5.3 is that Côte-des-Neiges shows very different characteristics from the other two study areas: Hochelaga-Maisonneuve and Plateau-Mont-Royal. While the negative values are more dominant in Côte-des-Neiges, the other two have positive values for component 2. This indicates a concentration of relatively negative QOP (in terms of transportation modes and family status) in Côte-des-Neiges. However, this result is also not very surprising and eventually supports the social profile of the neighborhood. Since the immigrant population is higher in Côte-des-Neiges than it is compared with the other two, we can expect to see a mixed of negative and positive values for QOP.

In addition to these analyses, there is also need to compare the geographical distribution of the first and second components. It is interesting that an opposite structure is observed in the values of component 1 and 2. While the neighbourhoods on the western part of the Island such as Pointe-Claire and Beaconsfield had negative values for the first component, the same areas had positive loadings for the second component. This shows us a place can be loaded with different QOP meanings at the same time. For instance, Beaconsfield has positive "linguistic characteristics" as a variable of the human capital component of QOP but negative "transportation modes" as a variable of physical characteristics component of QOP.

The comparison of the first and second PCA_{st} components supports that, even within the objective dimension, QOP may be loaded with different meanings with different values. Thus, we can argue that the proposed conceptual framework is also verified through the PCA_{st} results.

Figure 5.4 shows the results of the component 3 where the "unemployment status" is analyzed. It is observed that unlike components 1 and 2, component 3 has different values in Plateau-Mont-Royal where more negative values for this component of QOP are observed. This result supports the socio-economic profile of this neighbourhood explained in chapter 4, since the average household income is relatively low (31 885 CAD). However the same neighborhood had positive QOP in terms of linguistic characteristics, education and transportation modes. The results of component 3, also indicate that the neighbourhoods on the western part of the Island such as Dorval had negative values for "unemployment status". Furthermore, when the geographical distribution of this component is compared with the previous two components, it is observed that QOP can be negative, when it is analyzed in terms of "unemployment status", not only in the outer parts but also in the central parts of the Island such as Plateau-Mont-Royal. It is also interesting that the area called as "Old Port" is the only census tract that has high positive values for component 3 while it was loaded with negative values for both first and the second components.

Figure 5.5 shows the results of component 4 which explains the "housing conditions". The analysis shows that the distribution of this component is relatively the same among the three neighbourhoods. There are both positive and negative values for QOP in terms of housing conditions in every neighbourhood. Among the three neighbourhoods Plateau Mont-Royal has more positive values for housing conditions; indicating that the majority of the houses are relatively new or are in good physical condition. However, there is only one census tract in this neighbourhood that shows an extremely negative value. When the geographical distribution of component 4 is analyzed, the results generally demonstrate that most parts of Ville-Marie have relatively negative QOP in terms of housing conditions. Since this neighbourhood is the oldest one in the city, the results are not surprising. We should also keep in mind that the negative values for QOP in this neighbourhood for component 4 do not necessarily point to an overall negative QOP evaluation. For instance, the same neighbourhood had positive QOP in terms of transportation modes or linguistic characteristics. This reality also supports the proposed conceptual framework where the necessity of combination of different components for QOP has been underlined.

Figure 5.6 shows the gender differentiations for work place, which was linked to "males, place of work status at home". It is observed that Hochelaga-Maisonneuve has negative values while the central parts of the Island have dominantly positive values. This brings up the question of whether there is a trend in place of work status at home. Since the positive values are observed in the central parts such as Old Port

(Ville-Marie) or Plateau-Mont-Royal, the results may be interpreted as a preference of high-skilled knowledge workers to work from their home. With the increasing use of technology and internet, this trend has also an important effect on QOP analysis because these results indicate that housing should not be evaluated as only a "living place" but also as a "work place".

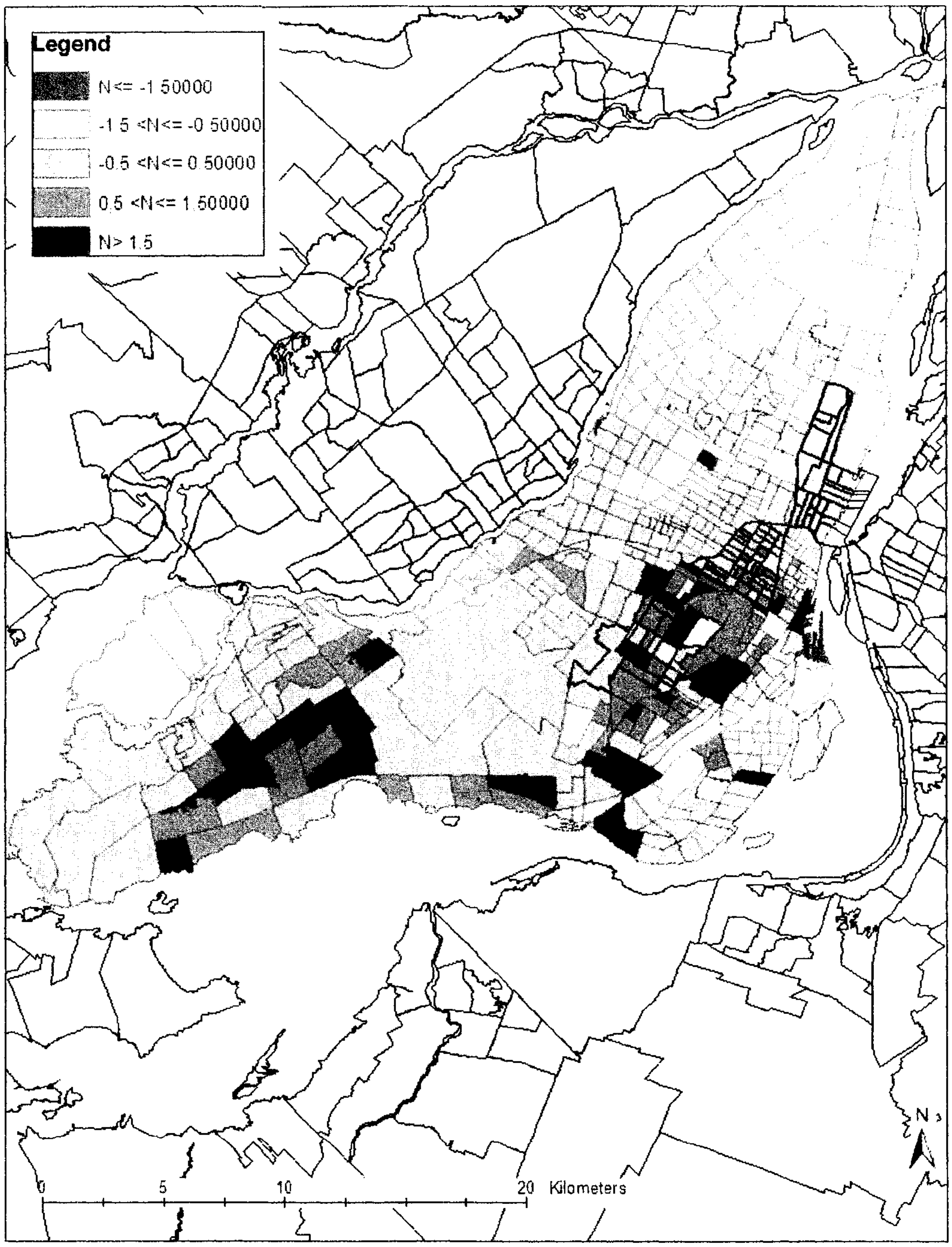


Figure 5.2: The geographical distribution of Component 1: The "socio-economic status", "education" and "linguistic characteristics"

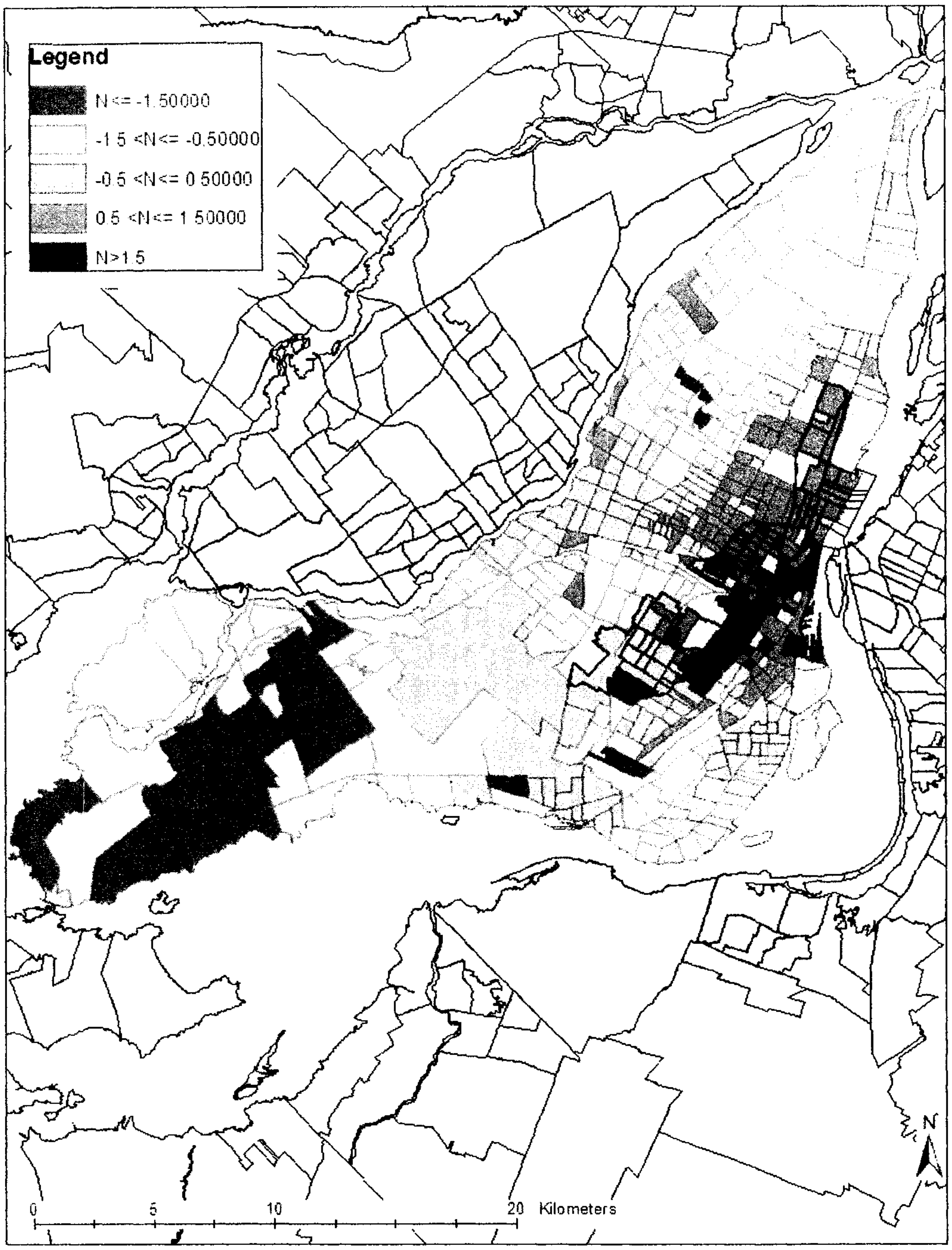


Figure 5.3: The geographical distribution of Component 2: The "family status" and "transportation modes"

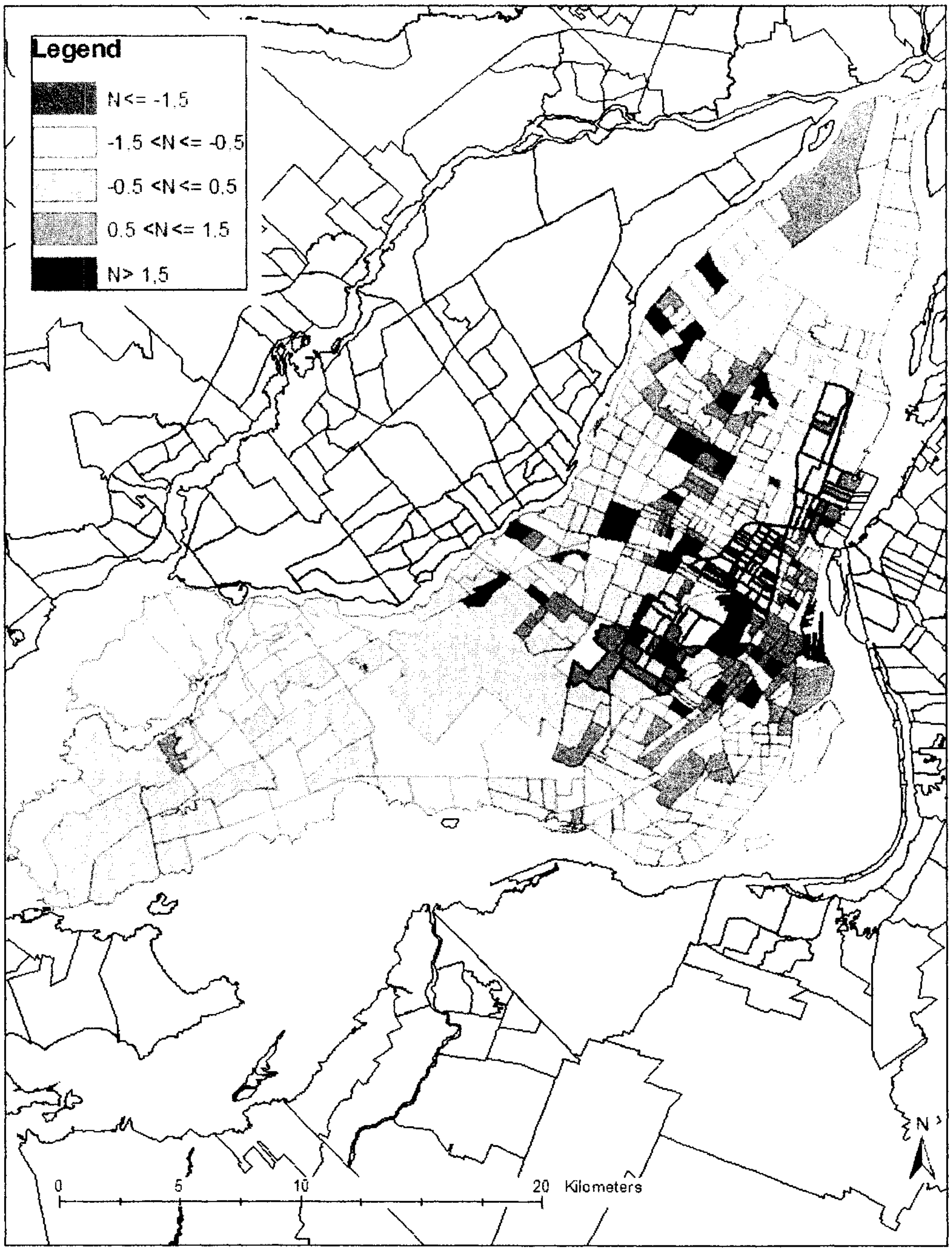


Figure 5.4: The geographical distribution of Component 3: The "unemployment status"

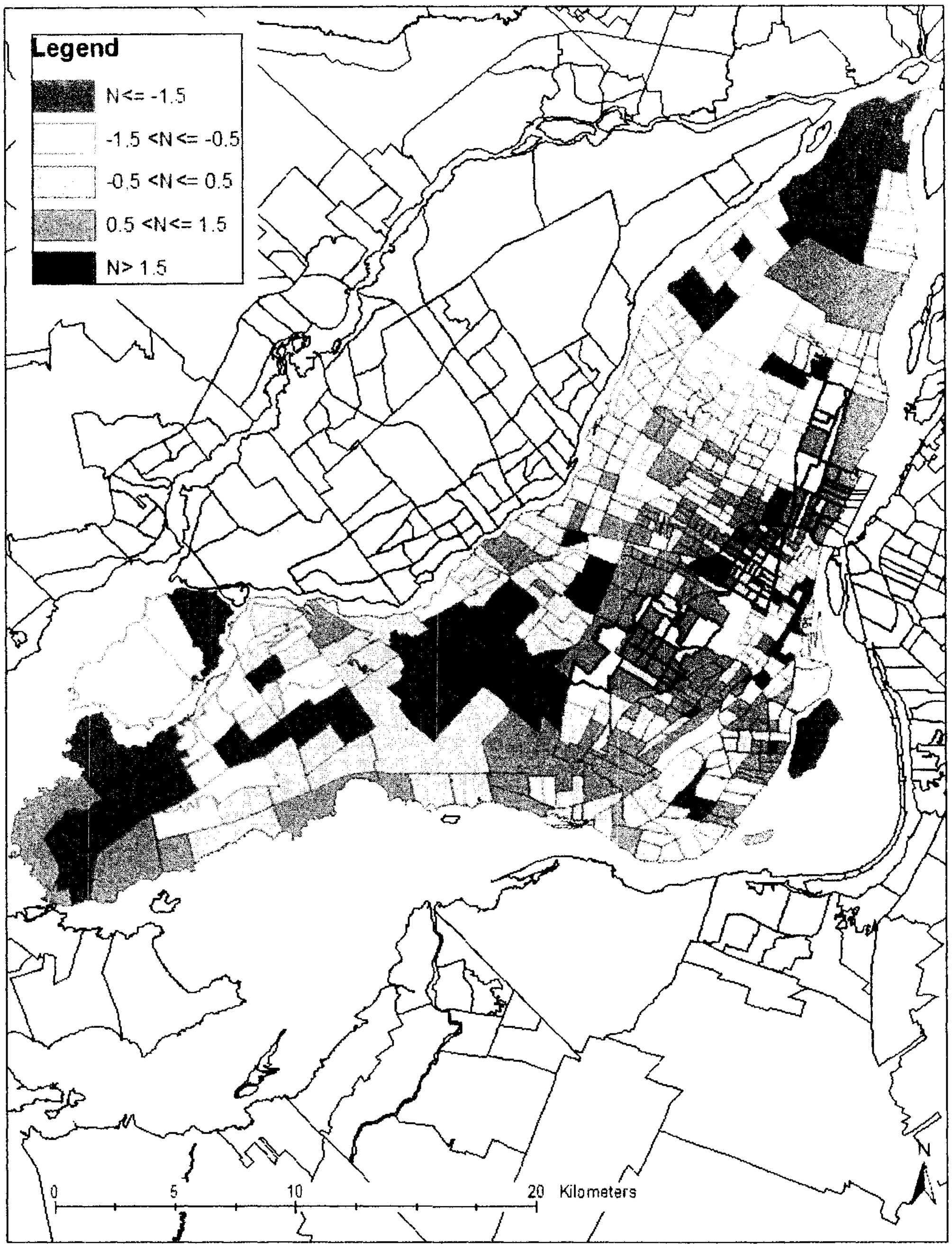


Figure 5.5: The geographical distribution of Component 4: The "housing conditions"

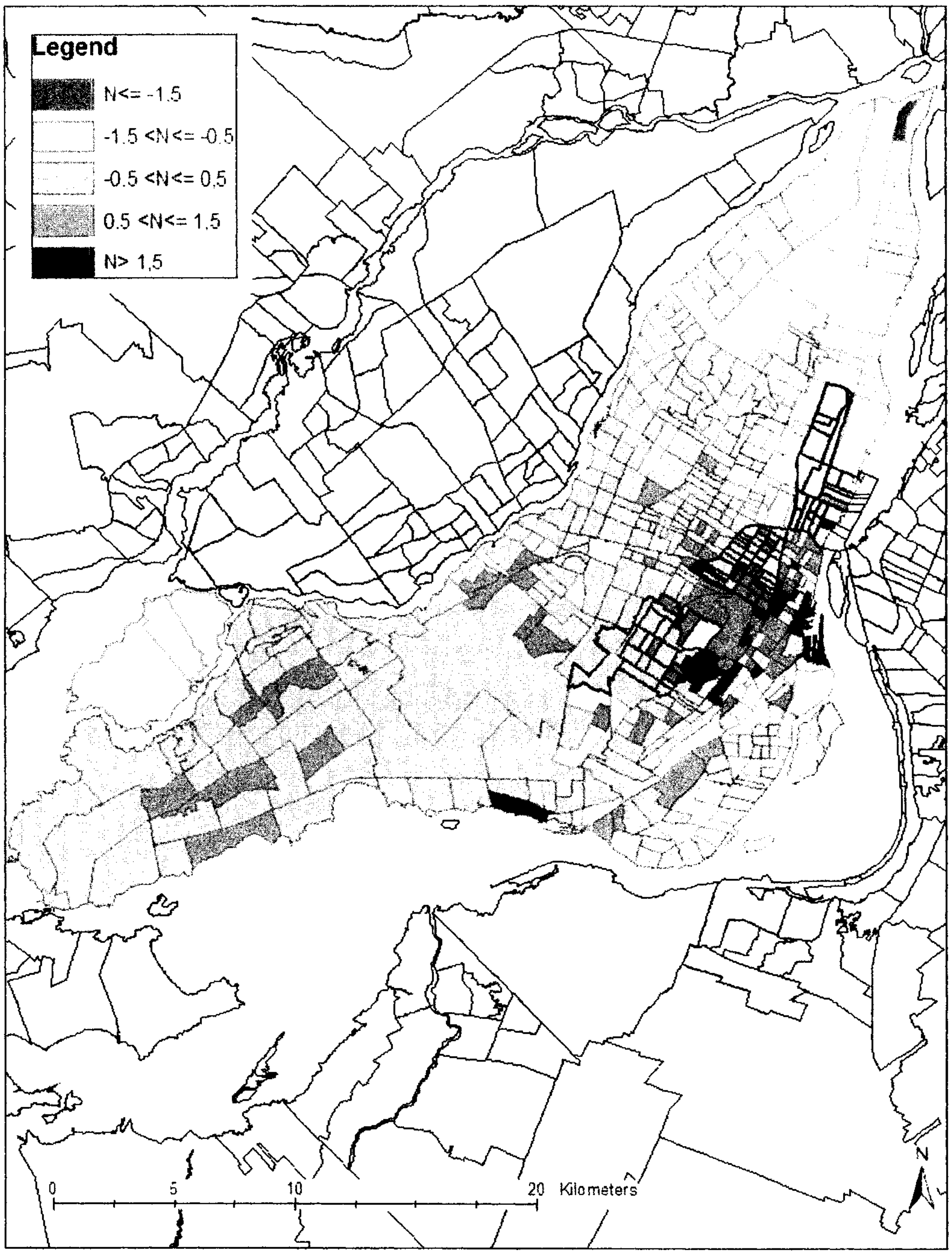


Figure 5.6: The geographical distribution of Component 5: The "gender" differentiations for work place"

5.2.1.2. Quality of place index derivation using census data

With the components derived in PCA_{st}, the next step is to calculate the QOP_{cs} for each CT using a weighted linear combination as has been described in chapter 3 (equation 3.1). Since the "eigenvalues" in this formula (e_i where i = 1, 2, 3, …, N) are the measures of relative importance of each component, they are used to give weights to each component. The eigenvalues attached to the five components are obtained from Table 5.2 as:

$$e_1 = 7.3,\ e_2 = 4.2,\ e_3 = 2.1,\ e_4 = 1.5,\ e_5 = 1.4$$

At the next step, QOP_{cs} is calculated for each CT and saved as a ".dbf" file to see the geographical distribution of the index in GIS (a snapshot of the ".dbf" file is shown in Table 5.4). With the help of these calculations, QOP is linked to the following meanings in an importance ranking of:

1. Socio-economic status, education and linguistic characteristics
2. Family status and transportation modes
3. Unemployment status
4. Housing conditions
5. Work place

The geographical distribution of the QOP_{cs} values is provided in Figure 5.7. From this figure, it is observed that the central parts of the island have higher scores (with blue color) while the outer regions perform at lower scores (red colors). This means that

Table 5.4: A snapshot of the ".dbf" file for QOP_{cs} values

CT_NAME	FAC1_1	FAC2_1	FAC3_1	FAC4_1	FAC5_1	FAC6_1	QOP_{cs}
0001.00	-1.10130	0.38778	-1.32135	0.15923	-0.81471	-0.22049	-2.02
0002.00	-1.15284	0.06464	-0.16548	0.30417	-0.54695	-0.67450	-1.76
0003.00	-0.83677	0.02085	-0.32091	-0.35774	-0.66966	-0.15853	-1.63
0004.00	-0.89491	0.40591	-0.83130	-0.14997	-0.61136	-0.65707	-1.53
0005.00	-1.01839	0.52677	-0.90108	0.28055	-0.76844	-0.64637	-1.55
0006.00	-0.72286	0.12738	0.04757	-0.34682	-0.88195	0.43620	-1.28
0007.00	-0.57728	0.36573	-0.07392	-0.06798	-0.65001	-0.56981	-0.77
0008.00	-0.73037	0.18805	-0.85886	0.42193	-0.88969	-0.05606	-1.39
0009.00	-1.08951	0.10978	-0.38243	0.89324	-0.93303	0.09585	-1.65
0010.00	-0.95790	0.61773	-0.86928	0.39045	-0.74854	0.05786	-1.34
0011.00	-0.54593	0.54827	-0.42190	-0.48572	-0.32470	-1.70191	-0.75

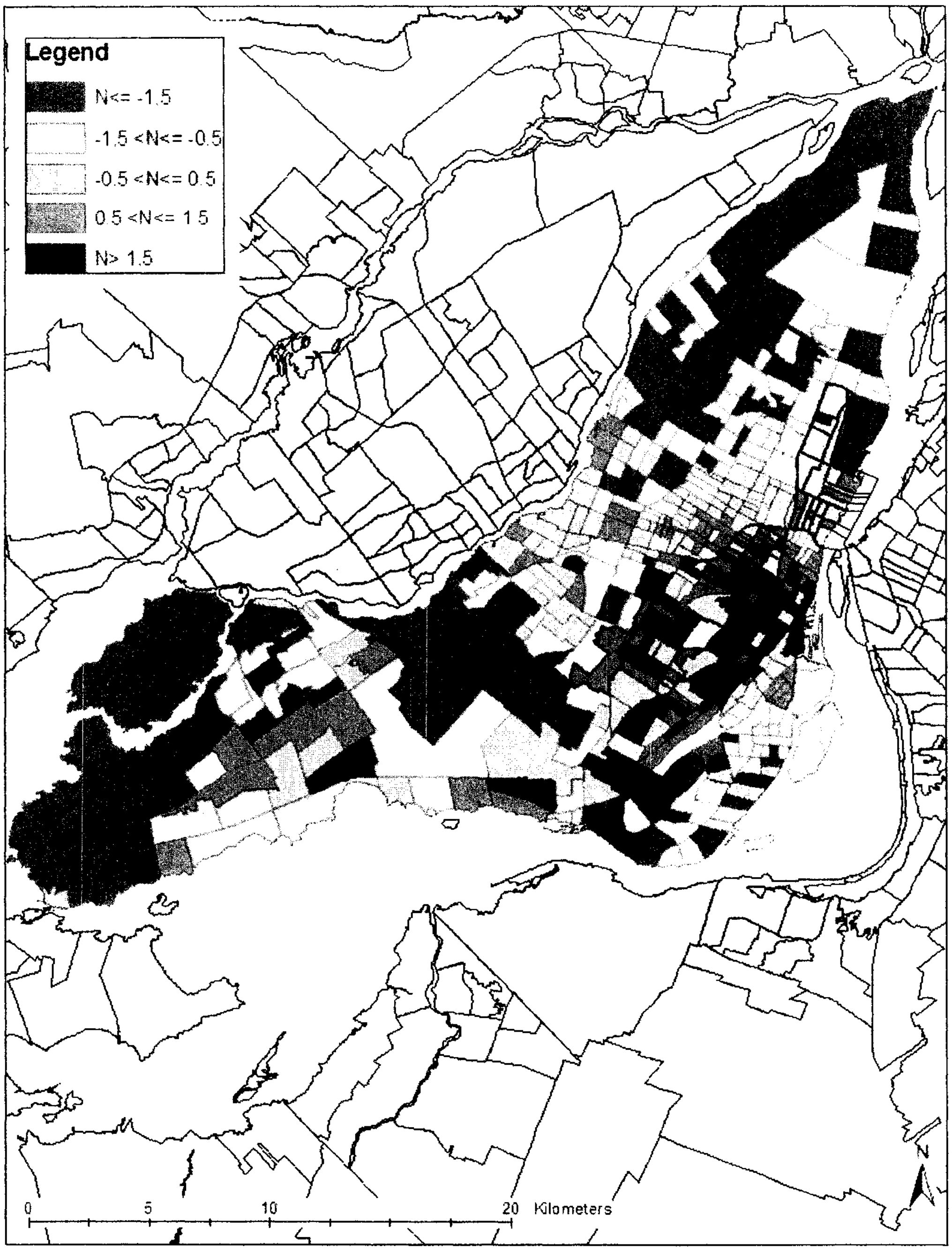


Figure 5.7: The spatial variation of the QOP_{cs} values in Montréal

the most of the census tracts in the neighbourhoods like Ville-Marie and Plateau Mont-Royal are relatively better places in terms of the criterion that are summarized above while the performance of the places in some census tracts of the outer neighbourhoods such as Rivière-des-Prairies or Saint-Laurent are not very satisfactory.

However, it is observed that while Côte-des-Neiges and Plateau-Mont-Royal have relatively positive values for OQP_{cs} (which is an indicator of good places), Hochelaga-Maisonneuve experiences a mixed structure where negative values are also observed. On the other hand, the comparison of QOP_{cs} with each of the PCA components derived before shows that Hochelaga-Maisonneuve had relatively good QOP_{cs} in terms of transportation modes and housing conditions; however, overall, the performance of the neighbourhood is not very good when other factors of QOP_{cs} are included.

Similarly, while Ville-Marie does not have relatively good housing conditions, when the overall QOP_{cs} is analyzed, it is observed that this neighbourhood has a good performance in terms of other factors such as transportation modes, work place or linguistic characteristics.

Another interesting result of Figure 5.7 is that there are also adjacent neighborhoods where the performance of QOP_{cs} shows the totally opposite structure. For instance, according to these results although Sainte-Anne-de-Bellevue and Baie d'Urfè are very close districts on the west end of the Island, census tracts in the first one suffer from poor QOP_{cs} while the latter has better conditions. However, this inequality of the geographical distribution of the index is not relevant in all neighborhoods. The northern and eastern parts of the Island, such as Rivière-des-Prairies and Montréal-Est are also adjacent neighbourhoods but the pattern of QOP_{cs} is consistent among the census tracts in both districts where generally negative values are observed (an indicator of relatively poor conditions). Although it is normal to expect negative values in these neighbourhoods due to the existence of industrial parks, the negative results for the western parts such as Sainte-Anne-de-Bellevue are questionable since average housing prices are high in these areas.

5.2.2. Accessibility to public services and land use

The literature review provided in chapter 2 showed that there is a high potential for the use of GIS and RS techniques on QOP measurements using spatial analysis techniques and land use information gathered from remotely sensed data. While the survey data provided the subjective opinions of people about the accessibility to public services, processing and analyzing the GIS based information makes important contributions in understanding the objective dimension of the QOP such as the existence and proximity of the green spaces or the accessibility to health, emergency and transportation facilities.

The following sections will provide the analysis results of both the land use classification which was obtained from remotely sensed data in RS environment and accessibility to public services that was analyzed in GIS through spatial analysis techniques.

5.2.2.1. Urban land use and greenness information extraction from remotely sensed data

Before the land use information extraction, the first step was atmospheric correction (absorption and scattering) and sensor radiometric calibration which was done by the Remote Sensing Laboratory of University of Ottawa. The second step was the geometric correction of the raw image data (IRS – 1D image of Montréal). Digital images usually contain geometric distortions so significant that they cannot be used directly as a map base without subsequent pre-processing. The sources of these distortions range from variations in the altitude, attitude, and velocity of the platform. Furthermore, there are also other factors such as panoramic distortion, earth curvature, atmospheric refraction, relief displacement, and non linearities in the sweep of a sensor's IFOV (Bannari *et al.*, 1995b, Lillesand and Kiefer, 2000). Therefore, the goal of geometric correction is to compensate for the distortions introduced by these factors so that the corrected image will have the highest practical geometric integrity. The integrity with other sources of data (especially maps stored in GIS) plays an important role. "*In order to be able to exactly overlay images and maps, their* *geometry has to be the same: that is, an orthogonal projection of all points of the ground to a reference surface.*" (Novak, 1992, pp: 339).

The image of Montréal Island has been rectified using "polynomial method". This method is chosen because, first, the inner city is generally a flat area (except the Plateau-Mont-Royal area); secondly, the main goal of this study is to obtain a land cover/use map which is thematic and will be integrated with other sources of data. The geometric correction was conducted with the help of GCPWorks module of the PCI Geomatica V9.0 software.

The image was geocorrected using the "Universal Transverse Mercator" (UTM) projection, NAD 83 and GRS 80 are selected for the datum and for the ellipsoid types, respectively. Seven ground control points (GCPs) from the different areas of the image are selected. The success of the geometric correction is measured with the term "root mean square error" (RMSE). After the rectification steps, the selected seven GCPs showed a very successful residual error of 0.06 pixels which is smaller than 1.2 meters (Figure 5.8). After geocorrection, the next step is to extract the information about the greenness of the study area. To do that, different vegetation indices have been analyzed through the literature survey in chapter 2 to find out which provides the best result in an urban environment. As a result, NDVI, SAVI and TDVI are applied to the study area and results are compared in the following section.

5.2.2.1.1. Vegetation indices

Having rectified the image in the previous section, the next step is to calculate the TDVI, NDVI and SAVI using the equations 2.2, 2.3 and 2.4 and "Easi Modelling" of the PCI software (Figures 5.9, 5.10 and 5.11). Furthermore, for validation purposes, a GIS based land use map has also been converted into raster format (Figure 5.12) to see the differences between the results of the indices and whether an improvement can be provided for the land use map or not. As a next step, for validation purposes, five types of places are selected where the vegetation cover is well known. These places are considered to have 0%, 25%, 50%, 75% or 100% vegetation cover (this selection was based on ground truth data). In order to compare

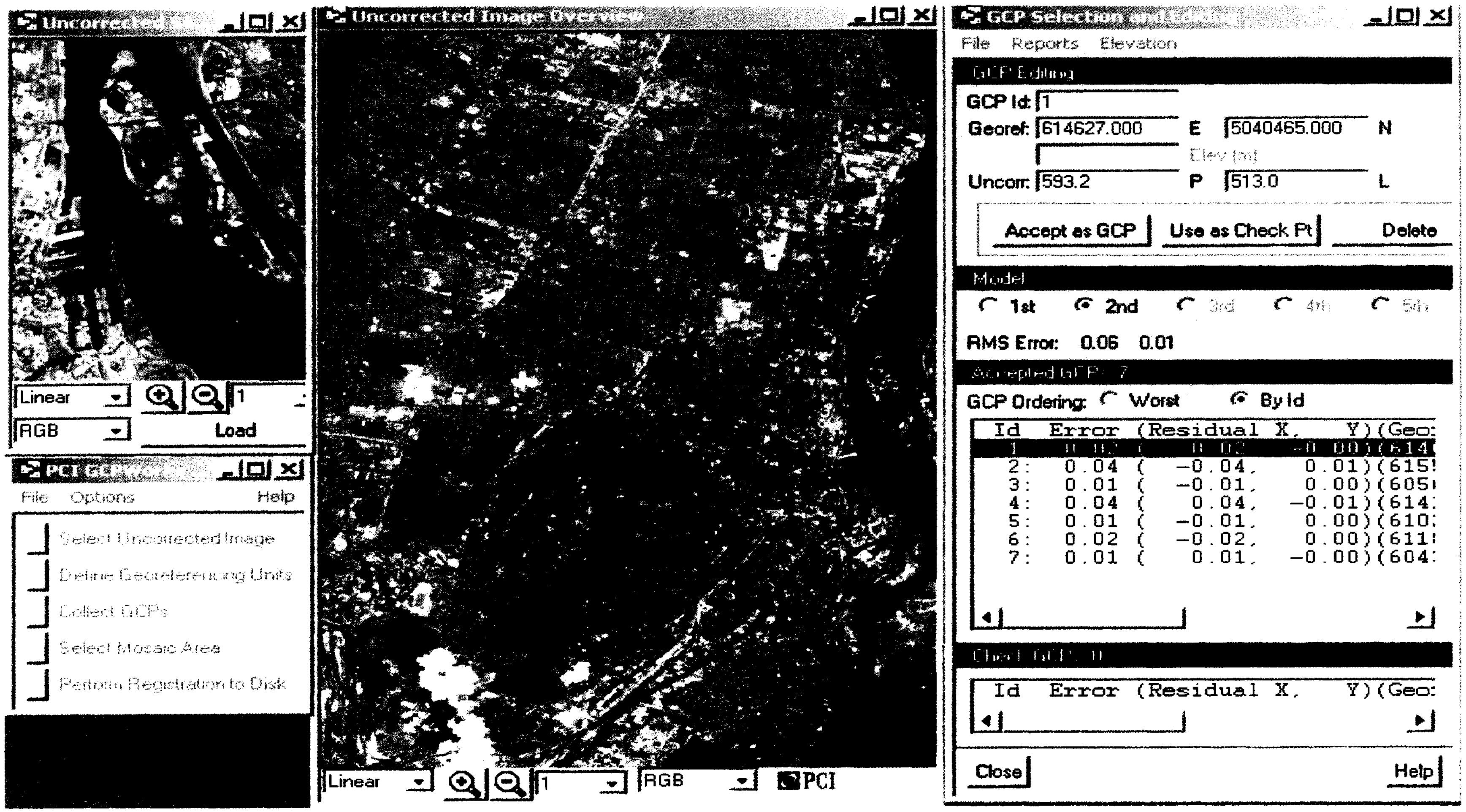


Figure 5.8: Geocorrection of IRS – 1D image of Montréal in PCI software

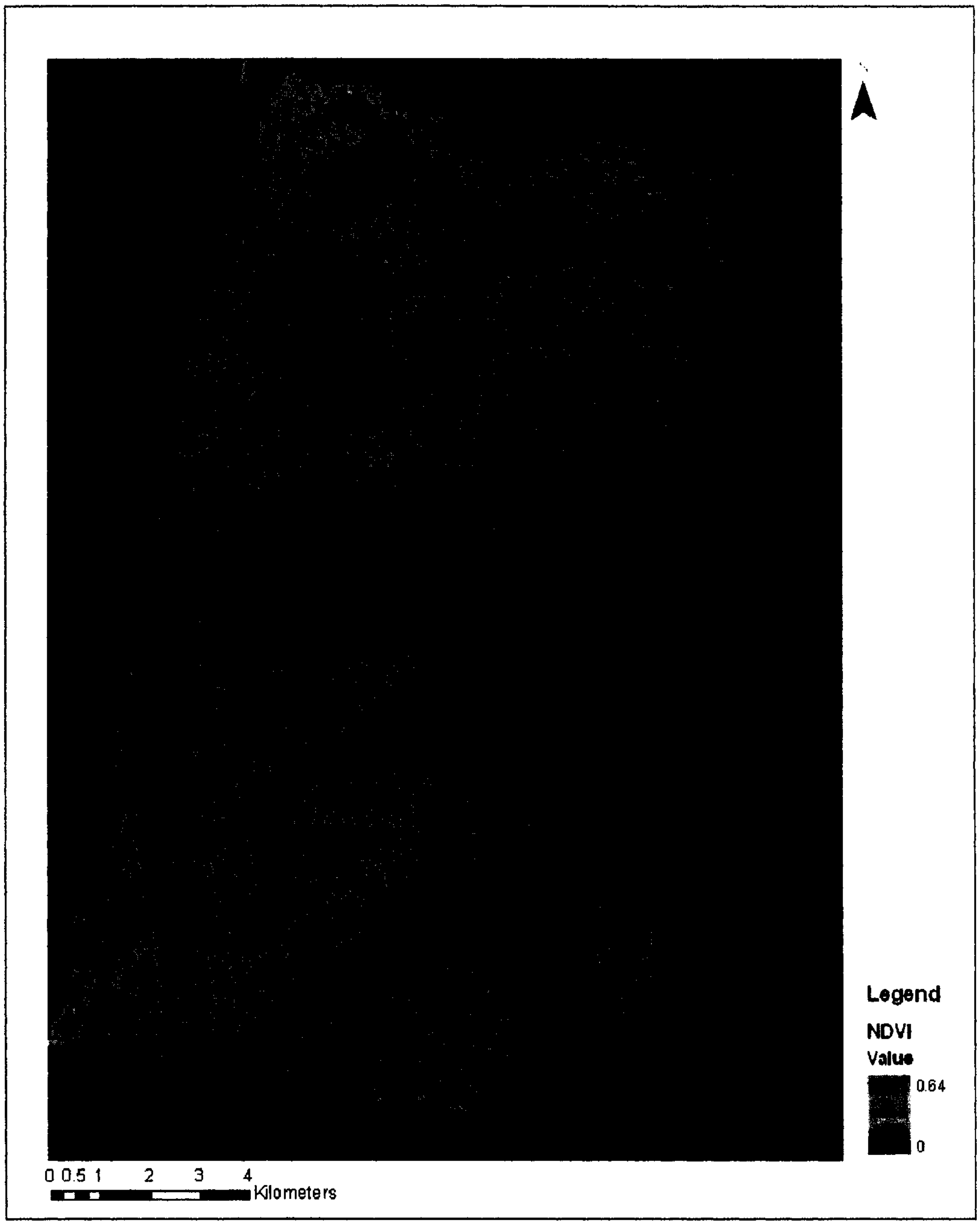


Figure 5.9: NDVI map of Montréal Island

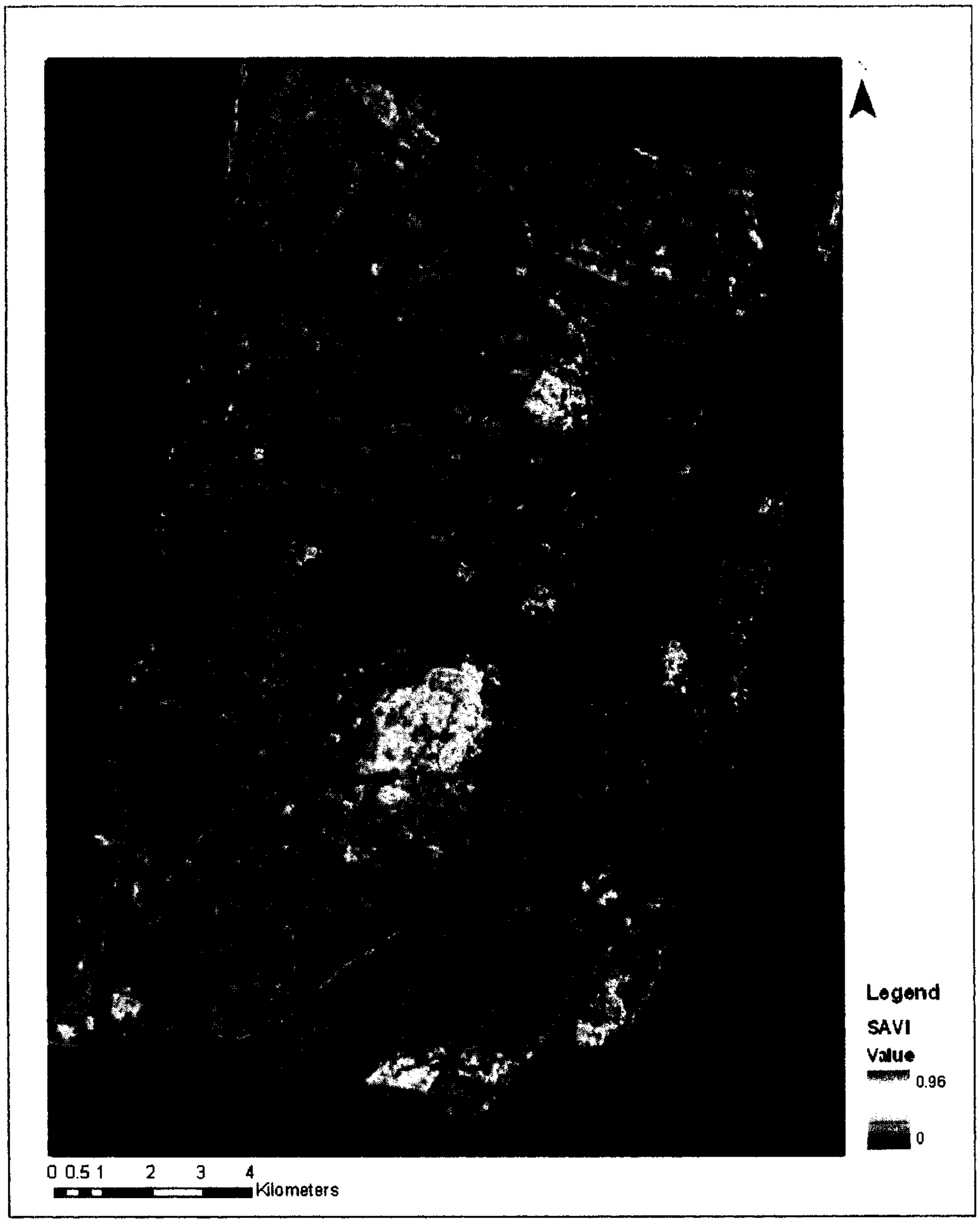


Figure 5.10: SAVI map of Montréal Island

Figure 5.11: TDVI map of Montréal Island

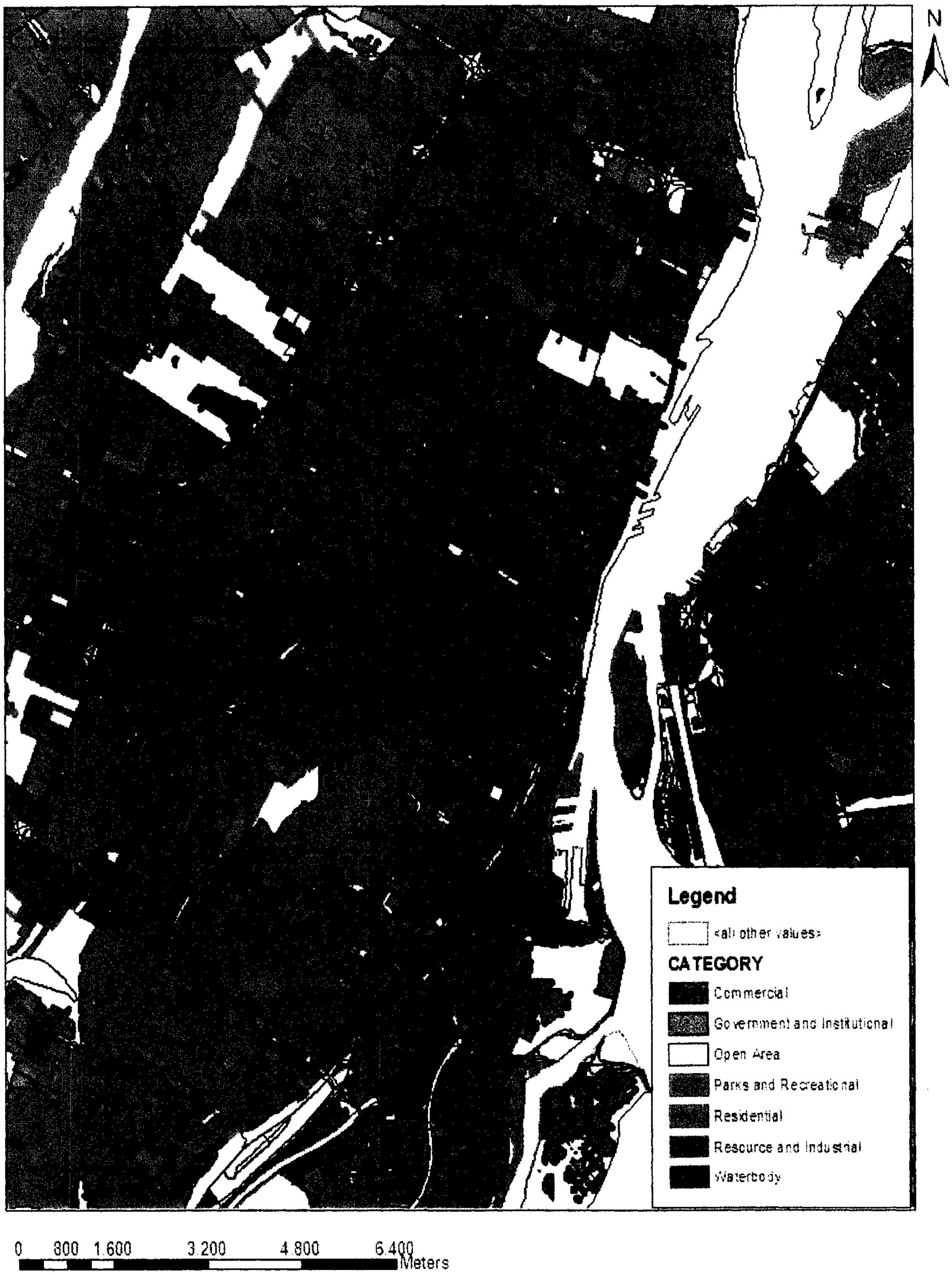


Figure 5.12: GIS based land use map of Montréal Island

the performance of TDVI with respect to SAVI and NDVI, the red and NIR reflectance of 10 randomly selected pixels for each vegetation cover category is read from the image and the trend line of the sensitivity of each index to the percent vegetation cover has been plotted (Figure 5.13).

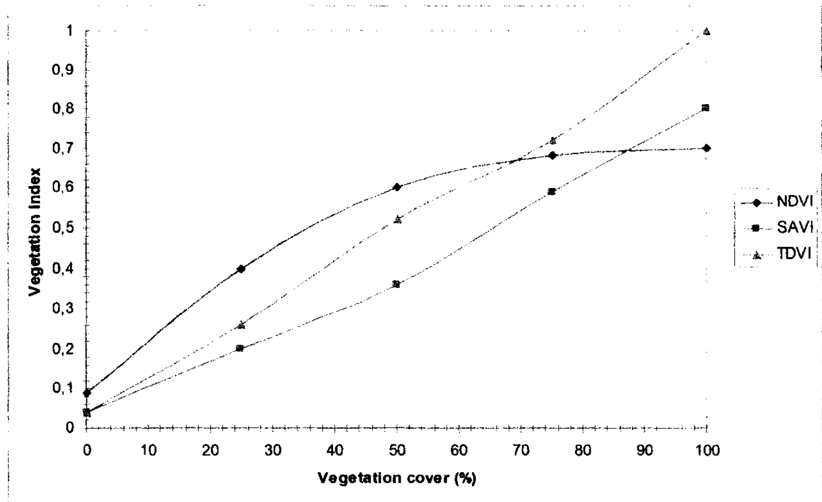


Figure 5.13: Sensitivity of vegetation indices to percent vegetation cover

From Figure 5.13, it is observed that for sparse vegetation cover (0-50%), NDVI overestimates the real situation by an error of approximately 25% while SAVI is more close to the real situation. When the vegetation cover is between 50-100%, this time NDVI provides an underestimation of 26% as an average (see Figure 5.9). Therefore, NDVI results in a saturation and overestimation problem in dense vegetation cover. However, independently from the vegetation cover rate, TDVI provides excellent linearity and description of the vegetation cover in urban environment.

As it has previously been indicated, the differentiations among the green areas play an important role in urban QOP studies. Since planning policies and urban management would differ in forestry areas or parks and amusement areas, this study has provided promising results in separating the different categories successfully. When we compare Figures 5.11 and Figure 5.12, it is observed that the general category for green areas (named as 'parks and recreational') in Figure 5.12 has been sub-categorized into different green vegetation covers in Figure 5.11 which indicates the power of TDVI. For instance, while Mont-Royal Park has been indicated as one class in the GIS based land use map, the green vegetation has been differentiated into more classes in Figure 5.11 which will, later on, be categorized as 'urban forest' and 'parks and cemetery' in the land use classification step of section 5.2.2.1.3 of this thesis.

5.2.2.1.2. Principal component analysis

As it has been covered in chapter 2, PCA is used to identify groups of inter-correlated variables and simplify the data set. Since the image data obtained from different wavelengths cover similar information, PCA is also used in remote sensing applications to reduce the redundancy in the data. According to Lillesand and Kiefer (2000), if this transformation is applied before image classification, it provides an important contribution to the accuracy of the classification results and the components are simply the linear combinations of the original data values. For these reasons, PCA_{rs} is applied to the IRS -1D image using the "Xpace" module of PCI software to derive the first three components (Figures 5.14, 5.15 and 5.16). Table 5.5 shows the PCA_{rs} report.

As Lillesand and Kiefer (2000) explain, the data along the first principal component have usually greater variance or dynamic range than the data plotted against either of the original axes. The data along the second principal component have far less variance. This is characteristics of all principal components. For channels of multispectral data, the first principal component (PC1) includes the largest percentage of the total scene variance and succeeding components (PC2, PC3,...,PC*n*) each contain a decreasing percentage of the scene variance. Furthermore, because successive components are chosen to be orthogonal to all previous ones, the data they contain are uncorrelated. These general characteristics have also been observed within the results of the PCA_{rs} conducted for this thesis. As it is observed from Table 5.5, PC1 expresses the majority (94.7 %) of the variance in the original data set, and PC1, PC2 and PC3 explain almost all of the variance (99.83 %).

Since principal component images can be analyzed as either in white and black or color combinations, in this thesis, Figures 5.14, 5.15 and 5.16 show the three components separately black and white color combination.

Table 5.5: PCA$_{rs}$ report

PCA Principal Component Analysis V8.2 EASI/PACE 12:08 29Apr2004

H:\PhDThesis\RS\STUDIES\New\montréal.pix[S 13BIC 675P 940L] 29Apr2004

Input Channels: 1 2 3 4

Output Channels: 8 9 10

Eigenchannels : 1 2 3

Sampling Window: 0 0 675 940

Sample size : 79650

Channel	Mean	Deviation
1	66.8686	46.3908
2	44.3325	32.5254
3	52.9114	40.5769
4	68.3067	53.0783

Covariance matrix for input channels:

	1	2	3	4
1	2152.11			
2	1488.36	1057.90		
3	1682.74	1152.59	1646.49	
4	2268.83	1600.85	2054.27	2817.30

Eigenchannel	Eigenvalue	Deviation	%Variance
1	4.3574	85.2898	94.79%
2	290.5764	17.0463	3.79%
3	96.2794	9.8122	1.25%
4	12.5862	3.5477	0.16%

Eigenvectors of covariance matrix (arranged by rows):

0.52875	0.36909	0.45725	0.61247
-0.60926	-0.44091	0.52276	0.40140
-0.27094	0.15433	-0.68843	0.65486
-0.52519	0.80346	0.20905	-0.18686

Scaling Information:

Eigen Channl	Output Channl	-----Unscaled----- Min	Max	Deviation Range	Midpoint	Scale Factor
1	8	-117.749	380.321	all	127.500	1.000
2	9	-111.870	83.900	all	127.500	1.000
3	10	-80.888	91.167	all	127.500	1.000

Figure 5.14: Principal Component 1 (PC1): Brightness

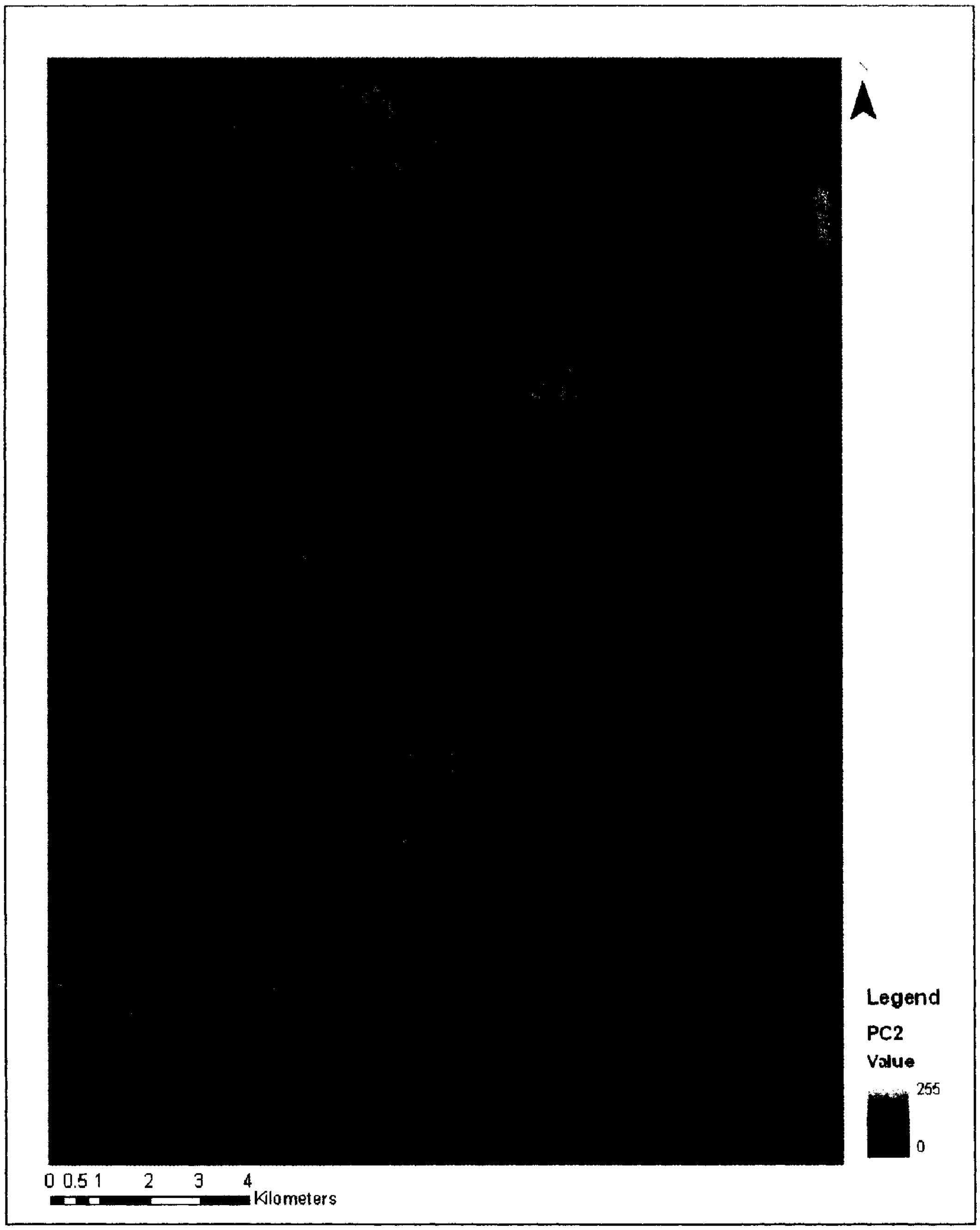


Figure 5.15: Principal Component 2 (PC2): Greenness

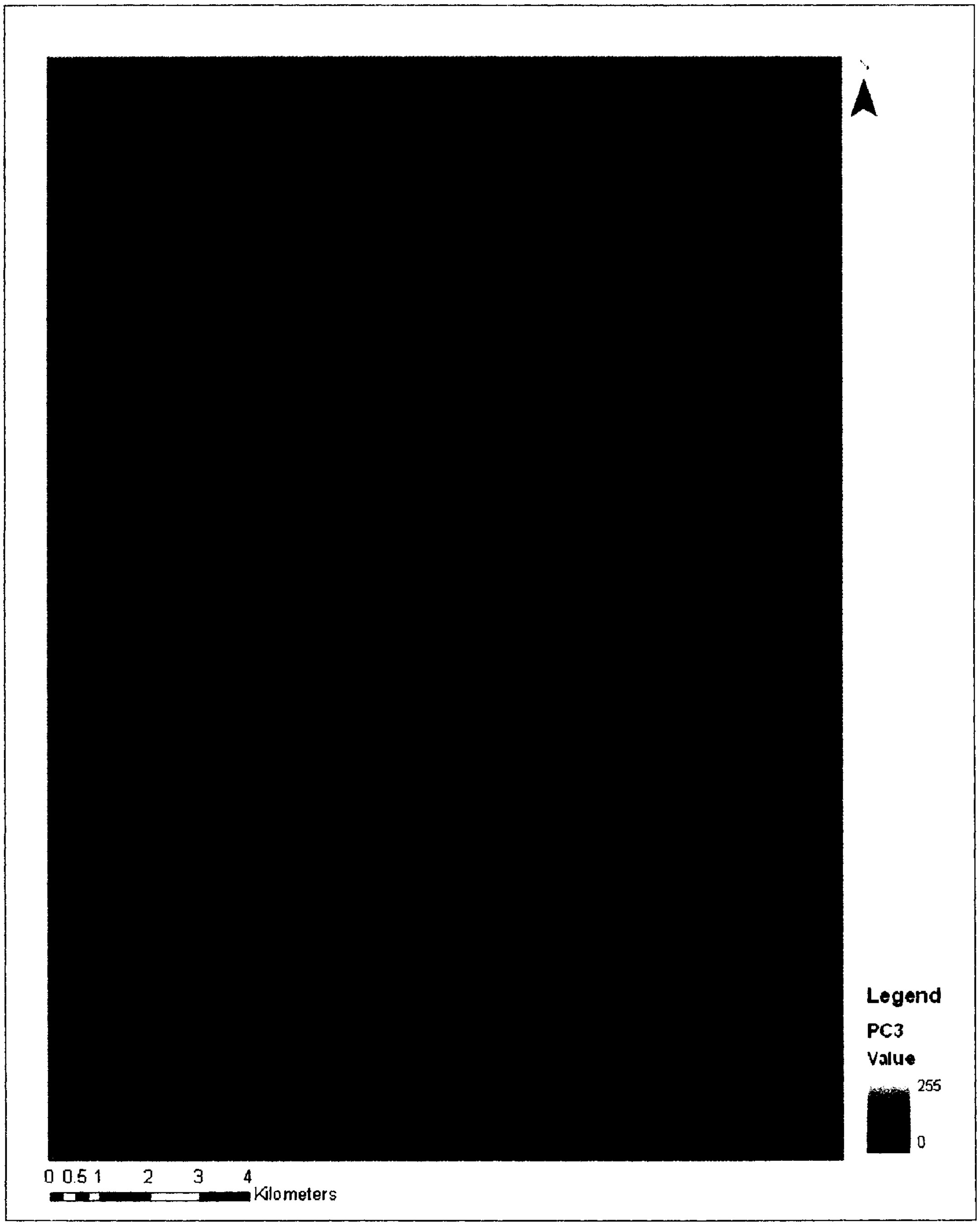


Figure 5.16: Principal Component 3 (PC3): Swirness

It should be noted from these three figures that while PC1 keeps the majority of the variance in the original data set, PC2 and PC3 illustrate certain features that were masked by more dominant patterns in the PC1. For instance, it is easier to detect the vegetation cover in PC2 than in PC1 (however, this feature is not very clearly identified in PC1). When each component is analyzed separately, it is observed that PC1 keeps the information for "brightness" and it also provides the topographical features strongly while the hydrological features such as lakes and rivers are weak. PC2, on the other hand, keeps the "greenness" information. Therefore the green areas such as parks and forestry areas are more detectable in this second component. The third component, PC3, keeps the "swirness" which highlights the hydrographical structures and moisture. Furthermore, PC4 contains virtually no information and tends to depict little more than system noise (Lillesand and Kiefer, 2000).

If used in an image classification process, principal component data are normally treated in the classification algorithm simply as if they were original data. Thus, after having successful results from the PCA_{rs}, the following section is devoted to classifying the image to obtain meaningful land use categories within the study field.

5.2.2.1.3. Urban land use classification

Digital image classification, also known as spectral pattern recognition, uses the spectral information contained in each image pixel. Classified images are thematic maps containing a mosaic of pixels belonging to different classes. The objective of the classification process is to assign all pixels in the image to themes or classes that represent objects in the ground cover.

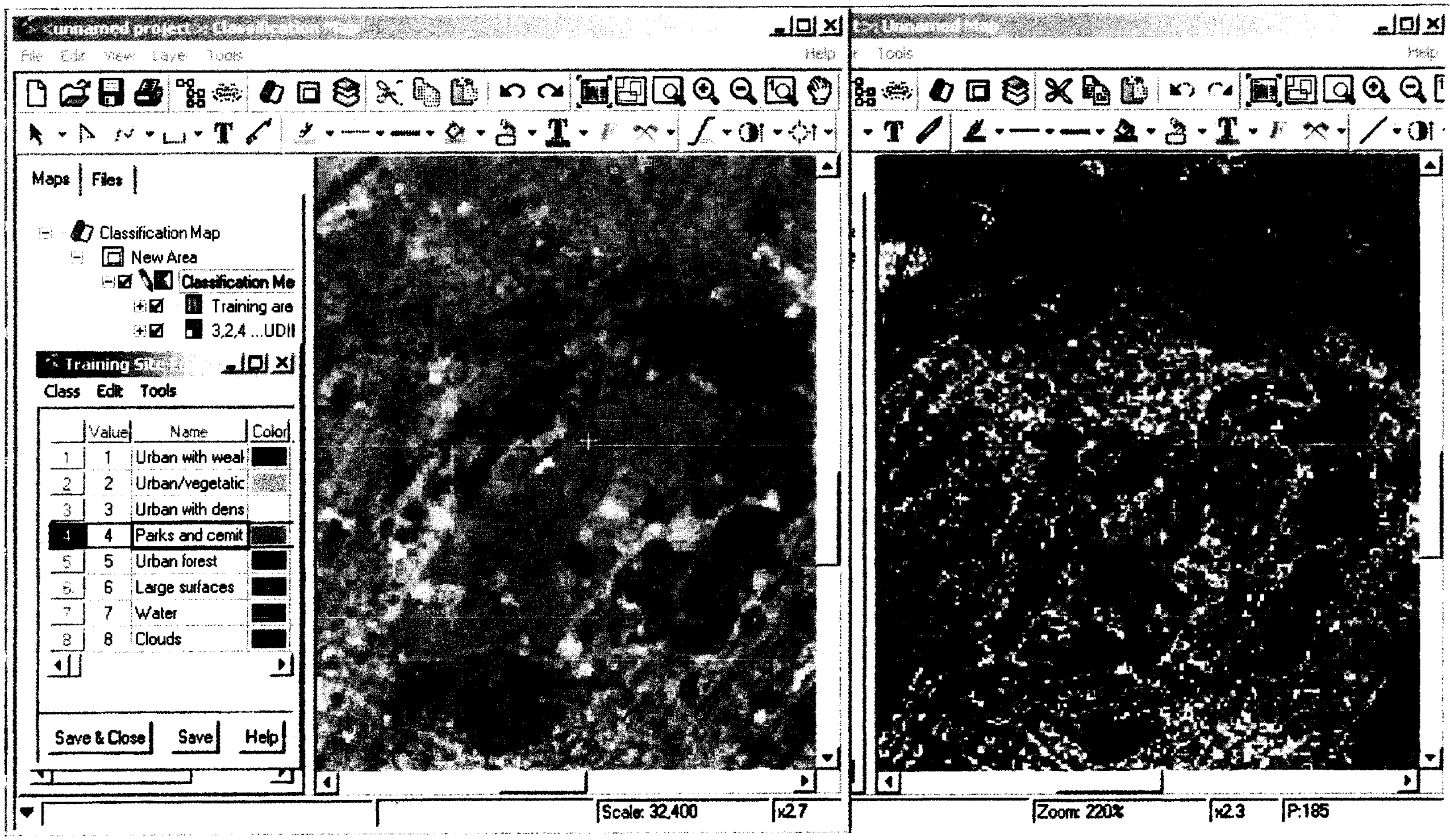
Classification distinguishes between information classes and spectral classes. Information classes are ground cover categories you are interested in identifying from the original spectral data in imagery. There are two broad types of classification: supervised and unsupervised classification techniques. In the supervised classification, the image analyst "supervises" the pixel categorization process by specifying, in the computer algorithm, numerical descriptors of the various land cover types present in a scene. To do this, reprsentative sample sites of known cover type, called training areas, are used to compile a numerical "interpretation key" that describes the spectral attributes for each feature type of interest. Each pixel in the data set is then compared numerically to each category in the interpretation key and labeled with the name of the category it "looks like". In the unsupervised approach, the image data are first classified by aggregating them into the natural spectral groupings, or clusters, present in the scene. Then the image analyst determines the land cover identity of these spectral groups by comparing the classified image data to ground reference data (Lillesand and Kiefer, 2000).

For this thesis, the supervised classification technique is applied to the IRS-1D image of Montréal that has been geocorrected and used to calculate the TDVI and PCA. To be consistent with the social data that have been analyzed in this thesis, the acquisition date of the image data is deliberately selected to match the same year of the census data (2001). Therefore, the result of this image classification reflects a land use map which is consistent with other data sources. The objective here is to understand the land use distribution within the study area that provides important feedback on the QOP. Furthermore, the reason for selecting the "supervised classification technique" is that it enables the image analyst to decide on the classes and specify the training areas. For this research, the following eight land use classes are identified:

1. Urban with weak vegetation (which is an indicator of high dense urban areas),
2. Urban / vegetation (which is an indicator of medium dense urban areas),
3. Urban with dense vegetation (which is an indicator of low dense urban areas),
4. Parks and cemetery,
5. Urban forest,
6. Large surfaces (such as open areas or big shopping malls),
7. Water,
8. Clouds (although this is not a land use category, since an image correction to remove the effect of clouds is not applied, this is entered as a separate category and identified easily in the training area selection)

To this end, first step is the selection of training areas which the supervised classification will be based on. In Figure 5.17 (a) and (b), training site selection for the vegetation cover is made by opening two windows side to side simultaneously. Figure 5.17.a shows the classification meta layer with NIR, Red and SWIR channels assigned for RGB (training sites for urban forest has been activated shown by dark green). Figure 5.17.b shows the TDVI image which is opened to see better the differentiations in the vegetation cover (where pink color shows forestry, red shows parks and cemetery, green shows urban with green vegetation, blue urban with very less vegetation cover and black color shows urban without vegetation cover).

In the training area selection, the goal is to identify homogeneous samples of different surface cover types in the image. Samples are created by drawing colored layers over the parts of the image that are likely to be the information classes that the image analyst wishes to examine. Selecting appropriate training areas is based on the familiarity of the analyst with the geographical region and knowledge of the actual surface cover types shown in the image. For this purpose, to understand the study area better two trips were made to Montréal where survey data (which is analyzed in the following sections) were also collected.



(a) (b)

Figure 5.17: (a) The training area selection for the supervised classification - **(b)** TDVI image

PCI software also provides several methods for insuring that the training areas are representative and complete. For that purpose, once the training areas are selected, different methods are used for testing purposes such as histograms, signature separability, signature statistics and scatter plots. Figure 5.18 shows an example of the "signature statistics" result obtained for Class#1 (see Appendix D for the signature statistics results of all other classes). It is observed that the number of training areas selected for Class#1 (which refers to the "Urban with weak vegetation" category) is 1566 pixels which provide an acceptable level of pixel numbers for the calculation of that class in the classification step. The number of pixels for each category is given in Table 5.6 (obtained from the "Signature Statistics" in Appendix D).

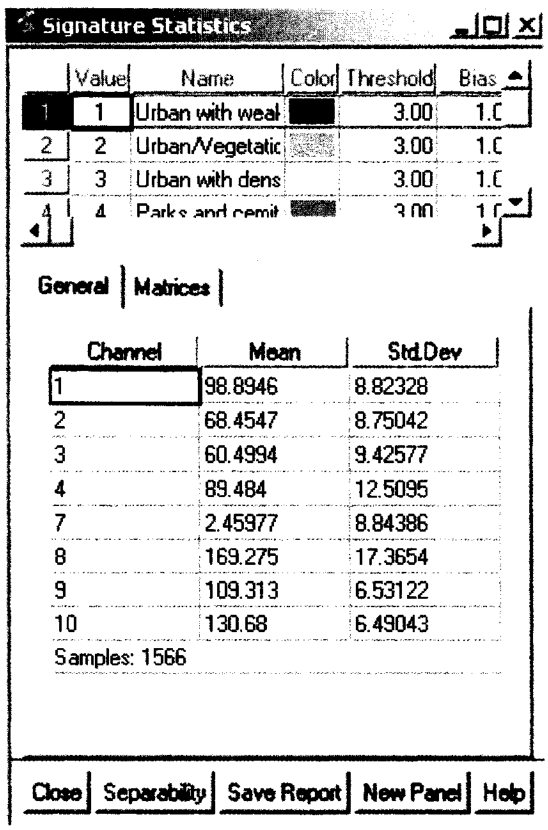


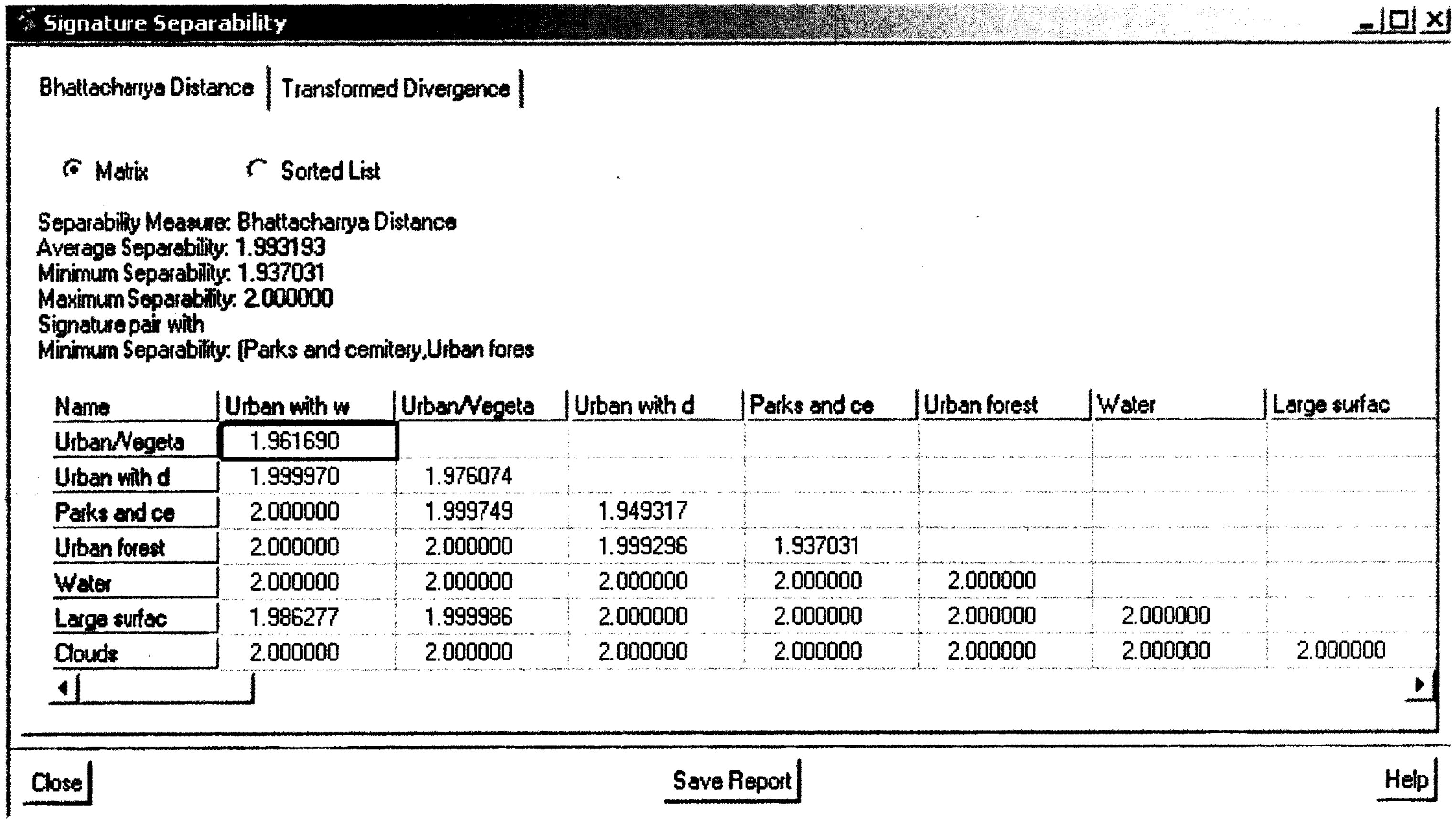
Figure 5.18: Signature statistics for class#1 (Urban with weak vegetation)

Within each class definition, PCI also enables the analyst to enter a "threshold" and a "bias". Once the mean and variance are calculated for each class from the training data, the threshold determines the maximum spectral distance within which pixels could occur while still being within the same class. Threshold is measured in standard deviations. The area (threshold) and position (mean) of a category within spectral space is thereby delineated for each class. Invariably, land cover categories will overlap in spectral space. The bias determines which category will be assigned to the overlapping pixels (i.e., a tiebreaker). Therefore, the threshold is a "priori" estimation of variance and the bias is a "priori" estimation of frequency. The default values within PCI (3.0 for threshold and 1.0 for bias) are selected for this study as shown in Figure 5.18.

Table 5.6: Number of pixels selected for each training class

Training Class	# of pixels
Urban with weak vegetation	1566
Urban / Vegetation	321
Urban with dense vegetation	542
Parks and cemetery	233
Urban forest	434
Large surfaces	12675
Water	109
Clouds	894
TOTAL	**16774**

The "Signature Separability" matrix provides us the most important information about the accuracy of the training areas (Figure 5.19). It is calculated as the statistical difference between pairs of spectral signatures. Divergence is shown as both "Bhattacharrya Distance" and "Transformed Divergence", with the Bhattacharrya Distance as the default calculation. Both elements are shown as real values between zero and two. A zero indicates complete overlap between the signatures of two classes and two indicates a complete seperation between the two classes (and hence excellent seperability). If the value is less than 1.90, the training area must be deleted and the selection should be repeated until the result is acceptable. These measurements are monotonically related to classification accuracies (PCI, 2001). As observed from Figure 5.19, the average separability is 1.99 while the minimum is 1.93 which shows an acceptable level of accuracy. The poorest separa-



Name	Urban with w	Urban/Vegeta	Urban with d	Parks and ce	Urban forest	Water	Large surfac
Urban/Vegeta	1.961690						
Urban with d	1.999970	1.976074					
Parks and ce	2.000000	1.999749	1.949317				
Urban forest	2.000000	2.000000	1.999296	1.937031			
Water	2.000000	2.000000	2.000000	2.000000	2.000000		
Large surfac	1.986277	1.999986	2.000000	2.000000	2.000000	2.000000	
Clouds	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000	2.000000

Figure 5.19: Signature separability of the selected training areas

bility occurs between the first three urban categories (the classes which usually show a mixed spectral signature in an urban area). Moreover, especially the category for "urban with dense vegetation" is not very well separated from the parks and cemetery category. This was anticipated before the analysis since it is usually very difficult to differentiate the spectral signature of the neighbourhoods having trees in the backyards of the houses and the parks exist within that neighbourhood.

"Scatter Plot" is another way of representation of the class separability which is shown in Figure 5.20 (see Appendix E for the Scatter Plot results showing how the other three original channels of the image are plotted versus the selected training classes). This figure shows that the training areas are separated well in the two dimensional plot of the Channel#1 (red) versus Channel#3 (NIR) of the image data set. It is also important to underline the effect of TDVI for the separability of the classes that have vegetation cover. For example, not only "urban forest" is generally separated perfectly from other classes but also some classes that have mixed spectral signature (like urban with dense vegetation) show a good separability (1.99).

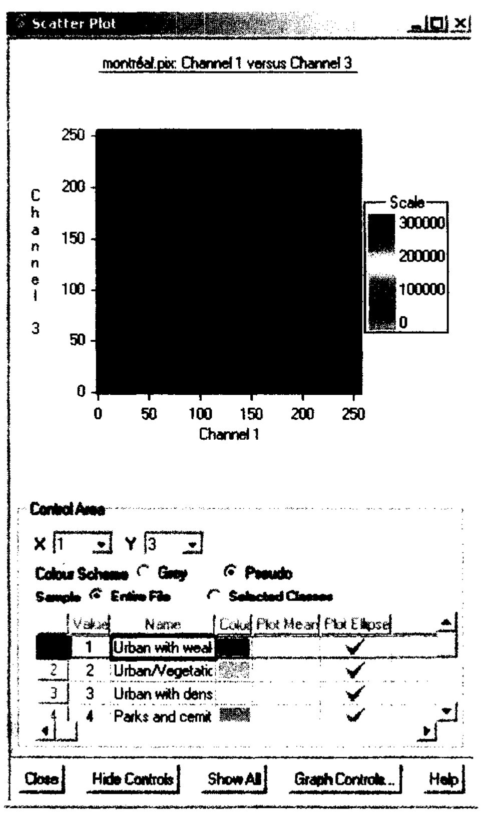


Figure 5.20: Scatter plot

Having acceptable levels for the separability of the training areas, the next step is to conduct the classification process. There are mainly three methods of conduction of a supervised classification: minimum-distance-to-means classifier, parallellpiped classifier and maximum likelihood classifier. Remote sensing software packages, such as PCI, construct bounding boxes, or parallelepipeds, around clusters of signatures collected from the training areas. The limits of these parallelepipeds represent each individual class in multi-spectral space. In classifying the entire image, certain decision rules govern how pixels are classified (Lillesand and Kiefer, 2000). Pixels whose multi-spectral reflectance values fall wihtin the limits of a parallelepiped are immediately classified to that parallelepiped's corresponding class. In areas where parallelepipeds overlap or for pixels that fall outside parallelepiped limits, the maximum likelihood decision rule determines the classification. This rule calculates the statistical probability of a pixel belonging to a particular class, based on the variance and covariance of the spectral signatures. Therefore, the combination of the parallelepiped and maximum likelihood decision rules results in an output map in which no pixels are left unclassified. Therefore, in the mixed urban environments this mixed approach is the most appropriate and used by researchers (Hill *et al.*, 2003; Pinard, 2004). For this thesis, since the study field is an urban area where the covariance is expected and it is very hard to differentiate the different categories, this mixed approach of the parallelepiped and maximum likelihood classifier technique is applied.

The resulting image is shown in Figure 5.21. The accuracy of the classification is also tested using the "Confusion Matrix" indicated in the resulting report of the classification shown in Table 5.7. A Confusion matrix is used to determine how well a classification has categorized a representative subset of pixels used in the training process of a supervised classification. This matrix is prepared by classifying the sampled training set pixels and listing the known cover types used for training (columns) versus the pixels actually classified into each land cover category by the classifier (rows).

According to Table 5.7, the probability of this classification to accept or reject a pixel was computed as 95%. The results show that 97.80 % of the pixels are classified into the correct classes (overall accuracy). This table also provides the

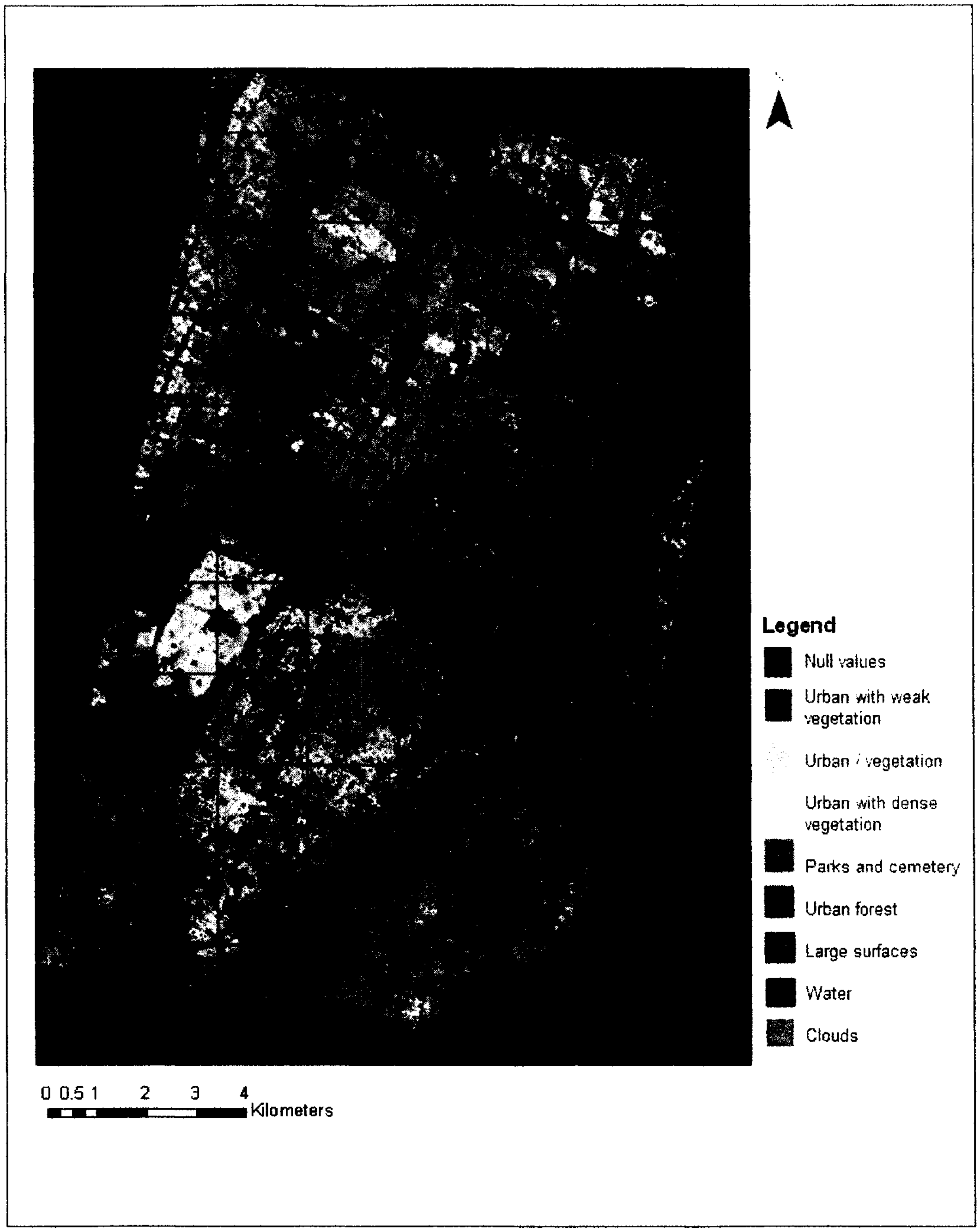


Figure 5.21: The resulting image of the mixed approach classification

Table 5.7: The confusion matrix of the mixed approach classification

CONFUSION MATRIX

Areas		Number of	Percent Pixels Classified by Code								
Name	Code	Pixels	0	1	2	3	4	5	6	7	8
Urban with we	1	1566	2.43	**93.42**	2.43	0.06	0.00	0.00	0.00	1.66	0.00
Urban/Vegetat	2	321	0.31	1.56	**98.13**	0.00	0.00	0.00	0.00	0.00	0.00
Urban with de	3	542	2.40	0.00	0.55	**94.65**	2.40	0.00	0.00	0.00	0.00
Parks and cem	4	233	4.72	0.00	0.00	0.43	**91.42**	3.43	0.00	0.00	0.00
Urban forest	5	434	3.92	0.00	0.00	0.00	1.15	**94.93**	0.00	0.00	0.00
Water	6	12743	0.42	0.42	0.00	0.00	0.00	0.00	**99.17**	0.00	0.00
Large surface	7	159	2.52	18.87	0.00	0.00	0.00	0.00	0.00	**78.62**	0.00
Clouds	8	894	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**94.30**

Average accuracy = **93.08**

Overall accuracy = **97.80**

KAPPA COEFFICIENT = **0.94798** Standard Deviation = 0.00261

Confidence Level :

99 +/- 0.00672

95 +/- 0.00511

90 +/- 0.00429

information about "errors of commission" and "errors of omission". For example, 1.15 % of pixels have been assigned to the fourth class which is "Parks and cemetery", indicates the error of commission for the class "Parks and cemetery". However, it also indicates the error of omission since that percentage of pixel should normally have been assigned to the class "Urban Forest".

The other information that can be obtained from Table 5.7 is the "Kappa Coefficient". This statistic is a measure of the difference between the actual agreement between the reference data and an automated classifier and the chance agreement between the reference data and a random classifier (Bannari *et al.*, 1998). Therefore, it is an indicator of the extent to which the percentage correct values of an error matrix are due to "true" agreement versus "chance" agreement. As "true" agreement approaches 1 and chance agreement approaches 0, the Kappa Coefficient approaches to 1 (which is the ideal case). The range of this statistic is between 0 and 1. From Table 5.7, it is observed that the Kappa Coefficient is 0.94 which is close to 1, hence this is also an indicator of a good classification.

Once an acceptable level of accuracy in the classification result is obtained, the next step is to apply a post-classification algorithm to integrate GIS based land use data with the resulting image of a mixed approach classification. This type of incorporation of GIS data in automated classification has been very commonly used in recent years. Many researchers have suggested the use of RS and GIS data to enhance each other's results (Janssen *et al.*, 1990; Kam, 1995; Milanova *et al.*, 1999; Thompson and Hardin, 2000). " *The premise of any such operations is that the accuracy and/or the categorical detail of a classification based on image and ancillary data will be an improvement over a classification based on either data source alone*" (Lillesand and Kiefer, 2000, pp:586).

There are different methods of integrating GIS based ancillary data with remotely sensed data. In this thesis, "a post-classification decision rules" will be applied to combine the resulting image of mixed approach classification with the GIS based land use data of Montrèal Island. To do that, first the GIS based land use data was rasterized (Figure 5.12) and assigned as another channel of the classified image. Next, the EASI Modeling Module of PCI software is used where the post classification algorithm is written and applied. The resulting image is also assigned as a channel of the image data (See Appendix F).

The decision rule is developed based on a priority of the functional differentiations of the urban land use categories. For example, if a pixel is assigned to any of the first three urban categories in the mixed approach classification ("urban with weak vegetation", "urban / vegetation" or "urban with dense vegetation"), then the digital value of the pixel is also compared with its corresponding value in the rasterized GIS based land use. Therefore, if the pixel is in an urban category, it is then sub-categorized into one of the urban classes such as commercial, industrial or governmental land use category.

The final post-classified image is, hence, an improved and detailed land use map of the study area which provides important input about the distribution of physical landuse information component of QOP (Figure 5.22). For example, if the green areas in Figure 5.12 are compared with Figure 5.22, it will be observed that the post-classified image has more detailed vegetation cover classes.

5.2.2.2. Spatial analysis of accessibility to public services using GIS

5.2.2.2.1. Linear distance calculation to public services

The main goal of using spatial analysis techniques in GIS for this thesis is to analyze the accessibility of each CT to public services which is an important component of QOP. To do that, "Straight Line Functions" of ArcGIS software is used which describe each cell's relationship to a source or a set of sources. The source is defined as the location of the objects of interest such as wells, roads, and forest stands (ArcGIS, 2005). The straight line distance raster contains the measured distance from every cell to the nearest source. The distances are measured in projection units, such as feet or meters, and are computed from cell center to cell center. The straight line distance function is used frequently as a standalone function for applications such as finding the nearest hospital for an emergency helicopter. Alternatively, this function can be used when creating a suitability map, when it is needed to include data representing the distance from a certain object.

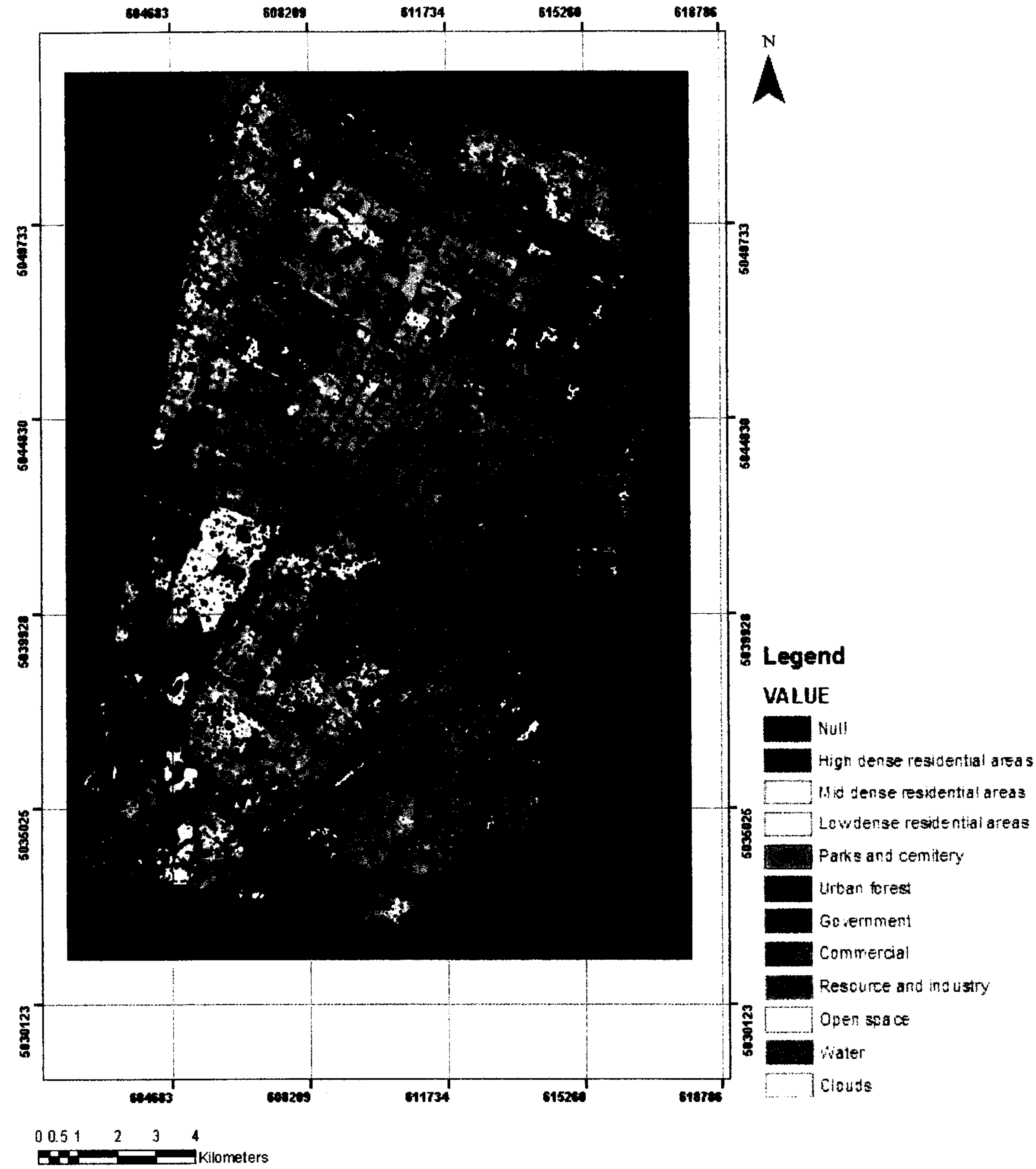


Figure 5.22: The result of post-classification algorithm (final land use map of Montrèal Island).

There are three potential outputs from the straight line function.

Primary output is:

- Straight Line Distance gives the distance from each cell in the raster to the closest source.

Optional outputs:

Straight Line Allocation identifies the cells that are to be allocated to which source based on closest proximity. Example of usage: Which town am I closest to?

- Straight Line Direction gives the direction from each cell to the closest source. Example of usage: What is the direction to the closest town?

For this thesis, accessibility of public services for each CT is analyzed for the five different types of sources as follows:

1. Metro stations,
2. Emergency services (fire stations, etc.),
3. Educational services (schools, universities, etc.),
4. Recreational services,
5. Health services (hospitals and other health related services).

Since all the vector data for the analysis (which has been summarized in chapter 3) have been provided as unprojected by DMTI, as a first step of the analysis, they are projected to the UTM Zone 18 (NAD 83 and GRS 80 are selected for the datum and for the ellipsoid types respectively). Next, the vector data of "building footprints" (Figure 5.23) in ".shp" format is processed to obtain different categories for public services of emergency, educational, recreational and health for Montréal Island. This is performed through a selection of features based on the "Category" field of the attribute table of the vector data. Once the features are selected for those four categories, they are exported to a new shape file and clipped by the study field boundaries. As a result, four types of vector data for each public service are obtained.

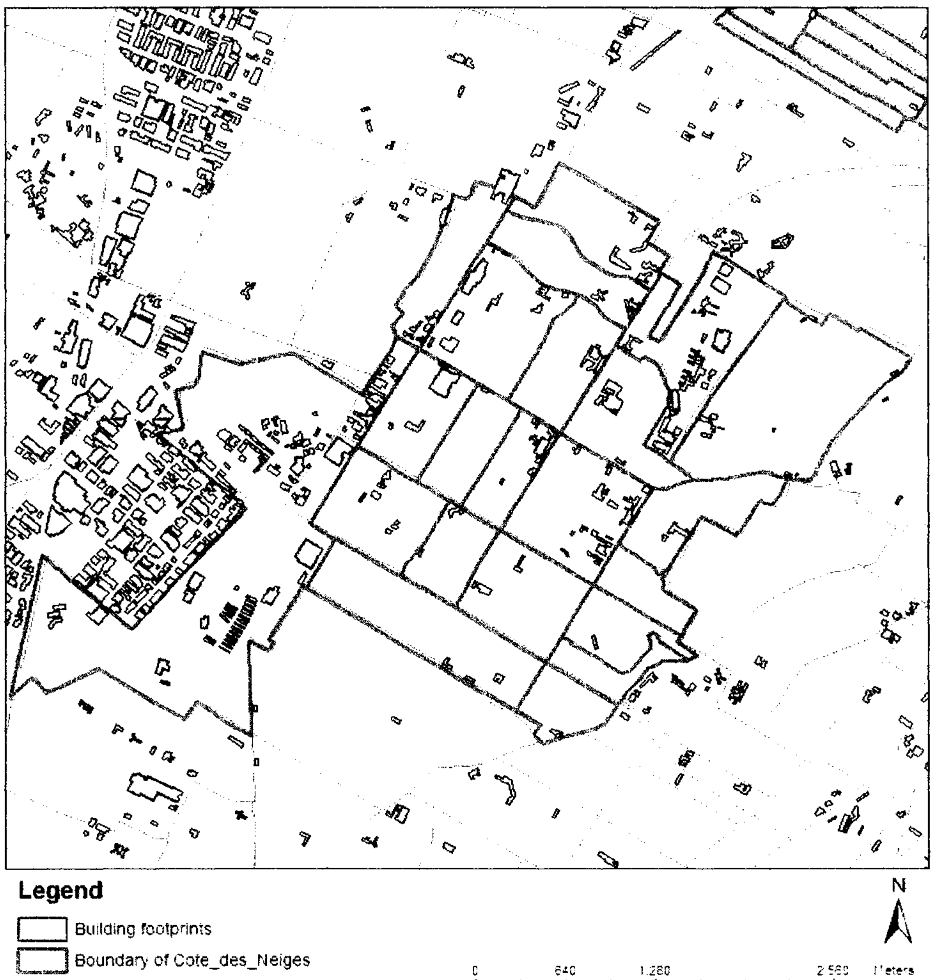


Figure 5.23: Map of all "building footprints" in Côte-des-Neiges

The next step is to calculate, for each CT, the straight line distance to the closest public service. For that purpose the "Spatial Analyst" toolbox of ArcGIS is used. In the configuration settings of the Spatial Analyst toolbox special attention is given to the output cell size since it is, later on, the aim to integrate the results of this analysis with the land use map obtained from remote sensing. Therefore, the cell size is chosen as the same resolution of the satellite image which is 20 meters. This procedure is repeated for all five types of public services and as a result, five maps are obtained (Figures 5.24, 5.25, 5.26, 5.27 and 5.28)

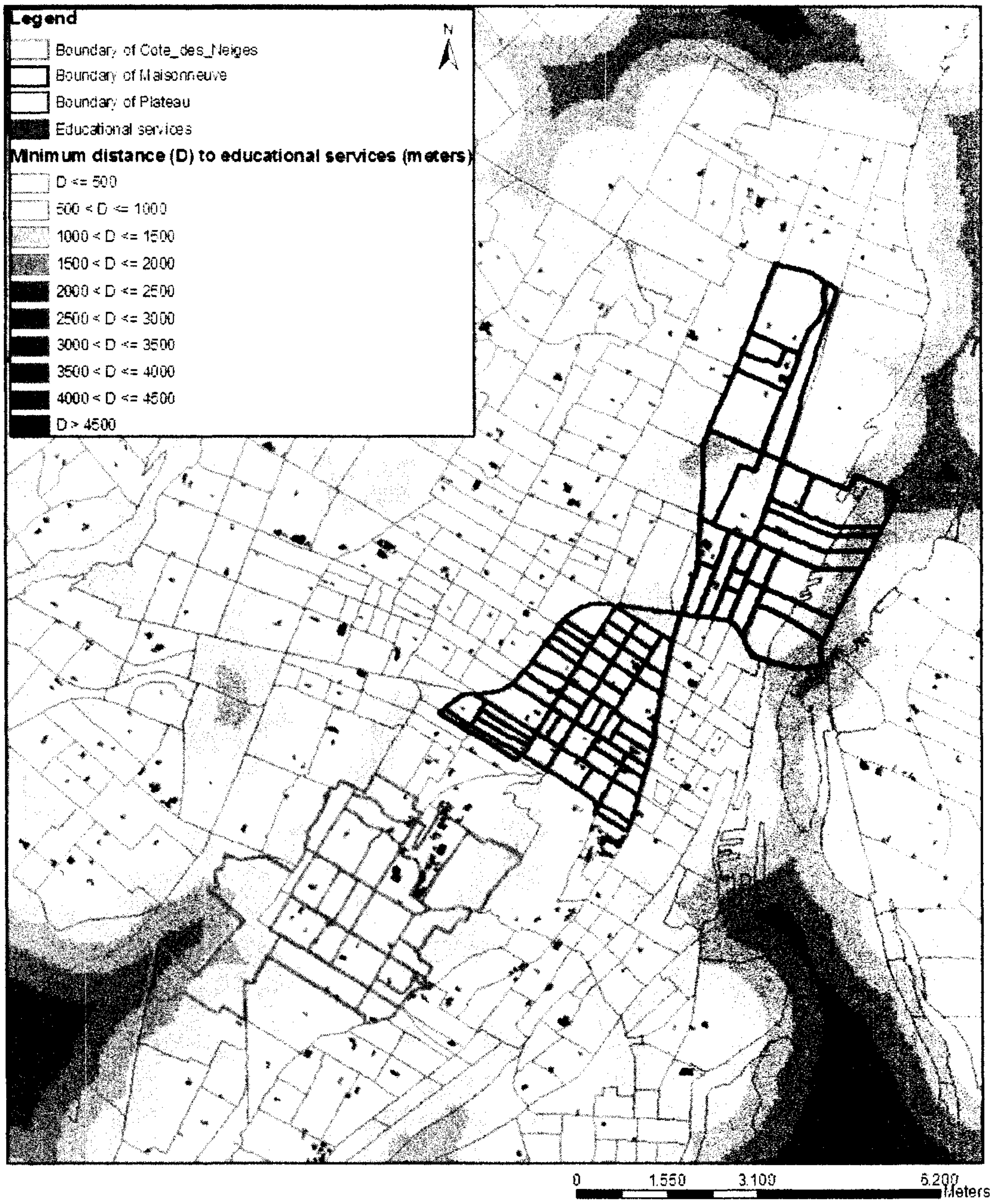


Figure 5.24: Minimum distance calculation to the educational services

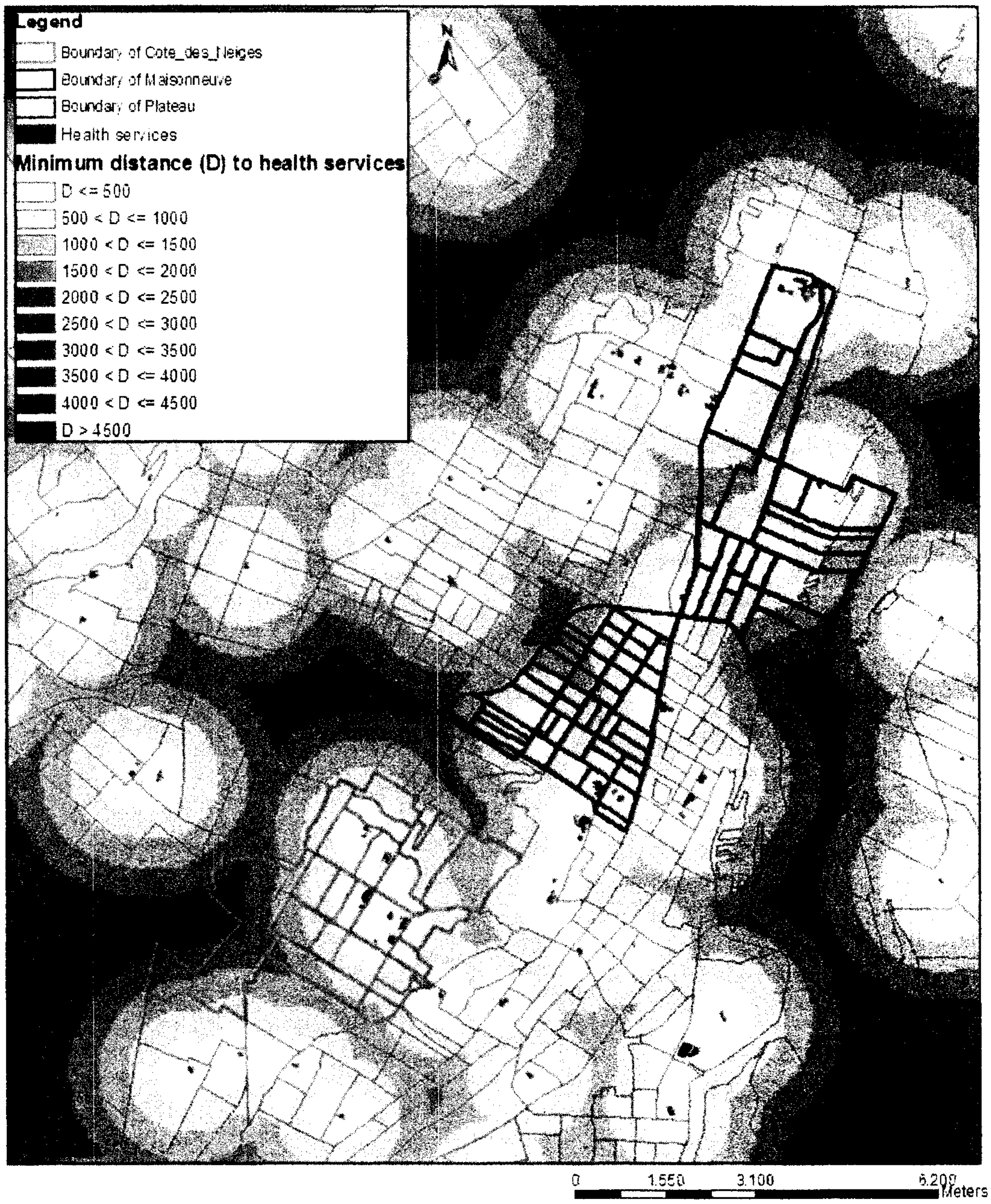


Figure 5.25: Minimum distance calculation to the health services

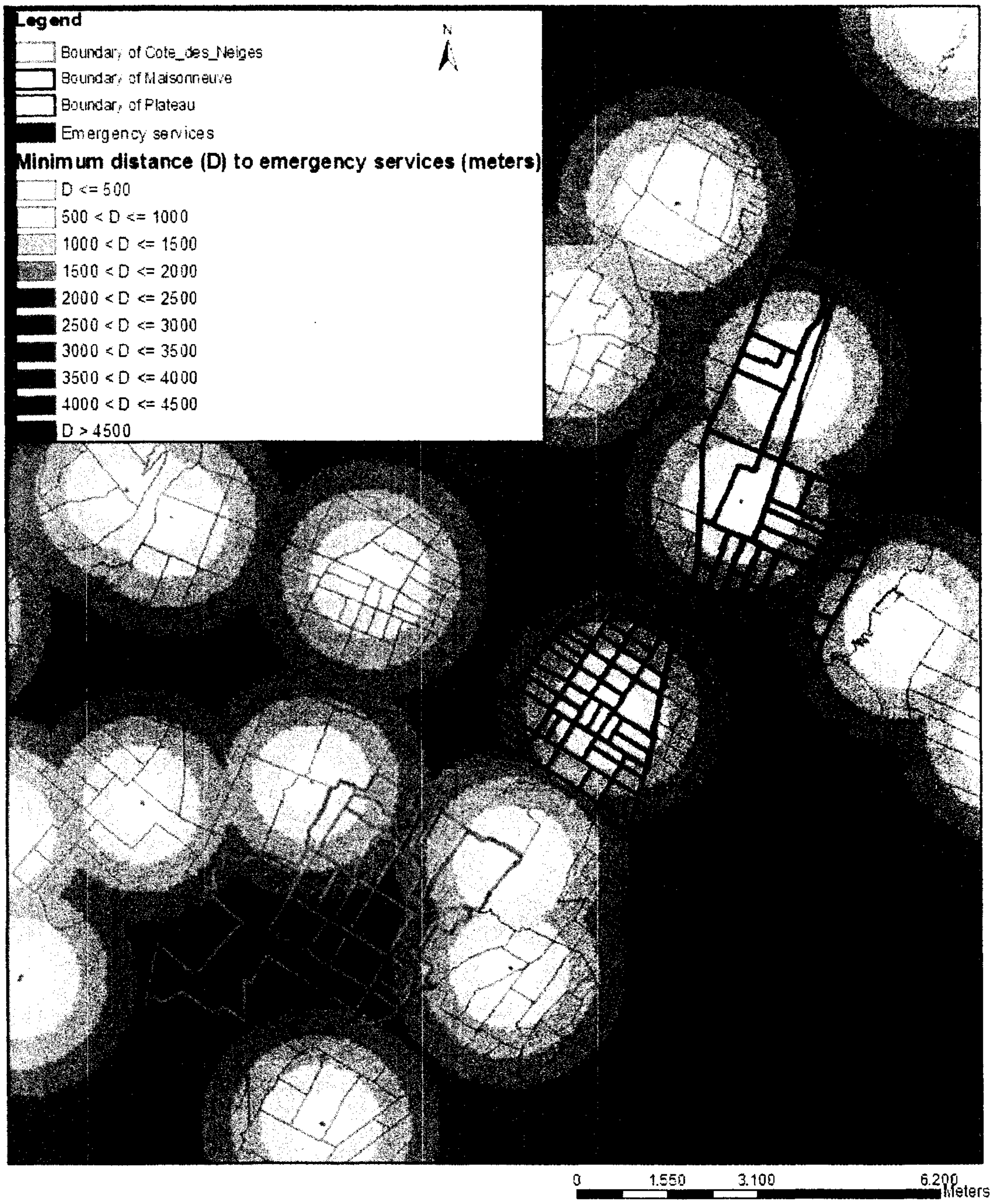


Figure 5.26: Minimum distance calculation to the emergency services

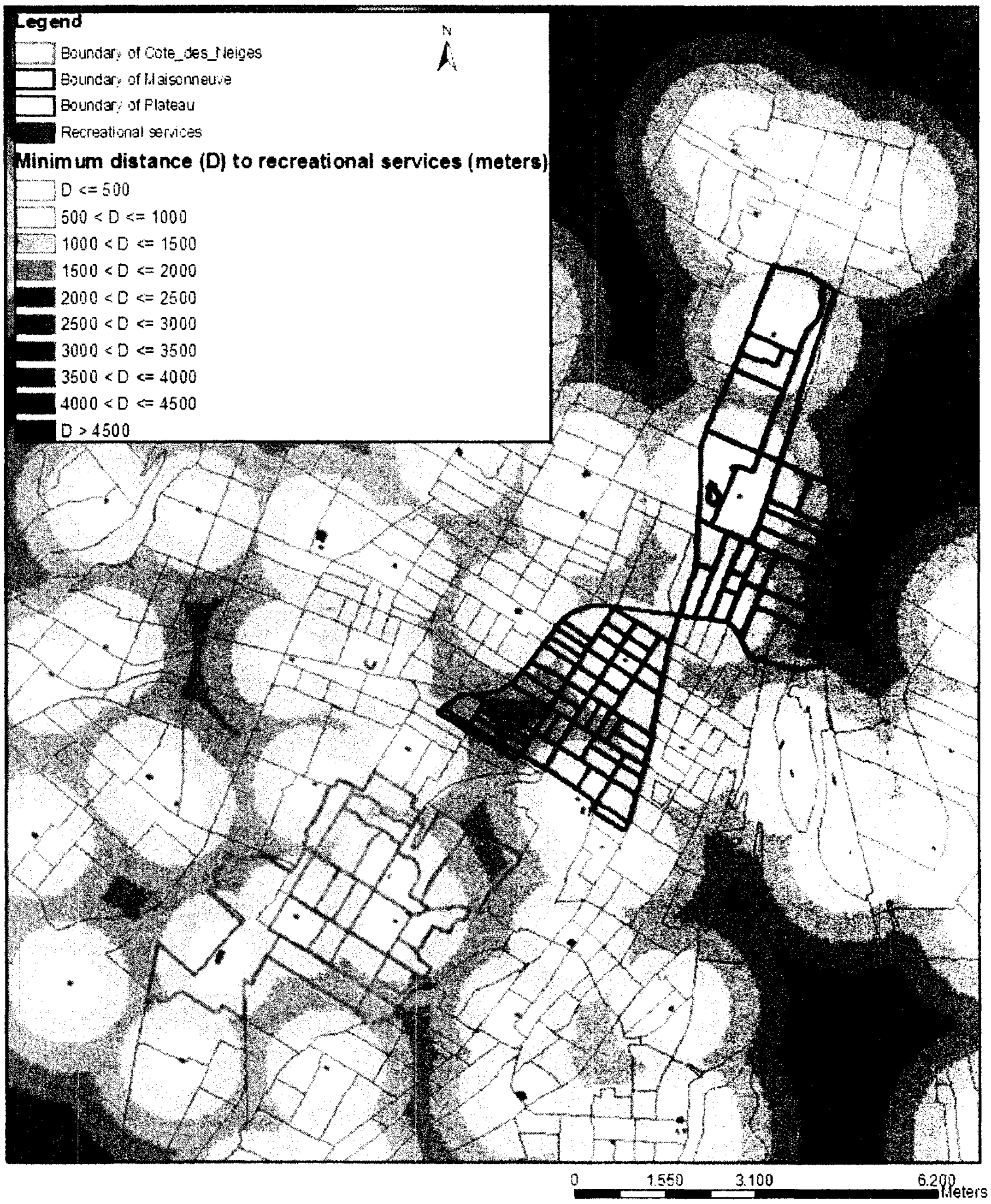


Figure 5.27: Minimum distance calculation to the recreational services

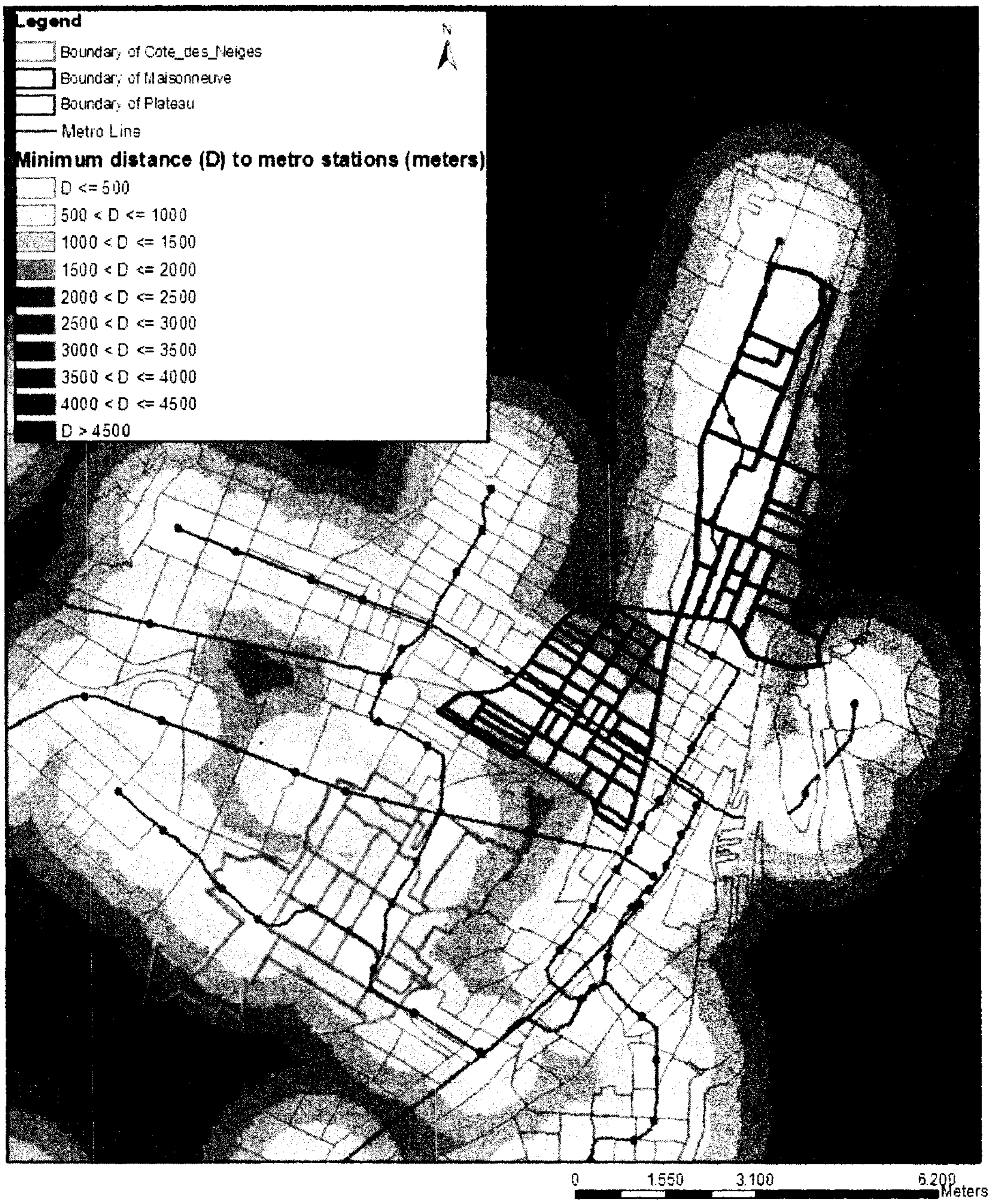


Figure 5.28: Minimum distance calculation to the metro stations

The other important factor in distance calculation is the decision for division breaks of the classes which is the indicator of each CT's accessibility to the public services. There are different definitions for an acceptable distance to walk to public services. Being one of them, Gehl (2001) explains in his research this phenomenon as: "*...the usual radius of action for most people on foot is limited to 400 to 500 meters (1,300 to 1,600 ft.) per excursion and the fact that the possibilities for seeing other people and courses of events are limited to a distance of between 20 and 100 meters (65 and 330 ft.), depending on what is to be seen, in practice very great demands on the degree of concentration*" (pp:85). Hence, for this thesis, the zones of the distance calculation maps are divided into 10 equal classes of 500 meters. Therefore, each class in these maps show a zone of 500 meters which is an acceptable level of walking to a place for a person within that neighbourhood.

When the Figures 5.24 to 5.28 are analyzed, it is observed that the accessibility to public services has different patterns for each service. For example, while most of the CTs in the neighbourhood of Plateau-Mont-Royal have accessibility to "educational" services within only a 500 meters zone, the accessibility to "emergency" services occurs within a zone of 2000 meters. Moreover, it is also observed from these results that not all the CTs have the same accessibility to public services. For instance, in Figure 5.26, the CTs on the south of the neighbourhood of Côte-des-Neiges have accessibility to the emergency services within a zone of 3000 meters while the CTs on the north have accessibility only within a 500 meters zone. Another result from these figures is that, among all public services, the best accessibility, generally, occurs for "educational" services. When the Figures 5.24 to 5.28 are analyzed, it is easily seen that the "emergency" services are the ones where the majority of the CTs have the worst accessibility. From Figure 5.27, it is observed that the three neighborhoods have good accessibility to "recreational facilities" although some CTs on the north of Plateau-Mont-Royal have less accessibility. Similarly, Figure 5.28 indicates that the three neighborhoods have access to "metro stations" at an acceptable walking distance. These results showed that the accessibility to public services component of QOP may have a different geographical distribution which influences the daily life of citizens and their perceptions about the place. The next step of the analysis is to calculate a mean value of these accessibility values for each CT to integrate with other data sources.

5.2.2.2.2. Zonal statistics calculation

With the "Zonal Statistics" function of ArcGIS software, a statistic is calculated for each zone of a zone dataset based on values from another dataset. A zone is all the cells in a raster that have the same value, regardless of whether or not they are contiguous. However, both raster and feature datasets can be used as the "dataset". For example, residential is a zone of a landuse raster dataset, or a roads feature dataset can be the zone for an accident dataset. Zonal statistical functions perform operations on a per-zone basis; a single output value is computed for every zone in the input zone dataset.

In this thesis, "Zonal Statistics" is used as an effective tool to calculate the mean values for each accessibility zone of public services within each CT. A part of the resulting output table of the zonal statistic anlaysis made for the accessibility to educational services for each CT is given in Table 5.8. Since CT has a unique ID called as "CTNAME", it is easy to integrate the mean values for the "minimum distance to educational services" to every CT.

For instance the CT with "0570.00" has a mean value for accessibility to educational services of 1308.06, which indicates that people living in that CT of the neighbourhood can access an educational service at an average value of 1.3 km. Similarly, when the procedure is repeated for all five public service types, different accessibility levels to each services for different CTs are obtained.

Once the mean values are calculated, the output tables are joined with the attribute table of the vector data of CTs. The purpose of this join process is to integrate these mean values for each public service at CT level with both the QOP_{cs} values (which are derived in the previous sections) and SQOPI values which will be derived in section 5.3 of this thesis.

Table 5.8: A part of the output table of "Zonal Statistics" for "minimum distance to educational services"

Attributes of Zonal_edu

OID	ZONE	COUNT	CTNAME	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
0	1	31226	0570.00	12490400	0	2411.389893	2411.389893	1308.060059	516.038025	40845600
1	2	1908	0583.00	763200	0	698.570007	698.570007	266.613007	139.192993	508698
2	3	2970	0708.01	1188000	0	728.010986	728.010986	310.003998	147.322006	920711
3	4	2310	0290.06	924000	0	660.302979	660.302979	270.015991	128.445999	623736
4	5	4310	0290.02	1724000	128.061996	1434.020020	1305.949951	797.140991	268.108002	3435680
5	6	4082	0584.00	1632800	0	756.041992	756.041992	295.713989	150.751999	1207110
6	7	2444	0290.09	977600	384.187012	1280.160034	895.968994	803.247009	194.759995	1963140
7	8	27822	0887.03	11128800	0	2580	2580	1438.410034	518.208008	40019300
8	9	87403	0888.00	34961200	0	4550.560059	4550.560059	2249.209961	970.419006	196588000
9	10	13082	0627.00	5232800	0	1989.270020	1989.270020	836.080994	503.135986	10937600
10	11	5230	0290.05	2092000	0	1700	1700	773.526978	459.733002	4045550
11	12	11187	0703.02	4474800	0	1578.479980	1578.479980	792.487000	341.377014	8865550
12	13	3427	0706.00	1370800	0	1000.200012	1000.200012	476.039001	242.173996	1631390
13	14	6353	0660.03	2541200	0	1543.109985	1543.109985	796.390015	369.005005	5059460
14	15	1597	0290.03	638800	624.820007	1460.140015	835.317017	1109.780029	155.845993	1772320
15	16	19873	0594.02	7949200	0	1883.079956	1883.079956	1068.329956	415.859009	21230800
16	17	44299	0901.03	17719600	0	5321.350098	5321.350098	1798.729980	1074.640015	79682000
17	18	2993	0290.01	1197200	600	1625.420044	1025.420044	1093.609985	233.242004	3273160
18	19	4294	0659.06	1717600	0	1734.589966	1734.589966	608.221985	454.781006	2611700

Record: 0 Show: All Selected Records (0 out of 862 Selected.) Options

5.3. Subjective dimension

For the subjective dimension of the QOP, a questionnaire was distributed to the three selected neighborhoods of Montréal as was been explained in chapter 4. The selection of the neighborhoods is made according to the results of PCA_{st} applied to the 2001 census data which was explained in section 5.2.2.2. According to these results, three neighborhoods showed very different characteristics from each other:

- Plateau-Mont-Royal
- Côte-des-Neiges
- Hochelaga Maisonneuve

As it was explained in chapter 4, the questionnaire which was used for this thesis was distributed to the three neighborhoods in summer 2002 in two versions, French and English, (See Appendix A and B for both versions). The questionnaire included 97 variables (see Table 4.8 in chapter 4) in four sections.

The sampling procedure to select the individuals was conducted at two levels. First, 10 census tracts (CTs) were randomly selected by using a table of random numbers generated by function "RAND" of the Excel software of Microsoft. The result of this procedure is shown in Figure 4.7 (chapter 4) where 30 CTs are shown in yellow. Secondly, in each CT, 5 people are randomly selected. The method of selection, within the boundaries of CTs, consisted of choosing by chance an individual, either at home or on the street. On the whole, 150 people agreed to answer the questionnaire.

5.3.1. Statistical description of the survey data

Before the analysis of the survey data, a profile of the respondents was done in SPSS (see Appendix G for the syntax file) to understand the general social structure of the three neighborhoods. According to Table 5.9, the whole sampling has an almost equal distribution for the variable 'sex'; which is 48.7 % for female and 44.0 % for male. For the whole sampling, "French" is the major mother tongue (72 %).

When the household structure is analyzed, it is observed that the categories for 'just you', 'you and your spouse' and 'you, your spouse and children' have almost the same distribution.

Table 5.9: Socio-demographic profile of the responders

Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	73	48.7	52.5	52.5
	Male	66	44.0	47.5	100.0
	Total	139	92.7	100.0	
Missing	System	11	7.3		
Total		150	100.0		

Age group

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	15-29 years	35	23.3	23.3	23.3
	30-49 years	47	31.3	31.3	54.7
	50-64 years	35	23.3	23.3	78.0
	65 and over	33	22.0	22.0	100.0
	Total	150	100.0	100.0	

Mother tongue

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	French	108	72.0	72.0	72.0
	English	16	10.7	10.7	82.7
	French and English	7	4.7	4.7	87.3
	Other	19	12.7	12.7	100.0
	Total	150	100.0	100.0	

Marital Status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single	49	32.7	32.7	32.7
	Married/Common law	75	50.0	50.0	82.7
	Separated/Divorced	15	10.0	10.0	92.7
	Widow (er)	11	7.3	7.3	100.0
	Total	150	100.0	100.0	

Table 5.9 (continue)

Household size

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Just you	40	26.7	26.7	26.7
	You and your spouse	39	26.0	26.0	52.7
	You and children	13	8.7	8.7	61.3
	You, your spouse and children	33	22.0	22.0	83.3
	You and other family members	14	9.3	9.3	92.7
	You and other who are not family members	11	7.3	7.3	100.0
	Total	150	100.0	100.0	

The socio-economic profile (Table 5.10) shows that people living in these three neighborhoods are not very rich (only 4 % of people have incomes $70.000 and over). In addition to this, the category for the people who are not working is a high percent value (25.3 %). When the education level of the respondents is analyzed, it is observed that 40 % graduated from only high school whereas 24 % from university and 24 % from college.

Table 5.10: Socio-economic profile of the responders

Income

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than $15,000	37	24.7	25.5	25.5
	$15,000 - 29,999	36	24.0	24.8	50.3
	$30,000 - 49,999	24	16.0	16.6	66.9
	$50,000 - 69,999	4	2.7	2.8	69.7
	$70,000 and over	6	4.0	4.1	73.8
	No income	38	25.3	26.2	100.0
	Total	145	96.7	100.0	
Missing	System	5	3.3		
Total		150	100.0		

Table 5.10 (continue)

Worker status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Employed	39	26.0	26.2	26.2
	Self employed	30	20.0	20.1	46.3
	Retired	42	28.0	28.2	74.5
	Not working	38	25.3	25.5	100.0
	Total	149	99.3	100.0	
Missing	System	1	.7		
Total		150	100.0		

Place of work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	At home	16	10.7	10.9	10.9
	In this neighborhood	23	15.3	15.6	26.5
	In the downtown area	16	10.7	10.9	37.4
	Elsewhere in Montréal	16	10.7	10.9	48.3
	Outside the city of Montréal	4	2.7	2.7	51.0
	Not applicable	72	48.0	49.0	100.0
	Total	147	98.0	100.0	
Missing	System	3	2.0		
Total		150	100.0		

Education level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Primary	17	11.3	11.4	11.4
	High School	60	40.0	40.3	51.7
	College	36	24.0	24.2	75.8
	University	36	24.0	24.2	100.0
	Total	149	99.3	100.0	
Missing	System	1	.7		
Total		150	100.0		

Residential profile (Table 5.11) of the respondents shows that people generally live in apartments (in buildings of 3 floors or less). In addition, 68 % of the respondents own their apartments or houses.

Table 5.11: Residential profile of the responders

Type of residence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single family dwellin	10	6.7	6.7	6.7
	Duplex or row housi	30	20.0	20.0	26.7
	Apartment (in buildin of 3 floors or less)	103	68.7	68.7	95.3
	Apartment (in buildin of 4 floors or more)	5	3.3	3.3	98.7
	Other	2	1.3	1.3	100.0
	Total	150	100.0	100.0	

Type of tenure

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Owner	102	68.0	68.0	68.0
	Renter	48	32.0	32.0	100.0
	Total	150	100.0	100.0	

Construction period

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Before 1950	97	64.7	67.4	67.4
	Between 1950 and 1980	40	26.7	27.8	95.1
	After 1980	7	4.7	4.9	100.0
	Total	144	96.0	100.0	
Missing	System	6	4.0		
Total		150	100.0		

Preceding place of residence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	In this neighborhood	63	42.0	42.3	42.3
	In another neighborhood of the city of Montréal	65	43.3	43.6	85.9
	Outside the city of Montréal but inside the metrop. area	5	3.3	3.4	89.3
	Outside teh metropolitan area	16	10.7	10.7	100.0
	Total	149	99.3	100.0	
Missing	System	1	.7		
Total		150	100.0		

Mode of transportation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	By foot	21	14.0	16.2	16.2
	Bicycle	12	8.0	9.2	25.4
	Public transportation	48	32.0	36.9	62.3
	Private car	47	31.3	36.2	98.5
	Taxi	2	1.3	1.5	100.0
	Total	130	86.7	100.0	
Missing	System	20	13.3		
Total		150	100.0		

Furthermore, Table 5.12 shows the comparison of the neighborhoods where cross tabulations have been used for sex, age, mother tongue, marital status, household size, worker status, place of work, education, income, type of residence, tenure type and construction period etc. The results show that, in Hochelaga-Maisonneuve, French is spoken more as a mother tongue, while in Côte–des–Neiges neither English nor French are the dominant languages as mother tongue which shows the different ethnic structure of the neighborhoods. When we compare the residential

Table 5.12: Residential profile comparison of the neighbourhoods

Name of the neighbourhood * Sex Crosstabulation

Count

		Sex		
		Female	Male	Total
Name of the neighbourhood	Côte-des-Neiges	24	21	45
	Plateau Mont-Royal	27	21	48
	Hochelaga-Maisonneuve	22	24	46
Total		73	66	139

Name of the neighbourhood * Age group Crosstabulation

Count

		Age group				
		15-29 years	30-49 years	50-64 years	65 and over	Total
Name of the neighbourhood	Côte-des-Neiges	13	17	10	10	50
	Plateau Mont-Royal	8	18	14	10	50
	Hochelaga-Maisonneuv	14	12	11	13	50
Total		35	47	35	33	150

Name of the neighbourhood * Mother tongue Crosstabulation

Count

		Mother tongue				
		French	English	French and English	Other	Total
Name of the neighbourhood	Côte-des-Neiges	20	13	1	16	50
	Plateau Mont-Royal	42	3	3	2	50
	Hochelaga-Maisonneuve	46		3	1	50
Total		108	16	7	19	150

Table 5.12 (continue)

Name of the neighbourhood * Marital Status Crosstabulation

Count

		Marital Status				
		Single	Married/Co mmon law	Separated/ Divorced	Widow (er)	Total
Name of the neighbourhood	Côte-des-Neiges	17	31	2		50
	Plateau Mont-Royal	21	18	6	5	50
	Hochelaga-Maisonneuve	11	26	7	6	50
Total		49	75	15	11	150

Name of the neighbourhood * Household size Crosstabulation

Count

		Household size						
		Just you	You and your spouse	You and children	You, your spouse and children	You and other family members	You and other who are not family members	Total
Name of the neighbourhood	Côte-des-Neiges	6	10	2	20	9	3	50
	Plateau Mont-Royal	22	13	6	4	2	3	50
	Hochelaga-Maisonneu	12	16	5	9	3	5	50
Total		40	39	13	33	14	11	150

Name of the neighbourhood * Worker status Crosstabulation

Count

		Worker status				
		Employed	Self employed	Retired	Not working	Total
Name of the neighbourhood	Côte-des-Neiges	16	11	12	11	50
	Plateau Mont-Royal	9	13	12	15	49
	Hochelaga-Maisonneuve	14	6	18	12	50
Total		39	30	42	38	149

Name of the neighbourhood * Place of work Crosstabulation

Count

		Place of work						
		At home	In this neighborhood	In the downtown area	Elsewhere in Montréal	Outside the city of Montréal	Not applicable	Total
Name of the neighbourhooc	Côte-des-Neiges	4	6	9	5	1	24	49
	Plateau Mont-Royal	7	8	6	4		24	49
	Hochelaga-Maisonneu	5	9	1	7	3	24	49
Total		16	23	16	16	4	72	147

Name of the neighbourhood * Education level Crosstabulation

Count

		Education level				
		Primary	High School	College	University	Total
Name of the neighbourhood	Côte-des-Neiges	3	12	18	17	50
	Plateau Mont-Royal	4	21	11	13	49
	Hochelaga-Maisonneuve	10	27	7	6	50
Total		17	60	36	36	149

Table 5.12 (continue)

Name of the neighbourhood * Income Crosstabulation

Count

		Income						
		Less than $15,000	$15,000 - 29,999	$30,000 - 49,999	$50,000 - 69,999	$70,000 and over	No income	Total
Name of the neighbourhood	Côte-des-Neiges	15	10	7	2	5	10	49
	Plateau Mont-Royal	12	13	11	2		12	50
	Hochelaga-Maisonneuve	10	13	6		1	16	46
Total		37	36	24	4	6	38	145

Name of the neighbourhood * Type of residence Crosstabulation

Count

		Type of residence					
		Single family dwelling	Duplex or row housing	Apartment (in building of 3 floors or less)	Apartment (in building of 4 floors or more)	Other	Total
Name of the neighbourhood	Côte-des-Neiges	6	20	21	3		50
	Plateau Mont-Royal	3	5	38	2	2	50
	Hochelaga-Maisonneuve	1	5	44			50
Total		10	30	103	5	2	150

Name of the neighbourhood * Type of tenure Crosstabulation

Count

		Type of tenure		
		Owner	Renter	Total
Name of the neighbourhood	Côte-des-Neiges	24	26	50
	Plateau Mont-Royal	36	14	50
	Hochelaga-Maisonneuve	42	8	50
Total		102	48	150

Name of the neighbourhood * Construction period Crosstabulation

Count

		Construction period			
		Before 1950	Between 1950 and 1980	After 1980	Total
Name of the neighbourhood	Côte-des-Neiges	27	21	2	50
	Plateau Mont-Royal	35	7	3	45
	Hochelaga-Maisonneuve	35	12	2	49
Total		97	40	7	144

Table 5.12 (continue)

Name of the neighbourhood * Length of residency at the residence Crosstabulation

Count

		Length of residency at the residence			
		Less than 5 years	Between 5 and 10 years	More than 10 years	Total
Name of the neighbourhood	Côte-des-Neiges	16	8	26	50
	Plateau Mont-Royal	20	12	18	50
	Hochelaga-Maisonneuve	22	12	16	50
Total		58	32	60	150

Name of the neighbourhood * Length of residency in the neighbourhood Crosstabulation

Count

		Length of residency in the neighbourhood			
		Less than 5 years	Between 1950 and 1980	After 1980	Total
Name of the neighbourhood	Côte-des-Neiges	9	10	31	50
	Plateau Mont-Royal	15	10	25	50
	Hochelaga-Maisonneuve	12	7	31	50
Total		36	27	87	150

Name of the neighbourhood * Preceding place of residence Crosstabulation

Count

		Preceding place of residence				
		In this neighborhood	In another neighborhood of the city of Montréal	Outside the city of Montréal but inside the metrop. area	Outside teh metropolitan area	Total
Name of the neighbourhood	Côte-des-Neiges	20	20	1	9	50
	Plateau Mont-Royal	17	29		3	49
	Hochelaga-Maisonneuve	26	16	4	4	50
Total		63	65	5	16	149

Name of the neighbourhood * Mode of transportation Crosstabulation

Count

		Mode of transportation					
		By foot	Bicycle	Public transportation	Private car	Taxi	Total
Name of the neighbourhood	Côte-des-Neiges	5	1	18	20		44
	Plateau Mont-Royal	9	5	17	10	2	43
	Hochelaga-Maisonneuv	7	6	13	17		43
Total		21	12	48	47	2	130

profiles with the PCA_{st} results that were obtained in section 5.2.1.1, it is observed that the results of Table 5.12 are very consistent with those of component 1 that explained the socio-economic status, education and linguistic dimension of QOP in the objective domain. For instance, Figure 5.2 showed that more negative values (and hence negative QOP) were obtained for component 1 in Hochelaga-Maisonneuve where the majority of the residents speak French. As it was mentioned before, these negative results demonstrated that the adaptability of minority groups to the neighbourhood might be less (which results in a relatively poor QOP conditions) in terms of the language since the majority of people speak French. Thus, those results obtained in the objective dimension are also supported with the results obtained in Table 5.12 which indicates that there is a strong relationship between the objective and subjective dimensions of QOP as it was proposed in the conceptual framework of this study.

Another interesting result of Table 5.12 is that, in Côte-des-Neiges, the rate of "renters" is higher than the one in other two neighborhoods which again supports the link between the objective and subjective dimensions of QOP. As it was observed in section 5.2.1.1, the immigrant population was higher in this neighborhood. Therefore the results for tenure type obtained in Table 5.12 are not surprising since renting a place is easier than buying a house for the new comers to Canada.

5.3.2. Subjective quality o place index

Having analyzed the profile of the responders, this section will focus on the derivation of the "subjective QOP index" (SQOPI) as it was proposed in the methodological framework. The goal here is to understand the personal evaluations about QOP in the three ne ighbourhoods. O nce the responses for each item in t he questionnaire are obtained, the replies are coded as numerical values from 1 to 5 for both the "satisfaction" and "importance" columns (so that it is ensured that each item has been loaded with two numbers from a rank of 1 – 5). To extract experiential structural information at the individual level, for each CT, the next step is to calculate the SQOPI (see Appendix H for the syntax file of calculations made in SPPS) based on a study of Raphael *et al.* (1996) as explained in chapter 3 as follows (Table 5.13

shows a part of the index values calculated in SPSS software for each CT):

$$SQOPI = (Importance / 3) \times (Satisfaction - 3) \quad (3.2)$$

Since there are five respondents in each CT, an average value of SQOPI (ASI) will be computed in order to use in the MCE stage as follows:

$$ASI = (\sum_{i=1}^{5} SQOPI_i) / 5 \quad (3.3)$$

In this calculation, "importance" scores are considered as weights for converting satisfaction scores into SQOPI values. The items in the questionnaire rated as "very important" produce "very high" SQOPI scores for items where high satisfaction is indicated by the respondent. Furthermore, items rated as "very important" produce "very low" SQOPI scores where lack of satisfaction is indicated. Items rated as being less important produce more moderate SQOPI scores. Values range from -3.33 (which means "not at all satisfied with very important items) to +3.33 (which means "very satisfied with very important items). If the value of the SQOPI is above "0", then it can be considered as the respondent has a positive QOP perception, but if it has a value of below "0" then the QOP is negative for that individual (see Table 5.14 for a "key" explanation of the SQOPI scores). While dividing importance scores by 3 merely restricts the range of QOP scores, it also makes explicit that a rating of 3 for importance (leading to a weight of 1) is associated with QOP score being equal to the unweighted satisfaction score. The subtraction of 3 from satisfaction scores serves to set the range of satisfaction scores from +2 to -2 and allows higher importance scores to increase the magnitude of QOP scores.

The questionnaire evaluated the needs and the satisfaction of the individuals living in the neighborhood in two parts: neighborhood as a place to live and access to goods and services in the neighborhood. Since both parts aim to analyze different dimensions about the quality of the place, the SQOPI values are calculated for each item asked in the questionnaire. Then, the respondents are also asked to evaluate an overall quality of the place for both parts at the end. Hence, two general SQOPI values are also calculated to reflect these responses as well. The following sections will provide the comparison of the three neighborhoods based on these resulting SQOPI scores.

Table 5.13: A part of the SQOPI values calculated in SPSS for each CT

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1 : sisize -1

	sisize	sicond	simaint	sicomf	sires	sigreen	siquiet	sisafety	siupkeep	siairq	sienv
1	-1.0	-1.7	-1.7	-1.7	-1.5	.0	-1.3	-1.3	.	-1.3	
2	3.3	3.3	3.3	3.3	3.3	3.3	1.7	1.7	1.3	3.3	2.3
3	.0	1.3	3.3	.0	1.2	1.3	1.3	1.3	1.3	1.3	1.3
4	1.3	1.3	1.3	1.3	1.3	1.7	3.3	3.3	1.7	1.7	2.3
5	1.3	.0	.0	.0	.3	1.7	1.7	1.7	.0	.0	1.0
6	1.7	-1.7	-1.7	-1.7	-.8	1.7	.0	.0	.0	1.7	.7
7	2.7	.0	.0	.0	.7	.0	.0	.0	1.7	1.7	.7
8	.0	.0	.0	.0	.0	.0	.0	.0	1.7	-3.3	-.3
9	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	1.7	.0	2.3
10	3.3	3.3	3.3	3.3	3.3	3.3	.0	3.3	3.3	.0	2.0
11	-1.7	.0	.0	.0	-.4	.0	.0	.0	1.7	1.7	.7
12	3.3	3.3	3.3	3.3	3.3	3.3	1.7	1.7	1.7	3.3	2.3
13	3.3	3.3	3.3	3.3	3.3	.0	3.3	3.3	3.3	-1.7	1.7
14	-1.7	3.3	3.3	3.3	2.1	1.7	3.3	3.3	3.3	3.3	3.0
15	3.3	3.3	3.3	3.3	3.3	1.7	3.3	3.3	3.3	1.7	2.7
16	.0	3.3	3.3	3.3	2.5	3.3	3.3	3.3	3.3	3.3	3.3

Data View / Variable View

SPSS Processor is ready

Table 5.14: Key chart for the SQOPI scores

If Importance =	and Satisfaction	SQOPI Score
5	5	+3.33
	4	+1.66
	3	0
	2	-1.66
	1	-3.33
4	5	+2.66
	4	+1.33
	3	0
	2	-2.66
	1	-1.33
3	5	+2
	4	+1
	3	0
	2	-1
	1	-2
2	5	+1.32
	4	+0.66
	3	0
	2	-0.66
	1	-1.32
1	5	+0.66
	4	+0.33
	3	0
	2	-0.33
	1	-0.66

5.3.2.1. Analysis of the SQOPI for the neighborhood as place to live

Individuals were asked to evaluate the characteristics of their residence in terms of its size, condition, maintenance and comfort; their environment in terms of the presence of green spaces, quietness, safety, upkeep of the property and air quality; the public services in terms of fire fighters, police, garbage collection, road upkeep, snow removal, emergency services, quality of water, public transportation; and finally they were also asked to evaluate their involvement in their neighborhood. Table 5.15 summarizes the scores of SQOPI for each of these items and the results are also provided by each neighborhood to make a comparison. Results of Table 5.15 show that for the residence size, the index value has its maximum mean value (1.833) in Hochelaga-Maisonneuve which means that with a relative higher importance value (according to the key chart in Table 5.14, this value is regarded as "high" since it is between 1.66 and 3.33), people living in that neighborhood are much more satisfied with the size of their residences in comparison with the other two neighborhoods. The same higher results are also obtained for Hochelaga-Maisonneuve when the residence condition, maintenance and comfort components are analyzed. Therefore, it can be concluded that individuals in this neighborhood are generally more satisfied with the characteristics of their residences. This is also verified with the mean value of the index for the overall score calculated for the components of the residence characteristics (1.952).

However, the results for the components of the environment show different characteristics. This time, Côte-des-Neiges (which had lower scores for the residence characteristics) has higher values than other neighborhoods for the evaluations of the environment such as presence of greenness (1.68), quietness and peacefulness (1.60), safety (1.607) and air quality (0.83). The overall score for the environmental components, hence, indicate that people in Côte-des-Neiges are much more satisfied with their environment. When the three neighborhoods are analyzed in terms of satisfaction for the public services, it is observed that the neighborhoods have different dominant characteristics in different services. For instance, while Hochela-Maisonneuve performs well for the index for transportation, fire fighters, police and health services, it performs poorly for snow removal and sidewalk upkeep.

Table 5.15: Analysis of SQOPI for the neighborhood as a place to live

SQOPI for the residence

Name of the neighbourhood		residence size	residence condition	residence maintenance	residence comfort	residence (overall)
Côte-des-Neiges	Mean	1.513	1.660	1.773	1.780	1.682
	N	50	50	50	50	50
	Std. Deviation	1.696	1.600	1.530	1.563	1.428
Plateau Mont-Royal	Mean	1.537	1.483	1.524	1.844	1.597
	N	49	49	49	49	49
	Std. Deviation	1.556	1.658	1.689	1.373	1.411
Hochelaga-Maisonneuve	Mean	1.833	1.873	1.966	2.020	1.952
	N	50	50	49	50	49
	Std. Deviation	1.653	1.673	1.639	1.696	1.567
Total	Mean	1.629	1.673	1.755	1.881	1.743
	N	149	149	148	149	148
	Std. Deviation	1.632	1.641	1.619	1.544	1.467

SQOPI for the environment

Name of the neighbourhood		green spaces	quietness and peacefulness	safety	upkeep	air quality	environment (overall)
Côte-des-Neiges	Mean	1.680	1.600	1.607	1.395	.833	1.463
	N	50	50	50	49	50	49
	Std. Deviation	1.547	1.383	1.309	1.501	1.657	.980
Plateau Mont-Royal	Mean	1.367	.531	1.122	1.231	.313	.913
	N	49	49	49	49	49	49
	Std. Deviation	1.790	1.921	1.415	1.606	1.586	1.236
Hochelaga-Maisonneuve	Mean	1.367	.830	.847	1.041	.587	.940
	N	49	49	50	49	50	49
	Std. Deviation	1.659	1.991	1.926	1.630	1.714	1.307
Total	Mean	1.473	.991	1.192	1.222	.579	1.105
	N	148	148	149	147	149	147
	Std. Deviation	1.663	1.828	1.595	1.576	1.656	1.202

SQOPI for public services

Name of the neighbour.		public transportation	fire fighters	police	collection of garbage and recycling	road and sidewalk upkeep	snow removal	emergency health services	quality of water	public services (overall)
Côte-des-Neiges	Mean	1.593	2.093	2.140	1.844	1.286	1.401	2.253	.533	1.629
	N	50	50	50	49	49	49	50	50	49
	Std. Deviation	1.376	1.374	1.323	1.414	1.915	1.566	1.217	1.960	1.086
Plateau Mont-Royal	Mean	1.653	1.799	1.271	1.224	.816	.340	1.553	.313	1.132
	N	49	48	48	49	49	49	47	49	47
	Std. Deviation	1.550	1.479	1.855	1.657	1.791	1.681	1.655	2.051	1.168
Hochelaga-Maison.	Mean	1.993	2.567	2.353	1.693	.893	.646	2.619	1.653	1.820
	N	49	50	50	50	50	48	49	49	47
	Std. Deviation	1.689	1.145	1.379	1.652	1.950	1.944	1.139	1.769	1.052
Total	Mean	1.745	2.158	1.930	1.588	.998	.797	2.151	.831	1.529
	N	148	148	148	148	148	146	146	148	143
	Std. Deviation	1.542	1.366	1.592	1.590	1.885	1.782	1.412	2.005	1.132

Table 5.15 (continue)

SQOPI for the involvement in the neighborhood

Name of the neighbourhood		community life	political life	economic life	socio-cultural life	involvement in the neighbourhood (overall)
Côte-des-Neiges	Mean	.279	4.000E-02	8.667E-02	7.333E-02	.124
	N	49	50	50	50	49
	Std. Deviation	1.471	1.365	1.393	1.371	1.372
Plateau Mont-Royal	Mean	.313	-.319	-.201	.403	4.861E-02
	N	48	48	48	48	48
	Std. Deviation	1.714	1.537	1.611	1.698	1.355
Hochelaga-Maisonneuve	Mean	.493	-6.000E-02	6.667E-02	.153	.163
	N	50	50	50	50	50
	Std. Deviation	1.590	1.284	1.288	1.246	1.196
Total	Mean	.363	-.110	-1.351E-02	.207	.113
	N	147	148	148	148	147
	Std. Deviation	1.586	1.396	1.431	1.444	1.301

Similarly, while Plateau Mont-Royal performs poorly for the quality of water, snow removal and sidewalk upkeep, people are satisfied with the garbage and recycling services in that neighborhood.

The other type of results obtained from Table 5.15 shows the satisfaction level of the individual's involvement in social community activities such as political, economic or socio-cultural events. It is observed that the mean values of the index for these components show different patterns. For example, Plateau Mont-Royal has a relatively higher values in socio-cultural life involvements while Hochelaga-Maisonneuve in community life.

After analyzing the performance of the index among the different components of residence, environment, public services and social life involvement, the next analysis makes a comparison between the value of Global QOL perception item (which is the last item of the questionnaire) and the index score of the overall evaluation of the neighborhood (which is the last item of Part 4–A of the questionnaire).

Table 5.16 shows that while the residents of Côte-des-Neiges have a higher value for their Global QOL perceptions, they are not very satisfied with the neighborhood characteristics (2.66 and 1.480 respectively). However, while it is also observed that this pattern is relevant for all of the three neighborhoods, Plateau-Mont-Royal is the place where people are the most satisfied residents with the characteristics of their neighborhood (2.92).

Table 5.16: Evaluation of QOP: Global QOL perception versus SQOPI for the neighborhood as a place to live

Name of the neighbourhood		Overall evaluation of quality of life: today	subjective index for neighbourhood evaluation
Côte-des-Neiges	Mean	2.66	1.480
	N	50	50
	Std. Deviation	.80	1.090
Plateau Mont-Royal	Mean	2.92	1.776
	N	49	49
	Std. Deviation	.76	1.183
Hochelaga-Maisonneuve	Mean	2.54	1.480
	N	50	50
	Std. Deviation	.68	1.184
Total	Mean	2.70	1.577
	N	149	149
	Std. Deviation	.76	1.154

5.3.2.2. Analysis of the SQOPI for the accessibility to goods and services

A similar analysis conducted for the neighborhood evaluations are also repeated to understand the satisfaction levels of the respondents for the "accessibility to goods and services". For that purpose, individuals are asked to evaluate different items such as restaurants, corner stores, schools, parks, drug stores, banks, etc. The mean values of the SQOPI calculated for each of these items are analyzed in Table 5.17. The results show that different neighborhoods are dominant in the accessibility to goods and services. For instance, Côte-des-Neiges is the neighborhood where people are most satisfied in terms of the accessibility to "schools".

Furthermore, Plateau-Mont-Royal has a good performance in the accessibility to "supermarkets", "hardware stores", "restaurants", "boutiques", socio-cultural activities", "sports activities" and "leisure activities". On the other hand, Hochelaga-

Maisonneuve has higher values for “corner stores”, “banks”, “CLSC”, “hospitals”, “public transportation” and “parks”.

Next, the comparison between the value of Global QOL perception item (which is the last item of the questionnaire) and the index score of the overall evaluation of the accessibility to goods and services (which is the last item of Part 4 – B of the questionnaire) is provided in Table 5.18. The results show that while the residents of Côte-des-Neiges have a higher value for their Global QOL perceptions, they are not very satisfied with accessibility to the goods and services (2.66 and 1.853).

However, it should also be noted that the value of the overall evaluation for accessibility has obtained a higher value than the overall evaluation of the neighborhoods characteristics that has been calculated in section 5.3.2.1 (1.853 and 1.480). Moreover, it is also observed that this pattern is relevant for all of the three neighborhoods, and Plateau-Mont-Royal is the place where people are the most satisfied residents with the characteristics of their neighborhood.

Table 5.17: Analysis of SQOPI for the accessibility to goods and services

	Name of the neighbourhood											
	Côte-des-Neiges			Plateau Mont-Royal			Hochelaga-Maisonneuve			Total		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
corner store	2.040	50	1.676	2.497	49	1.185	**2.740**	50	1.013	2.425	149	1.346
supermarket	2.060	50	1.597	**2.483**	49	1.400	2.420	50	1.300	2.320	149	1.440
hardware	1.720	50	1.832	**2.320**	49	1.236	2.293	50	1.464	2.110	149	1.547
bank	1.927	50	1.749	2.190	49	1.537	**2.387**	50	1.386	2.168	149	1.565
restaurants	1.820	50	1.754	**2.537**	49	1.071	2.193	50	1.548	2.181	149	1.506
boutiques	1.853	50	1.776	**2.211**	49	1.406	2.020	50	1.635	2.027	149	1.610
CLSC	1.693	50	1.693	1.563	48	1.776	**2.173**	50	1.424	1.813	148	1.646
hospital	1.893	50	1.606	1.707	49	1.830	**2.127**	50	1.449	1.911	149	1.632
schools	**1.497**	49	1.646	1.197	49	2.003	1.381	49	1.337	1.358	147	1.677
public transportation	2.014	47	1.455	2.181	46	1.288	**2.551**	49	1.220	2.254	142	1.333
parks	1.929	47	1.597	2.312	46	1.175	**2.613**	50	1.134	2.291	143	1.337
sociocultural activities	1.060	50	1.774	**1.333**	47	1.602	1.320	49	1.506	1.235	146	1.626
sports activities	1.113	50	1.807	**1.426**	47	1.601	1.333	49	1.494	1.288	146	1.635
leisure activities	1.173	50	1.769	**1.461**	47	1.646	1.367	50	1.467	1.331	147	1.625

Table 5.18: Evaluation of QOP: Global QOL perception versus SQOPI for the accessibility to goods and services

Name of the neighbourhood		Overall evaluation of quality of life: today	overall evaluation of accessibility
Côte-des-Neiges	Mean	2.66	1.853
	N	50	50
	Std. Deviation	0.80	1.580
Plateau-Mont-Royal	Mean	2.92	2.293
	N	49	49
	Std. Deviation	0.76	1.132
Hochelaga-Maisonneuve	Mean	2.54	2.373
	N	50	50
	Std. Deviation	0.68	1.160
Total	Mean	2.70	2.172
	N	149	149
	Std. Deviation	0.76	1.319

5.4. Conclusions

This chapter has analyzed two major dimensions of the QOP defined in previous sections: objective and subjective through different sources of data, methods and techniques. On the objective dimension, both social structural information and physical information related with QOP have been analyzed. Social Structural Information was analyzed with the help of census data. PCA_{st} has helped, first, to identify the components that are related with QOP and secondly, define the meanings attached to each component.

The results showed that objective dimension of the QOP can be defined by five components: 1) socioeconomic status and education, 2) family status and transportation, 3) unemployment status, 4) housing conditions, and 5) gender differentiations for work place. Another important contribution of the PCA_{st} to the objective dimension is the "QOP_{cs}" derivations which are again based on the calculations of the components and the weights attached to each component. A simple weighted linear index has been calculated for each CT and mapped to see the geographical distribution. It showed that the index scores had higher values within the inner parts of Montreal Island whereas lower values in the outer zones.

The second information about the objective dimension of QOP was analyzed with the capabilities of integration of remote sensing and GIS. Since greenness is one of the most important physical components of QOP, special attention has been given to extract the presence of green areas on the Island. For that purpose a new vegetation index, TDVI, is applied to the IRS 1-D satellite image and different processing algorithms are used to obtain effective land use information. Accessibility to public services on the objective dimension is also analyzed. To do that, "spatial analysis" techniques in GIS are used. Results showed that among the five types of public services, the best accessibility is for the "educational" whereas the worst is for the "emergency" services.

Being another dimension of QOP identified in the conceptual framework of this thesis, the subjective dimension was analyzed through a survey data which has been applied to a sample of CTs in the inner city of Montreal. Similar to the QOP_{CS}, an index based on literature survey, SQOPI has been defined and calculated using the responses to the items asked to people living in the three neighbourhoods of Montreal: Côte-des-Neiges, Plateau-Mont-Royal and Hochelaga-Maisonneuve. Based on the comparison of the index scores for the two major parts of the questionnaire (neighbourhood evaluations and accessibility to goods and services), it was observed that the satisfaction levels of the individuals for the accessibility to goods and services are higher than the ones for characteristics of their neighbourhood, such as the resident comfort, size or maintenance.

The results of the subjective dimension showed that the three neighbourhoods have different performances for the index values in terms of the neighbourhood and accessibility evaluations. Another interesting finding of the analysis is the relationship between the overall QOL perceptions and the SQOPI values. The general pattern is, while most people are satisfied with their QOL, the SQOPI is relatively low which also supports the view that the definitions of the two concepts (QOL and QOP) are different. While one is high the other may have lower scores or vice versa.

Since both objective and subjective dimensions analyzed accessibility to public services, it should also be noted that the results of the objective dimension which indicates that "educational" services have the best performance is also verified by the results obtained from the subjective dimension.

6 Integration of Objective and Subjective Dimensions Using Multi-Criteria Evaluation in GIS

"The best urban places have some mixtures of uses. The mixture responds to the values of publicness and diversity that encourage local community identity. Excitement, spirit, sense, stimulation and exchange are more likely when there is a mixture of activities than when there is not."[9]

6.1. Introduction

Integration of the results in both objective and subjective dimensions obtained in the previous chapter will be the main objective of this chapter. As an initial step, PCA_{st} will be applied to understand the contribution of the both dimensions to QOP. Then, with the help of PCA_{st} results, a Multi-Criteria Evaluation (MCE) analysis will be made where the objective will be to produce an "integrated QOP index" (IQOPI) based on weighted linear combination (WLC). This index will be derived first, for the variables within the objective dimension and secondly for all the variables within the both objective and subjective dimensions. The chapter will end up with the spatial distribution of these two indices in Montréal.

6.2. Principal component analysis

In this section, PCA_{st} is applied to see the relation between the "Social Structural Information" and the "Physical Structural Information" (which are explained in chapter 3) within the objective dimension of QOP (see Appendix I for the "Syntax File" created in SPSS). Social structural information is defined by "QOP_{cs}" values and physical

[9] Jacobs A. and Appleyard D., (2000), "*Toward an urban design manifesto*", in *City Reader,* LeGates R. and Stout F., London, p.499

structural information is defined by "land use distribution" and "accessibility to public services" which are derived and calculated in chapter 5. The second goal of PCA_{st} is to understand the relation between the variables within both the objective and subjective dimensions. Therefore, in the next step, ASI variables derived in chapter 5 are also included in the PCA_{st} for the selected CTs (see Appendix J for the "Syntax File" created in SPSS). Before applying PCA_{st}, first, percentage of each land use category at CT level is calculated using the post-classified image. To do that, total number of pixels within each CT and the total number of pixels for each land use category are calculated using the zonal statistics function of ArcGIS. Then the percentage of each land use class (at CT level) is calculated in Excel and stored in a table. Following this, the "mean" values for the accessibility to each public service (at CT level) which was calculated in chapter 5 (an example of these tables are provided in Table 5.8) are also entered into the same table that keeps the land use percentages. Thirdly, the ASI values for each item of the questionnaire are entered to the same Excel table and this final data table is used in SPSS for PCA_{st} Table 6.1 shows the variables that are subjected to PCA_{st}.

The first application of PCA_{st} is done within the "objective dimension" and applied only to the variables that are within this dimension. The number of components which explain the most of the data is derived from the "Rotation sums of squared loadings" (Table 6.2). According to Table 6.2, if only one component is used, 22.01 % of the data is explained. If the number of components is increased to five, then 65.07 % of the data is represented. A scree plot (Figure 6.1) is also used to see how many components to retain. From this graph, it is observed that five components are enough to represent the whole range of data.

Table 6.1: Variables used for PCA_{st} in both objective and subjective dimensions

Variable	Description	QOP dimension
Md_edu	Mean value for accessibility to educational services	Objective
Md_emer	Mean value for accessibility to emergency services	
Md_heal	Mean value for accessibility to health services	
Md_met	Mean value for accessibility to metro stations	
Md_recr	Mean value for accessibility to recreational services	
QOP_{cs}	Quality of Place Index	Objective
per_hden	Percentage of high-dense residential areas	Objective
per_mden	Percentage of mid-dense residential areas	
per_lden	Percentage of low-dense residential areas	
per_prk	Percentage of parks and cemetery areas	
per_urbf	Percentage of urban forestry	
per_gov	Percentage of government areas	
per_comm	Percentage of commercial areas	
per_reso	Percentage of resource and industrial areas	
per_open	Percentage of open spaces	
per_wat	Percentage of water	
asires	ASI for residence	Subjective
asienv	ASI for environment	
asipub	ASI for public services	
asiinv	ASI for involvement in the neighbourhood	
asiov	ASI for overall evaluation of the neighbourhood as a place to live	
asigpr	ASI for goods and services	
asise	ASI for services	
asiac	ASI for activities	
asiovac	ASI for overall evaluation of accessibility in the neighbourhood	

Table 6.2: Total variance explained in PCA_{st} for objective dimension of QOP

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3,640	22,752	22,752	3,640	22,752	22,752	3,523	22,018	22,018
2	3,398	21,236	43,988	3,398	21,236	43,988	3,201	20,009	42,027
3	1,220	7,623	51,611	1,220	7,623	51,611	1,444	9,025	51,052
4	1,093	6,833	58,444	1,093	6,833	58,444	1,156	7,224	58,276
5	1,061	6,629	65,074	1,061	6,629	65,074	1,088	6,798	65,074
6	,829	5,180	70,254						
7	,802	5,014	75,268						
8	,668	4,175	79,442						
9	,622	3,890	83,332						
10	,509	3,183	86,515						
11	,500	3,125	89,641						
12	,442	2,759	92,400						
13	,415	2,592	94,992						
14	,370	2,310	97,302						
15	,279	1,741	99,043						
16	,153	,957	100,000						

Extraction Method: Principal Component Analysis.

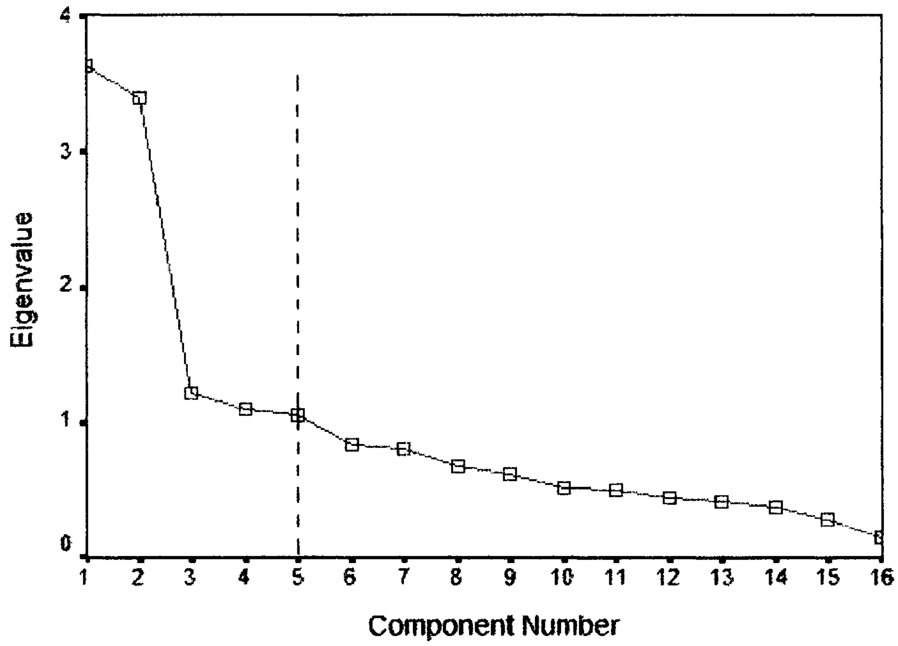

Figure 6.1: Scree plot of PCA_{st}

After deciding the number of components to retain, the next step is to understand the meaning of these components and to analyze which variables are explained in different components. This helps to see the relation between different types of variables and which component describes a different meaning of the QOP in the objective dimension. To do that, "Rotated Component Matrix" is used (Table 6.3). According to this table, most of the variables of the "land use distribution" (such as "percentage of urban forestry") are highly related with each other and represented in component 1. However, it should be noted that, according to this table, not all variables of the "land use distribution" are explained in the first component. While, the percentage of parks and cemetery, urban forestry, commercial areas, open space and water are explained in component 1, the variable for "percentage of mid-dense residential areas" is explained in the third component and the variable for "low-dense residential area" is explained in the fourth component. Among the variables in the first component, "urban forestry" has the highest value (0.93) and this category is highly and positively correlated with "open space" and "water" categories (0.84 and 0.87).

Table 6.3: Rotated Component Matrix[a]

Variable	Component				
	1	**2**	**3**	**4**	**5**
Mean value for accessibility to educational services	0.04	**0.64**	-0.35	-0,08	0.14
Mean value for accessibility to emergency services	0.01	**0.63**	0.01	-0.22	0.20
Mean value for accessibility to health services	-0.002	**0.71**	-0.10	-0.005	-0.08
Mean value for accessibility to metro stations	-0.05	**0.69**	-0.03	0.21	-0.10
Mean value for accessibility to recreational services	0.09	**0.70**	-0.33	-0.05	0.16
QOP_{cs}	0.03	**-0.72**	-0.28	-0.15	0.20
Percentage of high-dense residential areas	0.03	-0.04	0.40	-0.57	0.15
Percentage of mid-dense residential areas	0.05	-0.15	**0.82**	0.09	0.08
Percentage of low-dense residential areas	0.17	-0.10	0.20	**0.80**	0.15
Percentage of parks and cemetery areas	**0.60**	-0.13	-0.32	0.17	0.16
Percentage of urban forestry	**0.93**	-0.01	-0.02	0.06	0.02
Percentage of government areas	0.40	-0.34	-0.30	-0.16	0.33
Percentage of commercial areas	**0.75**	0.09	0.20	0.02	-0.20
Percentage of resource and industrial areas	0.23	-0.08	-0.05	-0.10	**-0.83**
Percentage of open space	**0.84**	0.04	0.03	-0.02	-0.14
Percentage of water	**0.87**	0.03	0.02	0.04	-0.04

Extraction Method: Principal Component Analysis

Rotation Method: Varimax with Kaiser Normalization

a. Rotation converged in 14 iteration

On the other hand, component 2 keeps the variables for "accessibility to public services" (such as "mean value for accessibility to educational services"). Another important result of this component is that it also keeps the "QOP_{cs}" variable. Since this matrix is also useful to understand the variables that are positive or negatively related with each other, it is observed that in component 2, the variables of the "accessibility to public services" and "QOP_{cs}" are negatively related with each other. This can be explained as the mean distances to access to a public service increases the QOP_{cs} decreases. For example, within a CT, QOP_{cs} has a lower value as the mean distance to a metro station increases. Furthermore, among the variables explained in component 2, accessibilities to "health services" and "recreational facilities" have the highest positive values (0.71 and 0.70). According to Table 6.3, the only variable that is explained by component 3 is the "percentage of mid-dense residential areas" (0.82). Similarly, "percentage of low-dense residential areas" is the only variable that is explained by component 4. While both variables in components 3 and 4 have positive values (0.82 and 0.80), component 5, on the other hand, keeps the variable for "percentage of resource and industrial areas" with a negative loading (-0.83).

As a summary, this first application of PCA_{st} showed that there's a relation between the "Social Structural Information", which is defined by QOP_{cs}, and the "Physical Structural Information", which is defined by "land use distribution" and "accessibility to public services". Since these results proved that there is a link between "Social Structural Information" and "Physical structural Information", the next goal is to see, whether there is also a link between those two and the "Experiential Community Structrural Information". Therefore, a similar PCA_{st} is also applied to the whole data set where ASI values are included for the selected CTs. Since the number of records that have ASI values is limited to 30, PCA_{st} is applied to the data set only where the CTs have ASI values together with other variables that were used in the previous step. Table 6.4 shows the results of the "Rotation sums of squared loadings". According to this table, eight components are enough to represent the whole range of data (since 80.2 % of the data is explained).

Table 6.4: Total variance explained in PCA_{st}

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6,406	25,623	25,623	6,406	25,623	25,623	5,032	20,129	20,129
2	3,005	12,021	37,643	3,005	12,021	37,643	2,889	11,556	31,685
3	2,737	10,948	48,591	2,737	10,948	48,591	2,425	9,701	41,386
4	2,407	9,629	58,220	2,407	9,629	58,220	2,188	8,751	50,137
5	1,834	7,337	65,557	1,834	7,337	65,557	2,161	8,644	58,781
6	1,440	5,761	71,318	1,440	5,761	71,318	2,123	8,493	67,274
7	1,189	4,757	76,075	1,189	4,757	76,075	1,909	7,635	74,909
8	1,048	4,192	80,267	1,048	4,192	80,267	1,340	5,358	80,267
9	,847	3,387	83,654						
10	,783	3,132	86,786						
11	,699	2,797	89,583						
12	,574	2,296	91,878						
13	,475	1,899	93,777						
14	,389	1,554	95,332						
15	,316	1,264	96,596						
16	,224	,896	97,493						
17	,193	,771	98,264						
18	,135	,539	98,803						
19	,102	,409	99,212						
20	7,068E-02	,283	99,495						
21	5,727E-02	,229	99,724						
22	4,083E-02	,163	99,888						
23	2,106E-02	8,422E-02	99,972						
24	5,547E-03	2,219E-02	99,994						
25	1,502E-03	6,008E-03	100,000						

Extraction Method: Principal Component Analysis.

After deciding the number of components to retain, the next goal is to understand the meaning of these components and to analyze the relation between the variables within both the objective and subjective dimensions. Rotated Component Matrix (Table 6.5) is used to understand which component describes a different dimension of QOP.

According to Table 6.5, component 1 keeps the variables of the "Experiential Community Structure" which are defined within the subjective dimension (such as "ASI for residence"). In this component, ASI values for residence, public services, goods and services, activities or overall evaluations are highly related to each other. Among these variables, ASI for "goods and services", "activities", "services" and "overall evaluation of accessibility in the neighbourhood" are better represented (0.90) than "residence" (0.61) and "public services" (0.70). On the other hand, the variable "ASI for involvement in the neighbourhood" is highly and positively related with the variables "percentage of parks and cemetery" and "percentage of urban forestry" and they are represented in component 2. The variables "accessibility to metro stations" and "ASI for environment" are represented in component 3; however, they are negatively related with each other.

The fourth component, on the other hand, represents the variables "accessibility to recreational services", "percentage of open spaces" and "percentage of water" where these three variables are positively related with each other. Component 5 keeps the variables "QOP_{cs}", "percentage of mid-dense residential areas" and "percentage of commercial areas". However, it should be noted that the "QOP_{cs}" is negatively related with the other two variables in component 5. The variables for accessibility to educational and health services are positively related with the variable "percentage of resource and industrial areas", and these three variables are represented in component 6. Moreover, the variable for accessibility to emergency services is positively related with the "percentage of low-dense residential areas" while negatively related with "percentage of high-dense residential areas" and these three variables are kept in component 7. Finally, the eighth component keeps only the variable "percentage of government areas".

Table 6.5: Rotated Component Matrix[a]

Variable	Component							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Mean value for accessibility to educational services	-0.31	0.02	-0.40	0.13	-0.42	**0.60**	0.20	0.02
Mean value for accessibility to emergency services	-0.30	0.16	-0.05	-0.05	0.24	0.23	**0.69**	0.19
Mean value for accessibility to health services	-0.32	-0.06	-0.07	0.13	0.04	**0.74**	0.12	0.32
Mean value for accessibility to metro stations	0.01	-0.03	**-0.82**	0.19	0.10	0.04	0.09	0.13
Mean value for accessibility to recreational services	-0.17	-0.32	0.07	**0.69**	0.32	0.20	0.09	0.13
ASI for residence	**0.61**	0.45	-0.26	0.12	0.03	-0.04	0.15	0.08
ASI for environment	0.30	0.11	**0.80**	-0.14	-0.06	0.02	0.18	0.06
ASI for public services	**0.60**	0.32	0.50	0.30	-0.30	-0.11	0.06	0.06
ASI for involvement in the neighbourhood	0.50	**0.60**	-0.20	0.30	0.10	-0.04	0.20	0.30
ASI for overall evaluation of the neighbourhood as a place to live	**0.70**	0.20	0.14	-0.40	0.009	0.06	0.02	0.40
ASI for goods and services	**0.90**	0.09	0.09	0.19	0.10	-0.10	-0.20	-0.02
ASI for services	**0.90**	0.04	0.20	0.20	-0.01	-0.16	-0.15	-0.16
ASI for activities	**0.90**	0.06	0.02	-0.09	0.14	-0.05	-0.11	-0.003
ASI for overall evaluation of accessibility in the neighbourhood	**0.90**	0.07	0.11	0.03	-0.05	-0.09	-0.30	-0.10
QOP_{cs}	0.09	0.24	0.42	-0.06	**0.60**	0.07	0.10	-0.31

Table 6.5 (continue)

Variable	Component							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Percentage of high-dense residential areas	-0.03	-0.30	-0.30	-0.20	0.40	-0.30	**-0.62**	0.41
Percentage of mid-dense residential areas	-0.13	-0.20	0.20	0.09	**-0.70**	-0.04	-0.12	-0.09
Percentage of low-dense residential areas	-0.13	-0.20	0.20	0.02	0.13	-0.12	**0.80**	-0.04
Percentage of parks and cemetery areas	0.11	**0.90**	0.12	0.09	0.10	-0.07	-0.10	-0.13
Percentage of urban forestry	0.13	**0.90**	0.20	-0.05	0.13	-0.04	0.02	-0.20
Percentage of government areas	0.03	0.20	-0.20	-20	0.20	-0.14	-0.03	**-0.70**
Percentage of commercial areas	0.007	0.009	0.10	-0.16	**-0.80**	0.13	-0.04	-0.07
Percentage of resource and industrial areas	0.02	-0.08	0.05	0.006	-0.03	**0.90**	-0.04	-0.07
Percentage of open space	0.30	0.30	-0.20	**0.70**	-0.10	0.14	-0.20	-0.01
Percentage of water	0.17	0.14	-0.34	**0.75**	-0.04	-0.07	0.06	0.15

Extraction Method: Principal Component Analysis

Rotation Method: Varimax with Kaiser Normalization

a. Rotation converged in 14 iterations

6.3. IQOP index derivation based on weighted linear combination (WLC)

In this section, based on the PCA_{st} results obtained in the previous section, an IQOPI is calculated by a linear combination of components at CT level. The eigenvalues (obtained from Table 6.2) are used for giving weights to each component. The index is calculated as follows:

$$IQOPI = (\sum_{i=1}^{N} e_i . C_i) / N \qquad (6.1)$$

This index is first applied to the PCA_{st} that was subjected to only the variables within the objective dimension. Therefore, the number of eigenvalues is computed as five and the index is calculated for all the CTs. The spatial distribution of this index is shown in Figure 6.2.

According to Figure 6.2, the index has generally positive values in the outer parts of the Island while negative values occur within the central parts. When the study areas of this research are analyzed, it is observed that Plateau-Mont-Royal has more negative values when compared to other two neighborhoods. Although, both Côte-des-Neiges and Hochelaga-Maisonneuve have some negative values, there are also CTs where the index has positive values. These are generally the CTs where accessibility to public services is easier and there are more recreational facilities.

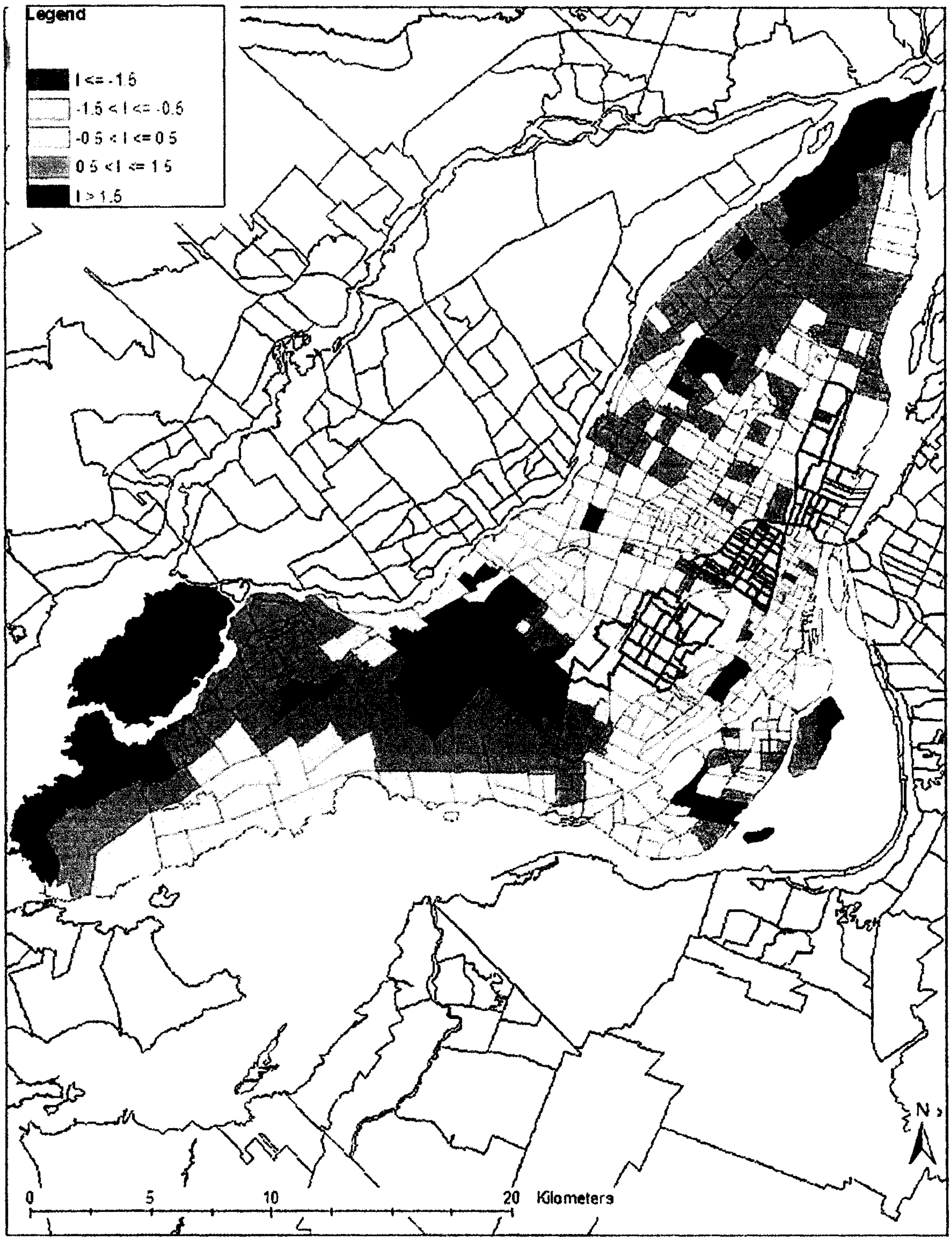

Figure 6.2: Spatial distribution of IQOPI in the objective dimension

The second and final step of this research is to calculate the IQOPI using the variables in both subjective and objective dimensions. For this purpose, the components and the eigenvalues derived in the previous section are used to calculate the index and the spatial distribution of this index is mapped in Figure 6.3. Since the questionnaires for the subjective dimension were distributed in a limited number of CTs, this map shows the index value for only those selected CTs.

According to Figure 6.3, selected CTs show a different pattern than the previous spatial structure (the same CTs are also shown in Figure 6.4 to make the comparison easier). When the same CTs is analyzed in both Figure 6.3 and 6.4, it is observed that there are cases where people evaluated their QOP differently than the objective methods. For example, in Figure 6.3, in Côte-des-Neiges, the CT which has been marked as red color, shows a negative value for the integrated index while in Figure 6.4 the same CT has an average value (green color). Moreover, there are also cases where, in Figure 6.4, the CT takes an average value (green color) but people have evaluated the QOP as positive in the questionnaire which results in a dark blue color in Figure 6.3.

6.4. Conclusions

In this chapter, first, different variables of the objective dimension of QOP are analyzed through PCA_{st}. It is observed that "physical structural information" and "social structural information" are correlated to each other. PCA_{st} that is conducted at the beginning of the chapter showed that all the variables in these social and physical structures, are represented at least in one component. Each component kept different variables and they keep different information related with QOP. For example, different land use characteristics are defined by different components such as the presence of green areas are kept in component 1 while density of residential areas are explained by components 3 and 4.

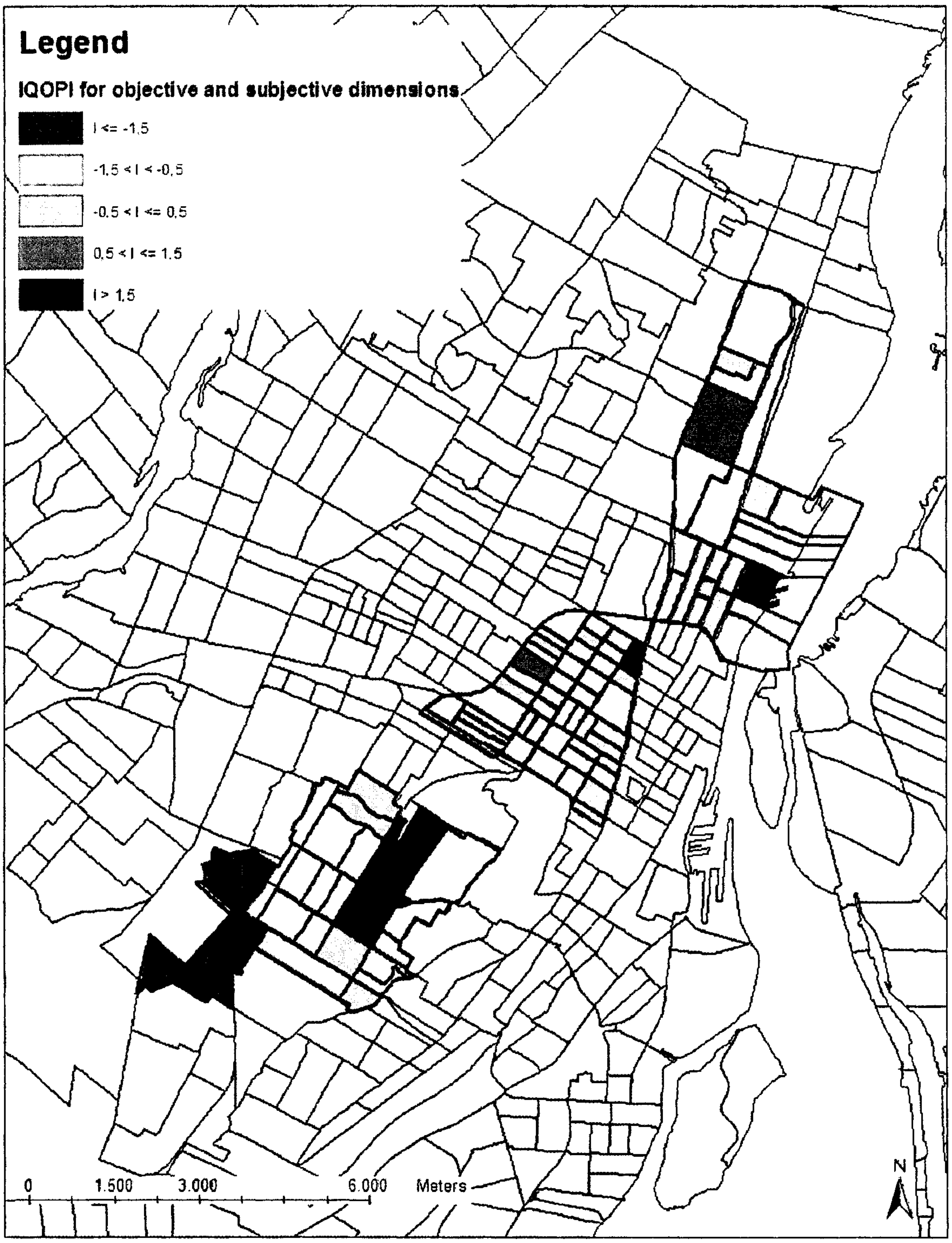

Figure 6.3: Spatial distribution of IQOPI in the objective and subjective dimensions

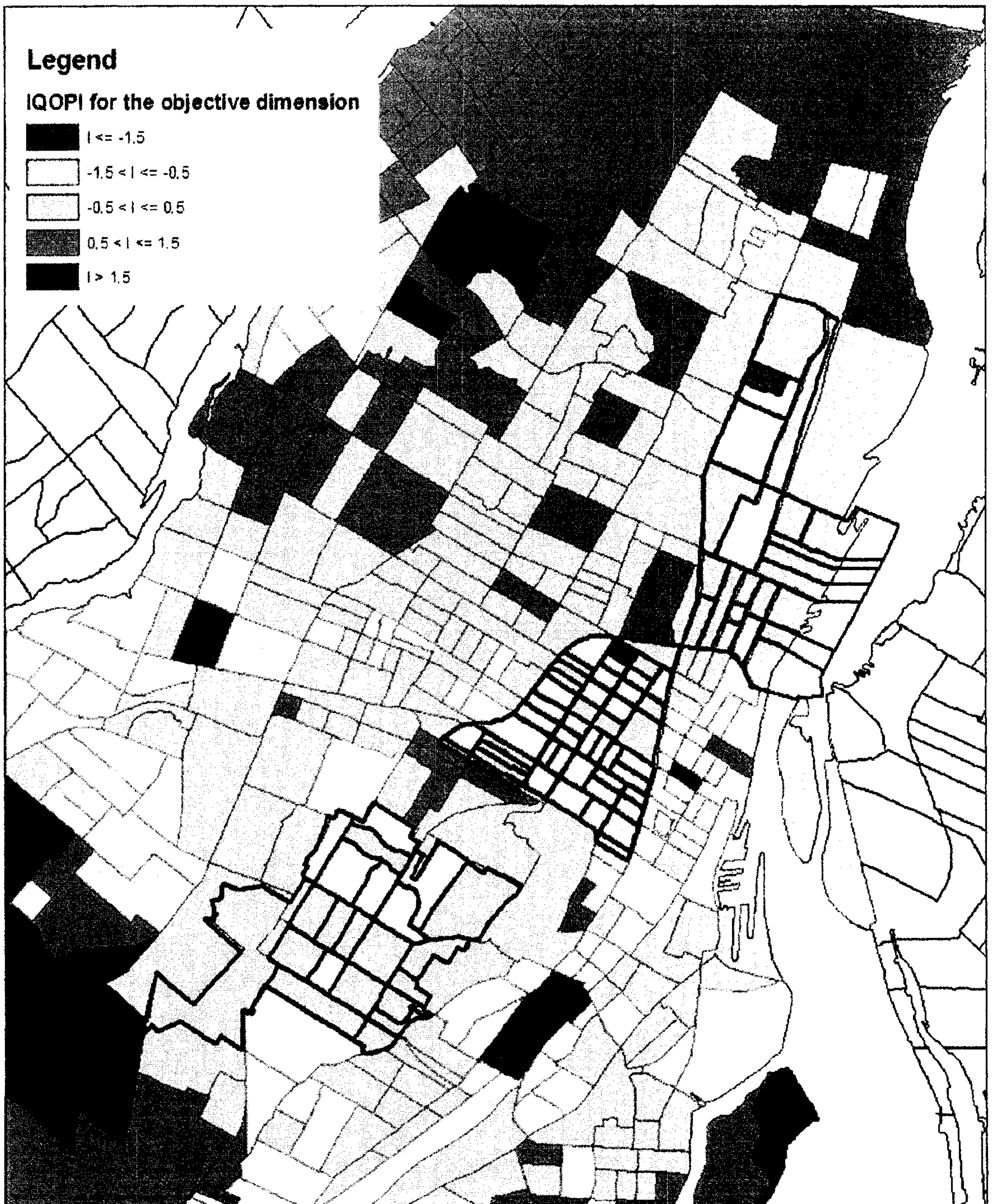

Figure 6.4: Spatial distribution of IQOPI in the objective dimension for selected CTs

The second PCA_{st} is performed to understand the contribution of the subjective dimension to the QOP concept. Therefore the index values derived from the questionnaires (ASI values) are also subjected to PCA_{st} together with the other variables used in the first step. The results showed that more components are identified when the subjective dimension is included into the model. Therefore, the methodology introduced in this thesis is supported by the results obtained in this section. Not only the components demonstrated different meanings of the QOP, but the eigenvalues obtained from this PCA_{st} are used to derive the IQOPI which is the final objective of the research.

IQOPI is calculated both for the variables in the objective and the final integrated set of variables to make a comparison. It is observed that when the index is calculated only for the variables in the objective dimension, some CTs show a different structure when it is calculated using the whole data set. This shows that, generally a CT may be defined with objective criteria for QOP; however, the real situation may be different when the perceptions of people living in that area are considered. Therefore, these results showed that there is a strong link between the objective and subjective dimensions of QOP and both dimensions should be considered for the complete picture.

7 Conclusions and Recommendations

> "Place has depth as well as surface: it has values, identities, morals, aesthetics, emotions, awareness, memory and spiritual needs."[10]

All over the world, people are engaged in activities which are related to places. Every year, millions of people buy or rent a house with little more than visual evidence of QOP. While homeowners redecorate or build additions to the buildings, neighborhood organizations put pressure on people to tidy their yards. The small room in a residence even becomes the place and home for a student for many years. Similarly, the city walls become the most important place for artists who write their tags and graffiti. Qualities of these places may include aesthetic, economic, social, political, environmental, human health, public safety, and other concerns. From another perspective, QOP is also essential for building a "competitive city" which is determined by the opportunities that the city can provide. For these reasons, not only physical characteristics of the neighborhoods or their social structure but also the perceptions and satisfaction they induce play important roles in the assessment of QOP. Because of this complex structure, the main objective of this thesis has been, first, to offer a new definition of QOP where both objective and subjective dimensions are integrated and secondly, to introduce a new methodology where the information technologies such as GIS and RS can be applied to understand the contribution of these two dimensions of QOP.

The objective dimension of QOP is analyzed through two types of information. To begin with, "social structural information" is analyzed using census data which help to understand the link between the socio-demographic/economic characteristics and QOP in census tract (CT) level at the city-wide scale. Then, "physical structural information" through accessibility to public services and urban land use is analyzed with the help of

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[10] Hodge G. and Robinson I., (2001), *Planning Canadian Regions*, UBC Press, Toronto, p.86

RS and GIS techniques. In addition, survey data is also used to explore the "experiential community structural information" that helps to understand the individual's own perceptions about the quality of the place where they live. Finally, both of the objective and subjective dimensions are then integrated through Multi-Criteria Evaluation in a GIS environment. The proposed methodological approach is tested for Montréal as a case study.

The results showed that the social structural dimension of the QOP can be defined by five components: 1) socioeconomic status, education and linguistic, 2) family status and transportation, 3) unemployment status, 4) housing conditions, and 5) gender differentiations in the work place. Results indicated that Côte-des-Neiges is one of the most ethnically diverse neighborhoods of Montréal, and hence, component 1 shows that the linguistic and educational characteristics are more diverse in this neighbourhood. While some census tracts show more positive values, negative values were also observed within the neighbourhood which indicates that some CTs may experience unsatisfactory QOP in terms of socio-economic status and linguistic characteristics. Côte-des-Neiges is also known as a working-class neighborhood. Therefore these results showed a meaningful geographical distribution of the component 1 for this neighborhood. However, less negative values for component 1, were observed in Plateau-Mont-Royal where ethnicity is less diverse and a more homogenous structure exist. The results of this component related to socio-economic status in Plateau-Mont-Royal, supports the socio-profile which was explained in chapter 4. Since this neighbourhood has more workers in cultural, communication and personal service sectors, it is expected to observe less negative values for component 1. On the other hand, more negative values for component 1 were observed in Hochelaga-Maisonneuve where the majority of the residents speak French. As it has been discussed in chapter 4, linguistic characteristics are one of the most important factors of QOP. These negative results of component 1 in Hochelaga-Maisonneuve demonstrate that the adaptability of minority groups to the neighbourhood would be relatively less (and hence the QOP that they experience may not be satisfactory for them) in terms of language since the majority of people speak French.

The results of component 2 generally provided information about "life style" such as family status (single people), transportation modes, etc. It was observed that positive values were more dominant in the downtown of the Island while negative values existed on the west. Positive values illustrate that the "life style" component of QOP is relatively high in the downtown. This result is not surprising since accessibility to public transportation is easier in the central parts when we compare with the neighbourhoods in the north. Furthermore, this component has also interesting interpretations for family status in the downtown and outer neighbourhoods of the Island such as Pointe-Claire, Beaconsfield, Rivière-des-Prairies and Anjou. These latter neighbourhoods are the places where negative values were loaded for the second component while the downtown districts had positive values. This indicates that single people are more willing to live in the downtown where the place offers a diversification for their life style whereas families with children relatively prefer outer neighbourhoods. This can also be explained by the gentrification process that was presented in chapter 4.

As it was analyzed in the literature review, with social upgrading and gentrification in the downtown neighbourhoods, more high-skilled knowledge workers, who are generally younger, preferred the central parts such as Plateau- Mont-Royal or Ville-Marie. The results also supported that QOP in terms of transportation was higher for these people in the downtown, since there is a positive relationship between "single family status" and "public transportation or bicycle use" as mode of transportation.

Another significant interpretation of the results was that Côte-des-Neiges showed very different characteristics from the other two study areas: Hochelaga-Maisonneuve and Plateau-Mont-Royal. While the negative values were more dominant in Côte-des-Neiges, the other two have positive values for component 2. This indicates a concentration of relatively negative QOP (in terms of transportation modes and family status) in Côte-des-Neiges. However, this result is also not very surprising and eventually supports the social profile of the neighborhood. Since the immigrant population is higher in Côte-des-Neiges than it is compared with the other two, we can expect to see a mix of negative and positive values for QOP.

In addition to these analyses, there is also need to compare the geographical distribution of the first and second components. It is interesting that an opposite structure was observed in the values of component 1 and 2. While the neighbourhoods on the western part of the Island such as Pointe-Claire and Beaconsfield had negative values for the first component, the same areas had positive loadings for the second component. This shows us a place can be loaded with different QOP meanings at the same time. For instance, Beaconsfield had positive "linguistic characteristics" as a variable of the human capital component of QOP but negative "transportation modes" as a variable of physical characteristics component of QOP.

The comparison of the first and second PCA_{st} components supported that, even within the objective dimension, QOP may be loaded with different meanings with different values. Thus, we can argue that the proposed conceptual framework is also verified through the PCA_{st} results.

The results of the component 3 explained "unemployment status". It was observed that, unlike to components 1 and 2, component 3 had different values in Plateau-Mont-Royal where more negative values for this component of QOP were observed. This result supports the socio-economic profile of this neighbourhood explained in chapter 4, since the average household income is relatively low (31 885 CAD). However the same neighborhood had positive QOP in terms of linguistic characteristics, education and transportation modes. The results of component 3, also indicated that the neighbourhoods on the western part of the Island such as Dorval had negative values for "unemployment status". Furthermore, when the geographical distribution of this component was compared with the previous two components, it was observed that QOP could be negative, when it was analyzed in terms of "unemployment status", not only in the outer parts but also in the central parts of the Island such as Plateau-Mont-Royal. It is also interesting that the area called as "Old Port" was the only census tract that had high positive values for component 3 while it was loaded with negative values for both first and the second components.

Furthermore, component 4 explained “housing conditions”. The analysis showed that the distribution of this component was relatively the same among the three neighbourhoods. There were both positive and negative values for QOP in terms of housing conditions in every neighbourhood. Among the three neighbourhoods Plateau Mont-Royal had more positive values for housing conditions; indicating that the majority of the houses are relatively new or are in good physical condition. However, there was only one census tract in this neighbourhood that showed extremely negative value. When the geographical distribution of component 4 was analyzed, the results generally demonstrated that the most parts of Ville-Marie had relatively negative QOP in terms of housing conditions. Since this neighbourhood is the oldest one in the city, the results are not surprising. We should also keep in mind that the negative values for QOP in this neighbourhood for component 4 do not necessarily point to an overall negative QOP evaluation. For instance, the same neighbourhood had positive QOP in terms of transportation modes or linguistic characteristics. This reality also supports the proposed conceptual framework where the necessity of combination of different components for QOP has been underlined.

The gender differentiations for work place, which was linked to “males, place of work status at home” was explained by component 5. It was observed that Hochelaga-Maisonneuve had negative values while the central parts of the Island had dominantly positive values. This brings the question of whether there is a trend in place of work status at home. Since the positive values were observed in the central parts such as Old Port (Ville-Marie) or Plateau-Mont-Royal, the results may be interpreted as a preference of high-skilled knowledge workers to work from their home. With the increasing use of technology and the internet, this trend has also an important effect on QOP analysis because these results indicated that housing should not be evaluated as only a “living place” but also as a “work place”.

Another important contribution of the PCA_{st} to the objective dimension is the “OQOPI” derivations which are based on the calculations of the components and the weights attached to each component. A simple weighted linear index has been calculated for each CT and mapped to see its geographical distribution. It was observed that the index scores had higher values within the inner parts of Montréal Island whereas lower values in the outer zones. This means that the most of the census tracts in the neighbourhoods like Ville-Marie and Plateau Mont-Royal are relatively better places (in terms of the importance of each five components) while the performance of the places in some census tracts of the outer neighbourhoods such as Rivière-des-Prairies or Saint-Laurent are not very satisfactory.

It was observed that while Côte-des-Neiges and Plateau-Mont-Royal had relatively positive values for OQP (which is an indicator of good places), Hochelaga-Maisonneuve experienced a mixed structure where negative values were also observed. On the other hand, the comparison of QOP_{cs} with each of the PCA components derived before shows that Hochelaga-Maisonneuve had relatively good QOP in terms of transportation modes or housing conditions; however, overall, the performance of the neighbourhood was not very good when other factors of QOP were included.

Similarly, while Ville-Marie did not have relatively good housing conditions, when the overall QOP_{cs} was analyzed, it was observed that this neighbourhood performed well in terms of other factors such as transportation modes, work place or linguistic characteristics.

The physical structural information of QOP was analyzed with the capabilities of integration of RS and GIS. Since greenness is one of the most important physical components of QOP, special attention was given to extract the presence of green areas on the Island. For that purpose a new vegetation index, TDVI, was applied to the IRS 1-D satellite image and different processing algorithms were used to obtain effective land use information. As it was previously indicated in the literature review, the differentiation among the green areas plays an important role in urban QOP studies. Since planning policies and urban management differ in forestry areas or parks and amusement areas, this thesis has provided promising results in separating the different categories successfully through the application of TDVI. Results of the image classification using

TDVI showed that a value of 0.94 was achieved for the Kappa Coefficient which is an indicator of good classification. With the help of these results, urban areas with vegetation cover were differentiated into three sub-categories such as: 1) urban with dense vegetation 2) urban/vegetation 3) urban with weak vegetation. Green areas were also separated as: 1) parks and cemetery and 2) urban forest. Furthermore, with the availability of GIS based land use data it was also possible to apply a post-classification algorithm where a decision rule was applied based on a priority of the functional differentiations among the three urban categories. Therefore, the results of the final post-classified image provided even more detailed urban classes such as commercial, industrial or governmental land uses.

Accessibility to public services was also analyzed to understand its meaning to QOP. To do that, "spatial analysis" techniques in GIS were used. When the results were analyzed, it was observed that the accessibility to public services had different patterns for each service. For example, while most of the CTs in the neighbourhood of Plateau-Mont-Royal had accessibility to "educational" services within only a 500 meters zone, the accessibility to "emergency" services occured within a zone of 2000 meters. Moreover, it was also observed from these results that not all the CTs had the same accessibility to public services. For instance, the CTs in the south of the neighbourhood of Côte-des-Neiges had accessibility to emergency services within a zone of 3000 meters while the CTs in the north had accessibility within a 500 meters zone.

Another result from the analysis of accessibility to public services is that, among all public services, the best accessibility, generally, occurred for "educational" services. Results indicated that the "emergency" services were the ones where the majority of the CTs had the worst accessibility. This showed that the accessibility to public services component of QOP may have a different geographical distribution which influences the daily life of citizens and their perceptions about the place.

The experiential community structure of QOP was analyzed through survey data which was applied to a sample of CTs in the inner city of Montréal. Similar to the QOP_{cs}, an index based on the literature survey, SQOPI was defined and calculated using the evaluation of people living in three neighbourhoods of Montréal: Côte-des-Neiges, Plateau-Mont-Royal and Hochelaga-Maisonneuve. Based on the comparison of the index scores for the two major parts of the questionnaire (neighbourhood evaluations and accessibility to goods and services), it was observed that the satisfaction levels of the individuals for the accessibility to goods and services are higher than the ones for characteristics of their neighbourhood, such as the resident comfort, size or maintenance.

The results of the analysis conducted on the subjective dimension showed that the three neighbourhoods have different performances for the index values in terms of the neighbourhood and accessibility evaluations. Another interesting finding of the analysis is the relationship between the overall QOL perceptions and the SQOPI values. The general pattern is, while most people are satisfied with their QOL, the SQOPI is relatively lower which also supports that the definitions of the two concepts (QOL and QOP) are different. While one is high the other may have lower scores or vice versa.

Since accessibility to public services was analyzed in both objective and subjective dimensions, it should also be noted that some results of both analyses were consistent with each other. For instance, among the all public services that were analyzed in Montréal, "educational" services had the best performance and this result was verified by the results obtained from the both dimensions.

Integration of both objective and subjective dimensions was also provided. PCA_{st} was applied to understand the contribution of both dimensions to QOP. Next, with the help of PCA_{st} results, a MCE analysis was performed where the objective was to produce IQOPI based on WLC. This index was derived first, for the variables within the objective dimension and secondly for all the variables within the both objective and subjective dimensions. Results indicated that "physical structural information" and "social structural information" are correlated to each other. PCA_{st} that was conducted showed that all the variables in the social and physical structures are represented at least in one component. Each component kept different variables and they keep different information related to

QOP. For example, different land use characteristics are defined by different components such as the presence of green areas are kept in component 1 while density of residential areas are explained by components 3 and 4. A second PCA_{st} was performed to understand the contribution of the subjective dimension to the QOP concept. Therefore the index values derived from the questionnaires (ASI values) were also subjected to PCA together with the other variables used in the first step.

The results showed that more components are identified when the subjective dimension is included in the model. Therefore, the methodology introduced in this thesis is supported by the results obtained. Not only the components demonstrated different meanings of the QOP, but the eigenvalues obtained from this PCA_{st} were used to derive the IQOPI which was the final objective of the research. IQOPI was calculated both for the variables in the objective and the final integrated set of variables to make a comparison. It was observed that when the index was calculated only for the variables in the objective dimension, some CTs showed a different structure than when calculated using the whole data set. This shows that, generally a CT may be defined with objective criteria for QOP; however, the real situation may be different when the perceptions of people living in that area are considered. Therefore, these results showed that there is a complex relationship between the objective and subjective dimensions of QOP and they should be evaluated together for QOP assessments.

A number of recommendations are made for future work:

- This thesis started, for the first time in QOP studies, a discussion of the integration of qualitative and quantitative methodologies using different components such as social, experiential and physical structures through information technologies. The model introduced in this research can be applied in various places where the behaviour of different community structures can be monitored.

- Since the community information is, generally, subject to changes over time, it is also recommended that the analysis introduced in this research to be repeated in regular time periods. Such a monitoring model would help to understand both the existing QOP within the neighbourhoods and also the future performance of planning policies and whether a modification is needed or not.

- Despite the fact that the common understanding for "quality" has been attached to economic growth in the past decades, future urban policies should seek competitiveness through an integration of social, environmental and governance quality.

- The integration of both objective and subjective dimensions not only provides a good framework to analyze the QOP but also helps to integrate citizens into planning policies more. With this method, governments can achieve the goal of participatory planning practice in an efficient way where the citizens' feedbacks are involved.

The thesis has also some limitations like every research project does. Some of these shortcomings can be listed as the number of questionnaire respondents, limited time to conduct the survey and technical obstacles encountered during the analysis.

> *"New technologies not only offer fresh opportunities for research but also impose new limitations"*.[11]

Despite the fact that the survey revealed many aspects of the QOP, due to the limited time and other constraints, a relatively small sample was obtained. A larger sample size would definitely strengthen the comparison between the social and the

[11] Christians C. G. and Chen S. S. (2004), "Introduction: technical environments and the evolution of social research methods", in *Online Social Research: Methods, Issues, and Ethics,* Johns, M. D., Chen, S. S. and Hall, G. J., New York, p.15

experiential structural information and hence the link between the objective and subjective dimensions of QOP would be stronger.

Furthermore, the number of survey respondents for each neighbourhood was the same where 50 people were asked to evaluate their QOL and QOP where they live or work. However, during the analysis it was observed that this number could have been adjusted with respect to the population of each neighbourhood. For instance, approximately five percent of households were interviewed in Plateau-Mont-Royal where the total population is 101 364. In Côte-des-Neiges, based on the same number of respondents, this percentage declines to three percent since the total population of this neighbourhood is 163 110. Similarly, four percent of households were subjected to the survey in Hochelaga-Maisonneuve while the total population is 128 440. For this reason, if this analysis were repeated, a suggestion would be to adjust the number of respondents with respect to the total number of each neighborhood.

Another obstacle encountered during this research was the integration of remotely sensed and GIS based data. Although the study gained much from this integration and had many advantages, there were also some disadvantages. Being one of them, using different software for RS and GIS applications raised some limitations during the integration step. While PCI was preferred because of its powerful image processing and classification tools, ArcGIS was used in GIS applications. Thus, it was expected to loose some information while converting from one file type to another.

Additionally, analyses for the accessibility to public services were limited to five types of services due to the availability of data. However, it should be noted that the model can be enhanced with other types of public services such as bus network system or garbage collection. Similarly, the "distribution of green areas" is one of the information types that can be extracted from remotely sensed data. Different variables such as air pollution or housing density can also be extracted from satellite images; however, due to the data availability only "greenness" and "land use" information were used in the model.

But, it is strongly recommended to test the model with more variables in different geographical locations and compare the performance.

Final limitation of the research takes its roots from the difficulties in human geography studies in general. Since the model introduced in this thesis attempted to integrate objective and subjective indicators, there is a risk of obtaining similar results if the model is run in different locations or even in the same geographies but with different individuals. This can be explained with the difficulties in measuring the subjectivity in human geography which depends on moods, daily stress or the feelings observed on the day the questionnaire items are asked. It is the challenge in human behaviour that can not be predicted before and subjected to changes in time even the same people are asked to evaluate their QOL and QOP. Hence, it should be noted that even if the same questions are applied to same individuals in a different day, there is a risk of obtaining different results. However, this thesis still provides promising results that supports the integration of both objective and subjective indicators.

To sum up, this thesis contributes to the literature and research in QOP from two perspectives: by introducing a new conceptual definition for QOP where it is differentiated from QOL with different dimensions and, outlining an effective methodological approach to measure this new definition. Since the research results supported the new approach defined in this project, the future work for the applicability of this method in various places and cities with different community structures is strongly suggested.

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APPENDIX A – Questionnaire forms in French

Enquête sur la qualité d'un lieu dans les quartiers centraux de Montréal

Responsable : André Langlois
Département de géographie
Université d'Ottawa (613-562-5800-1045)

Quartier: ______________
Questionnaire no: _______
Enquêteur : ____________

Partie 1 :
Qui êtes-vous?

1. Votre sexe : ☐ Femme ☐ Homme	**2. Votre groupe d'âge :** ☐ 15-29 ans ☐ 30-49 ans ☐ 50-64 ans ☐ 65 et plus
3. Votre langue maternelle : ☐ Français ☐ Anglais ☐ Français et anglais ☐ Autre	**4. Votre état matrimonial :** ☐ Célibataire ☐ Marié(e)/union libre ☐ Séparé(e)/divorcé(e) ☐ Veuf(ve)
5. La composition de votre ménage : ☐ Vous seul ☐ Vous et votre conjoint ☐ Vous et enfant(s)	☐ Vous, votre conjoint et enfant(s) ☐ Vous et autre(s) membre(s) de votre parenté ☐ Vous et personne(s) non apparentée(s)

Partie 2 :
Quel est votre profil socio-économique?

6. Votre statut de travailleur: ☐ Salarié(e) ☐ Travailleur (se) indépendant(e) ☐ Retraité (e) ☐ Ne travaille pas **6b. Votre profession:** ___________	**7. Votre lieu de travail :** ☐ À la maison ☐ Dans votre quartier ☐ Au centre-ville ☐ Ailleurs à Montréal ☐ À l'extérieur de Mtl ☐ Ne s'applique pas
8. Votre scolarité (plus haut niveau): ☐ Primaire ☐ Secondaire ☐ Collégiale ☐ Universitaire	**9. Votre revenu :** ☐ Moins de 15,000$ ☐ 15,000 - 29,999$ ☐ 30,000 - 49,999$ ☐ 50,000 - 69,999$ ☐ 70,000$ et plus ☐ Aucun

APPENDIX A - Continue

<u>Partie 3</u> :
Votre lieu de résidence

10. Votre type de résidence: ☐ Maison individuelle ☐ Maison en rangée ou duplex ☐ Appartement (immeuble 3 étages ou moins) ☐ Appartement (immeuble 4 étages ou plus) ☐ Autre	**11. Votre statut d'occupant:** ☐ Locataire ☐ Propriétaire
12. La période de construction de votre résidence : ☐ Avant 1950 ☐ Entre 1950 et 1980 ☐ Après 1980	**13. Votre durée de résidence dans ce logement:** ☐ Moins de 5 ans ☐ Entre 5 et 10 ans ☐ Plus de 10 ans
14. Votre durée de résidence dans ce quartier: ☐ Moins de 5 ans ☐ Entre 5 et 10 ans ☐ Plus de 10 ans	**15. Votre lieu de résidence précédent:** ☐ Dans ce quartier ☐ Dans un autre quartier de la ville ☐ À l'extérieur de la ville mais dans la région métropolitaine ☐ À l'extérieur de la région métropolitaine
16. Votre mode de transport principal: ☐ À pied ☐ Bicyclette ☐ Transport public ☐ Voiture privée ☐ Taxi	

APPENDIX A – Continue

Partie 4 :
Vos besoins et leur satisfaction dans votre quartier

(Pour chacun des éléments mentionnés ci-après précisez votre niveau de satisfaction ainsi que l'importance que vous donnez à cet élément comme facteur influençant votre qualité de vie dans votre quartier)

A. Évaluation de votre cadre de vie :	Satisfaction (cocher une case)					Importance (cocher une case)				
	Nulle	Faible	Moyenne	Grande	Très grande	Nulle	Faible	Moyenne	Grande	Très grande
1. Votre logement :										
a. Sa taille										
b. Sa condition										
c. Son entretien										
d. Son confort										
2. Votre voisinage:										
a. La présence d'espaces verts										
b. Le calme										
c. La sécurité										
d. L'entretien des propriétés										
e. La qualité de l'air										
3. Les services publics:										
a. Pompiers										
b. Police										
c. Déchets (cueillette)										
d. L'entretien des rues et trottoirs										
e. Déneigement										
f. Urgence Santé (911)										
g. Qualité de l'eau										
h. Transport en commun										
4. Votre implication dans votre quartier :										
a. Vie communautaire										
b. Vie politique										
c. Vie économique										
d. Vie socio-culturelle										
5. Évaluation générale de votre quartier comme cadre de vie:										

B. Votre évaluation de l'accès aux biens, services et lieux d'activités :

	Importance (cocher une case): Nulle	Faible	Moyenne	Grande	Très grande	Satisfaction (cocher une case): Nulle	Faible	Moyenne	Grande	Très grande
1. Commerces et services privés :										
a. Dépanneurs										
b. Supermarché										
c. Pharmacie										
d. Quincaillerie										
e. Banques, caisses										
f. Restaurants, cafés, bars...										
g. Boutiques, magasins...										
2. Services publics:										
a. CLSC										
b. Hôpital										
c. École (primaire ou secondaire)										
d. Transport en commun										
e. Parcs										
3. Lieux d'activités :										
a. Socio-culturelles										
b. Sportives										
c. Récréatives										
4. Votre évaluation générale de l'accessibilité dans votre quartier:										

C. Votre évaluation de la qualité de vie globale dans votre quartier :

	Cocher une case: Très faible	Assez faible	Moyenne	Assez élevée	Très élevée
1. Aujourd'hui					
2. Il y a 10 ans (s'il y a lieu)					
3. Dans 10 ans (selon votre estimation)					

APPENDIX B – Questionnaire forms in English

Part 1 :
Who are you?

1. Your sex: Female Male	**2. Your age group :** 15-29 years 30-49 years 50-64 years 65 and over
3. Your mother tongue: French English French and English Other	**4. Your marital status :** Single Married/Common law Separated/Divorced Widow (er)
5. The size of your household : Just you You and your spouse You and children	You, your spouse and children You and other family members You and other who are not family members

Part 2 :
What is your socio-economic profile?

6. Your worker status: Employed Self employed Retired Not working **6. Your occupation:** _____________	**7. Your place of work:** At home In this neighbourhood In the downtown area Elsewhere in Montreal Outside the city of Montreal Not applicable
8. Your education level: Primary High School College University	**9. Your income :** No income Less than $15,000 $15,000 - 29,999 $30,000 - 49,999 $50,000 - 69,999 $70,000 and over

APPENDIX B - Continue

Part 3 :
Your place of residence and mobility

10. Your type of residence: ☐ Single family dwelling ☐ Duplex or row housing ☐ Apartment (in building of 3 floors or less) ☐ Apartment (in building of 4 floors or more) ☐ Other	**11. Your occupancy status:** ☐ Owner ☐ Renter
12. The construction period of your residence : ☐ Before 1950 ☐ Between 1950 et 1980 ☐ After 1980	**13. Your length of residency at your place of residence:** ☐ Less than 5 years ☐ Between 5 and 10 years ☐ More than 10 years
14. Your length of residency in your neighbourhood: ☐ Less than 5 years ☐ Between 5 and 10 years ☐ More than 10 years	**15. Your preceding place of residence:** ☐ In this neighborhood ☐ In another neighborhood of the city of Montreal ☐ Outside the city of Montreal but inside the metropolitan area ☐ Outside the metropolitan area
16. Your main mode of transportation: ☐ By foot ☐ Bicycle ☐ Public transport ☐ Private car ☐ Taxi	

APPENDIX B - Continue

Part 4 :
Your needs and their satisfaction in your neighbourhood

(First, are you satisfied with these elements of your current life? Second, evaluate the importance of these elements in your life. Please answer both these questions for the elements in the following list.)

A: Evaluation of your neighbourhood as a place to live:	**Satisfaction** (check a box)					**Importance** (check a box)				
	None	Little	Moderate	High	Very	None	Little	Moderate	High	Very high
1. Your residence :										
a. Its size										
b. Its condition										
c. Its maintenance										
d. Its comfort										
2. The environment:										
a. The presence of green spaces										
b. Quietness and peacefulness										
c. Safety										
d. Upkeep of neighbours property										
e. Air quality										
3. Public services:										
a. Fire-fighters										
b. Police										
c. Collection of garbage and recycling										
d. Road and sidewalk upkeep										
e. Snow removal										
f. Emergency health services (911)										
g. Quality of water										
h. Public transportation										
4. Your involvement in your neighborhood :										
a. Community life										
b. Political life										
c. Economic life										
d. Sociocultural life										
5. Your overall evaluation of your neighbourhood as a place to live:										

APPENDIX B- Continue

B. Access to goods and services in your neighborhood:	Importance (check a box)					Satisfaction (check a box)				
	None	Little	Moderate	High	Very high	None	Little	Moderate	High	Very high
1. Goods and private services:										
a. Corner store										
b. Supermarket										
c. Drugstore										
d. Hardware										
e. Bank										
f. Restaurants, cafés, bars…										
g. Boutiques, stores…										
2. Services:										
a. CLSC										
b. Hospital										
c. Schools										
d. Public transportation										
e. Parks										
3. Activities :										
a. Sociocultural										
b. Sports										
c. Leisure										
4. Your overall evaluation of accessibility in your neighbourhood										

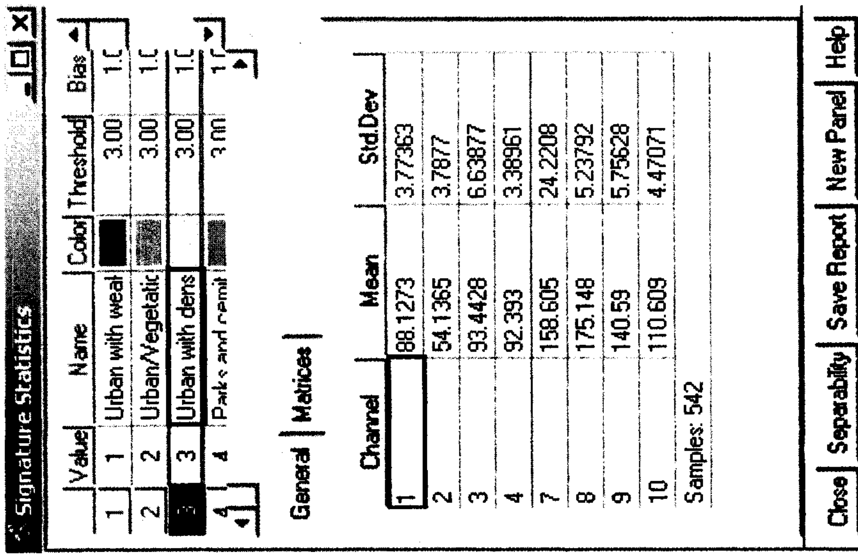
APPENDIX C– Syntax file for PCA of the census data in SPSS

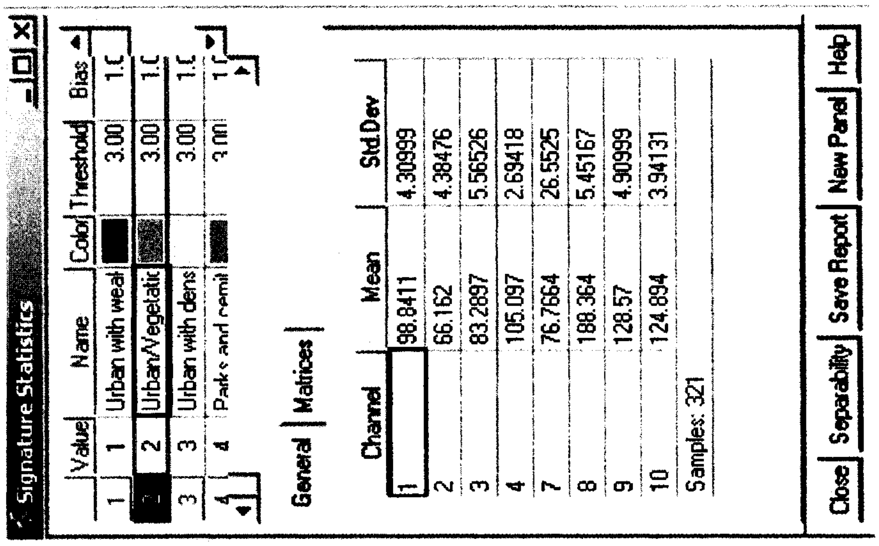
```
*PCA on census data by census tracts: Montreal, population and housing characteristics, 2001.
************************************************************************************************.
        GET FILE='total.sav' .

*Spatial scale.
****************.

        *Census tract selection for the new city of Montreal.
        select if (ctid < '0620.00').

*Percentages.
****************.

        compute pctyoun=(totyou/totpop)*100.
        format pctyoun (f5.1).
        variables label pctyoun '% total young population'.

        compute pctold=(totold/totpop)*100.
        format pctold (f5.1).
        variables label pctold '% total old population'.

        compute pctwspo=(wtospo/totmar)*100.
        format pctwspo (f5.1).
        variables label pctwspo '% people who are not living with a spouse'.

        compute pctmajr=(majrpr/totdwe)*100.
        format pctmajr (f5.1).
        variables label pctmajr '% number of dwellings that need major repairs'.

        compute pctoldb=(olddwe/totdwe)*100.
        format pctoldb (f5.1).
        variables label pctoldb '% old buildings'.

        compute pctnewb=(newdwe/totdwe)*100.
        format pctnewb (f5.1).
        variables label pctnewb '% new buildings'.

        compute pctengfr=(engfr/totofl)*100.
        format pctengfr (f5.1).
        variables label pctengfr '% people who can speak both english and french'.

        compute pctnenfr=(nengfr/totofl)*100.
        format pctnenfr (f5.1).
        variables label pctnenfr '% people who can speak neither english nor french'.

        compute pctuni=(univer/tothedu)*100.
        format pctuni (f5.1).
        variables label pctuni '% with bachelor degree or higher'.

        compute pctlegr9=(lessgr9/tothedu)*100.
        format pctlegr9 (f5.1).
        variables label pctlegr9 '% with education less than grade 9'.
```

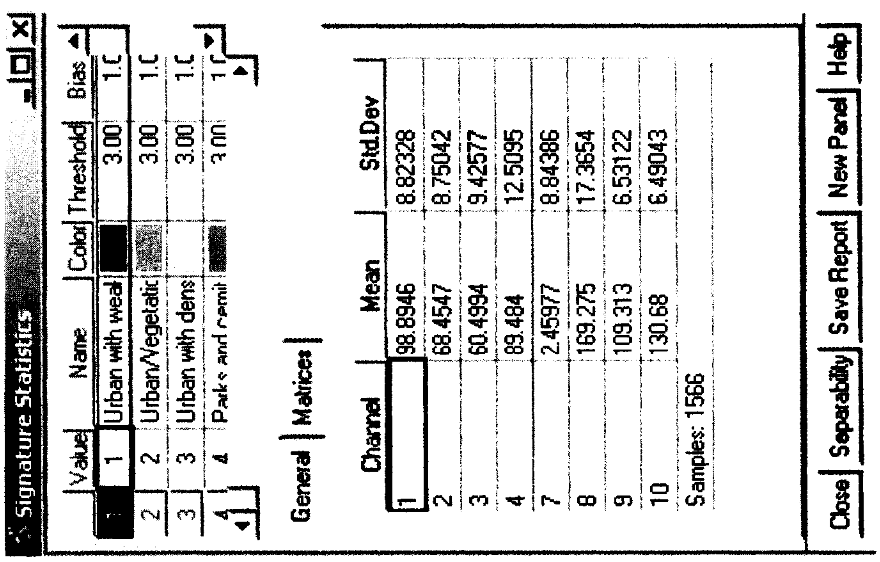
```
compute pctmcsd=(pwcsdm/totpwst)*100.
format pctmcsd (f5.1).
variables label pctmcsd '% males, place of work status in CSD of residence'.

compute pctmhom=(pwhomm/totpwst)*100.
format pctmhom (f5.1).
variables label pctmhom '% males, place of work status at home'.

compute pctfcsd=(pwcsdf/totpwst)*100.
format pctfcsd (f5.1).
variables label pctfcsd '% females, place of work status in CSD of residence'.

compute pctfhom=(pwhomf/totpwst)*100.
format pctfhom (f5.1).
variables label pctfhom '% females, place of work status at home'.

compute pctwabic=(walkbic/modtran)*100.
format pctwabic (f5.1).
variables label pctwabic '% people walked or use bicycle'.


*Saving the temporary fileand working with it.
****************************************************.
        save outfile=total2001
                /keep=ctid pctyoun pctold pctwspo avgroom pctmajr pctoldb pctnewb
                        pctengfr pctnenfr pctuni pctlegr9 totavin lowinc houavin valavdw
                        totunem unempm unempfe pctmcsd pctmhom pctfcsd pctfhom pctwabic.
        get file='total2001'.

*Statistical Analysis.
************************.
        DESCRIPTIVES variables= pctyoun pctold pctwspo avgroom pctmajr pctoldb pctnewb
                        pctengfr pctnenfr pctuni pctlegr9 totavin lowinc houavin valavdw
                        totunem unempm unempfe pctmcsd pctmhom pctfcsd pctfhom pctwabic
                /statistics=min max mean stddev.

        CORRELATIONS variables=pctyoun pctold pctwspo avgroom pctmajr pctoldb pctnewb
                        pctengfr pctnenfr pctuni pctlegr9 totavin lowinc houavin valavdw
                        totunem unempm unempfe pctmcsd pctmhom pctfcsd pctfhom pctwabic.


*Principal Component Analysis.
************************************.
        FACTOR
                /VARIABLES  pctyoun pctold pctwspo avgroom pctmajr pctoldb pctnewb
                        pctengfr pctnenfr pctuni pctlegr9 totavin lowinc houavin valavdw
                        totunem unempm unempfe pctmcsd pctmhom pctfcsd pctfhom pctwabic
                /MISSING LISTWISE
                /ANALYSIS pctyoun pctold pctwspo avgroom pctmajr pctoldb pctnewb
                        pctengfr pctnenfr pctuni pctlegr9 totavin lowinc houavin valavdw
                        totunem unempm unempfe pctmcsd pctmhom pctfcsd pctfhom pctwabic
                /PRINT INITIAL EXTRACTION ROTATION
                /PLOT EIGEN
                /CRITERIA MINEIGEN(1) ITERATE(25)
```

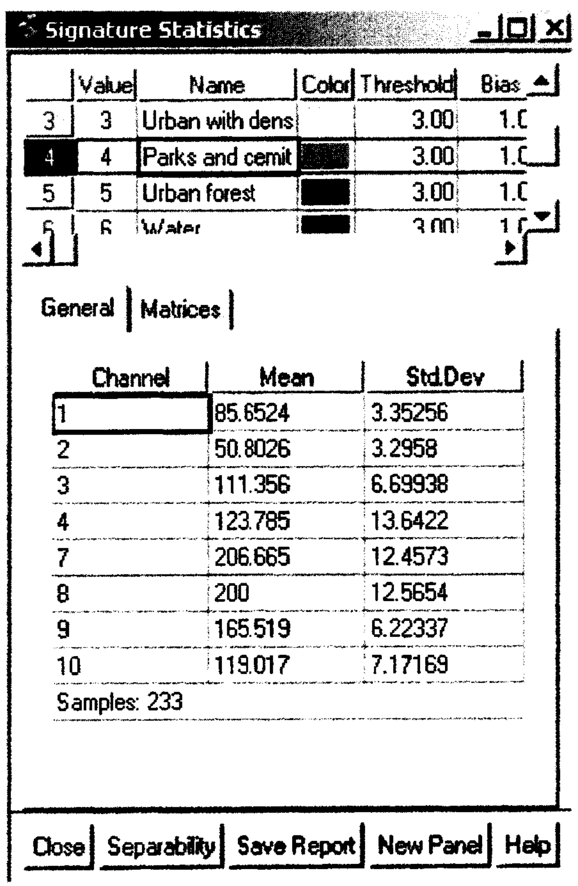
```
                /EXTRACTION PC
                /CRITERIA ITERATE(25)
                /ROTATION VARIMAX
                /SAVE REG(ALL)
                /METHOD=CORRELATION .

*Cluster analysis.
********************.
        *CLUSTER  fac1_1 fac2_1 fac3_1 fac4_1 fac5_1
                /METHOD CENTROID
                /MEASURE= SEUCLID
                /ID=ctid
                /PRINT SCHEDULE CLUSTER(5,10)
                /PLOT HICICLE(3,20,1)
                /SAVE CLUSTER(12).
        *FREQUENCIES
                VARIABLES=clu12_1
                /ORDER=  ANALYSIS .
        *MEANS
                TABLES=fac1_1 fac2_1 fac3_1  fac4_1 BY clu12_1
                /CELLS MEAN COUNT STDDEV  .

*Saving the file for ArcView.
*******************************.
        *save translate
                /outfile=mtltotal2001.dbf
                /type=db3
                /keep=ctid        fac1_1 fac2_1 fac3_1 fac4_1
                /replace.
Execute.
```

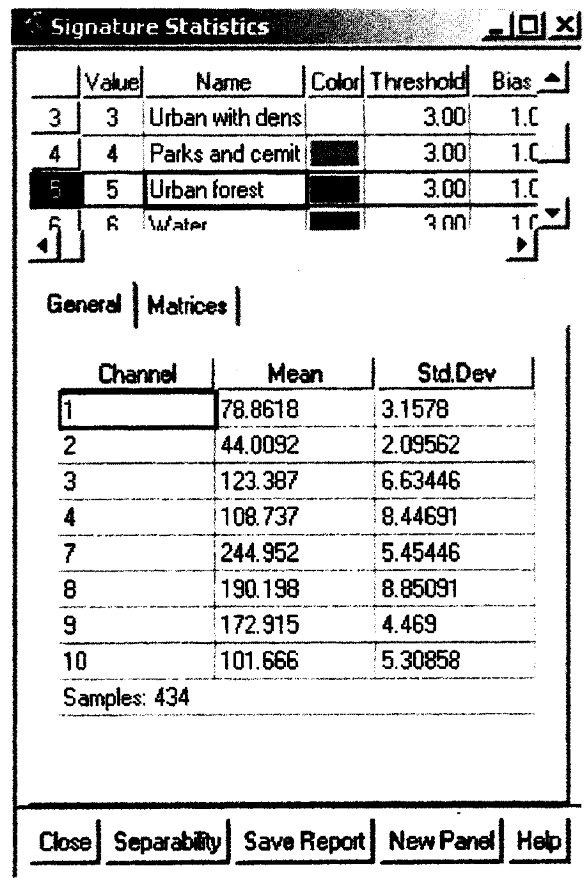
APPENDIX D – Signature Statistics Results

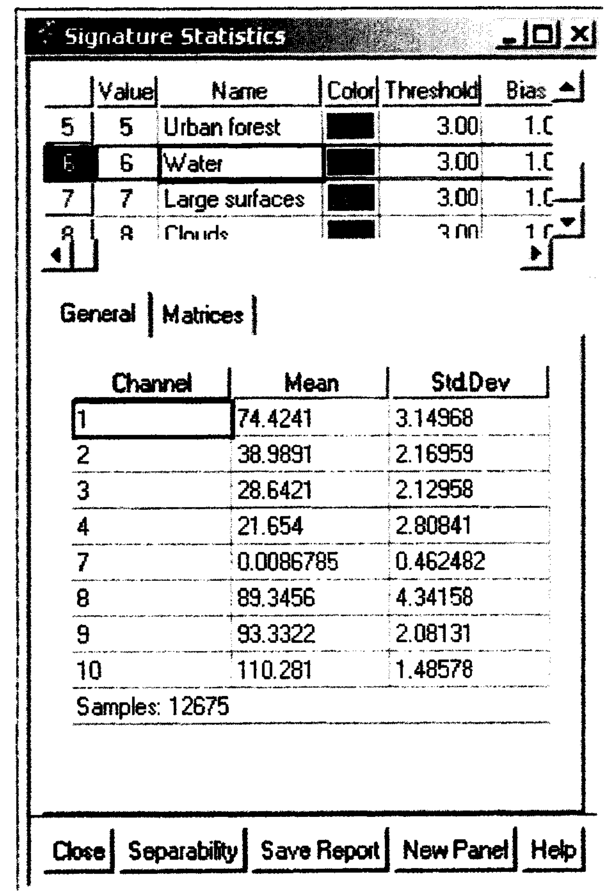


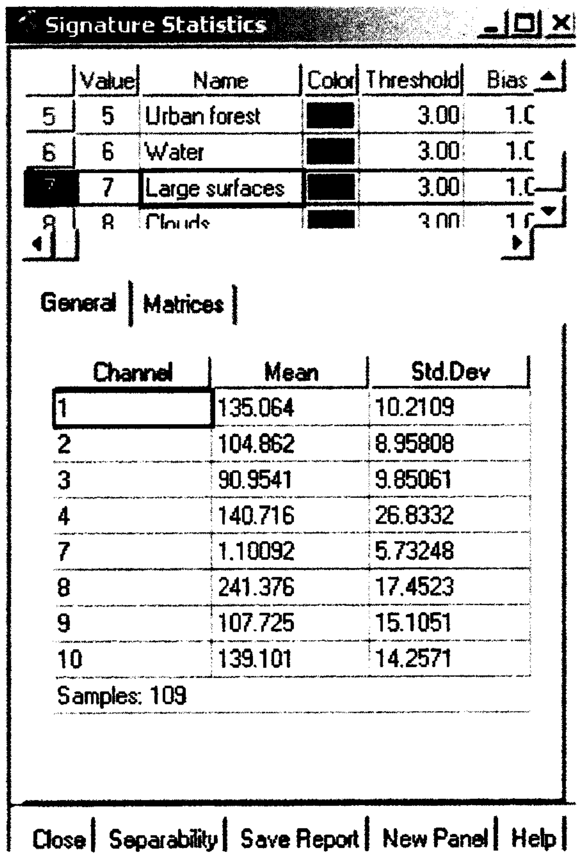


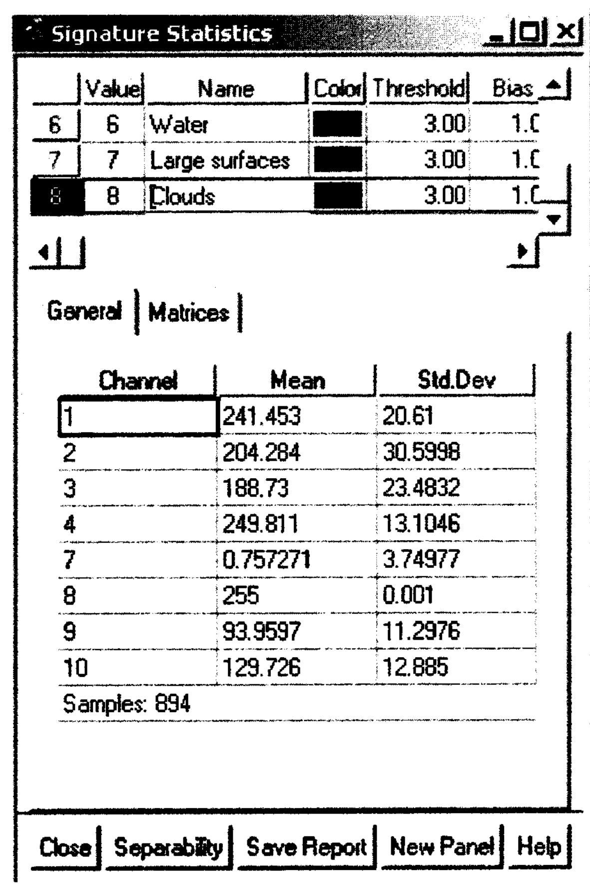



Signature Statistics
Value | Name | Color | Threshold | Bias
3 | 3 | Urban with dens | 3.00 | 1.C
4 | 4 | Parks and cemit | 3.00 | 1.C
5 | 5 | Urban forest | 3.00 | 1.C
General | Matrices
Channel | Mean | Std.Dev
1 | 85.6524 | 3.35256
2 | 50.8026 | 3.2958
3 | 111.356 | 6.69938
4 | 123.785 | 13.6422
7 | 206.665 | 12.4573
8 | 200 | 12.5654
9 | 165.519 | 6.22337
10 | 119.017 | 7.17169
Samples: 233
Close | Separability | Save Report | New Panel | Help

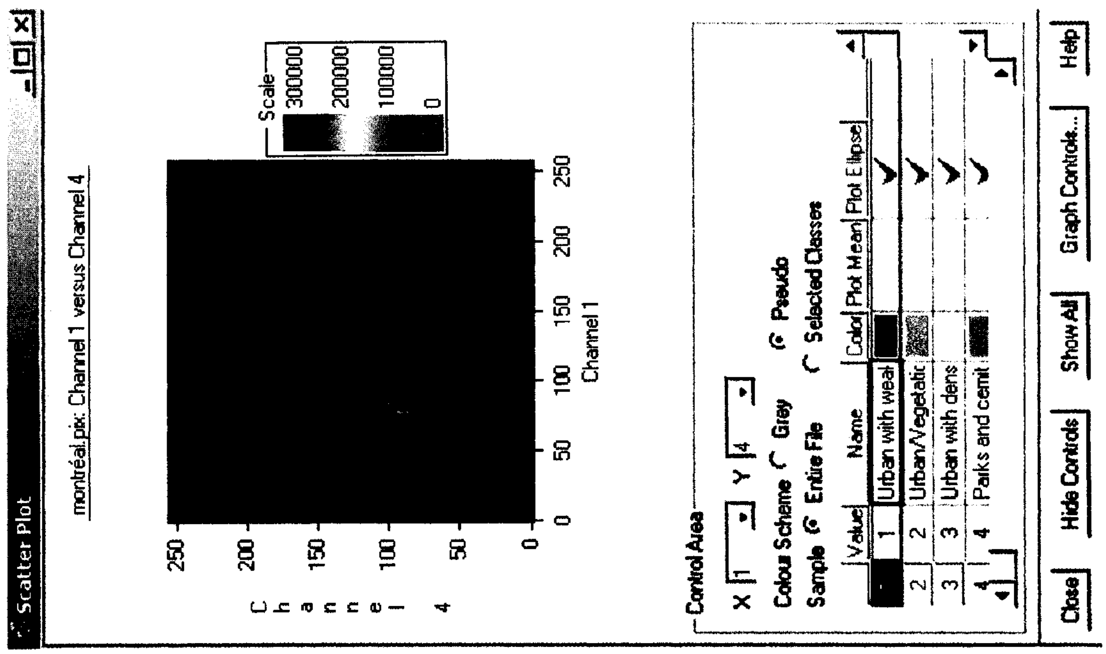

Signature Statistics
Value | Name | Color | Threshold | Bias
3 | 3 | Urban with dens | 3.00 | 1.C
4 | 4 | Parks and cemit | 3.00 | 1.C
5 | 5 | Urban forest | 3.00 | 1.C
General | Matrices
Channel | Mean | Std.Dev
1 | 78.8618 | 3.1578
2 | 44.0092 | 2.09562
3 | 123.387 | 6.63446
4 | 108.737 | 8.44691
7 | 244.952 | 5.45446
8 | 190.198 | 8.85091
9 | 172.915 | 4.469
10 | 101.666 | 5.30858
Samples: 434
Close | Separability | Save Report | New Panel | Help

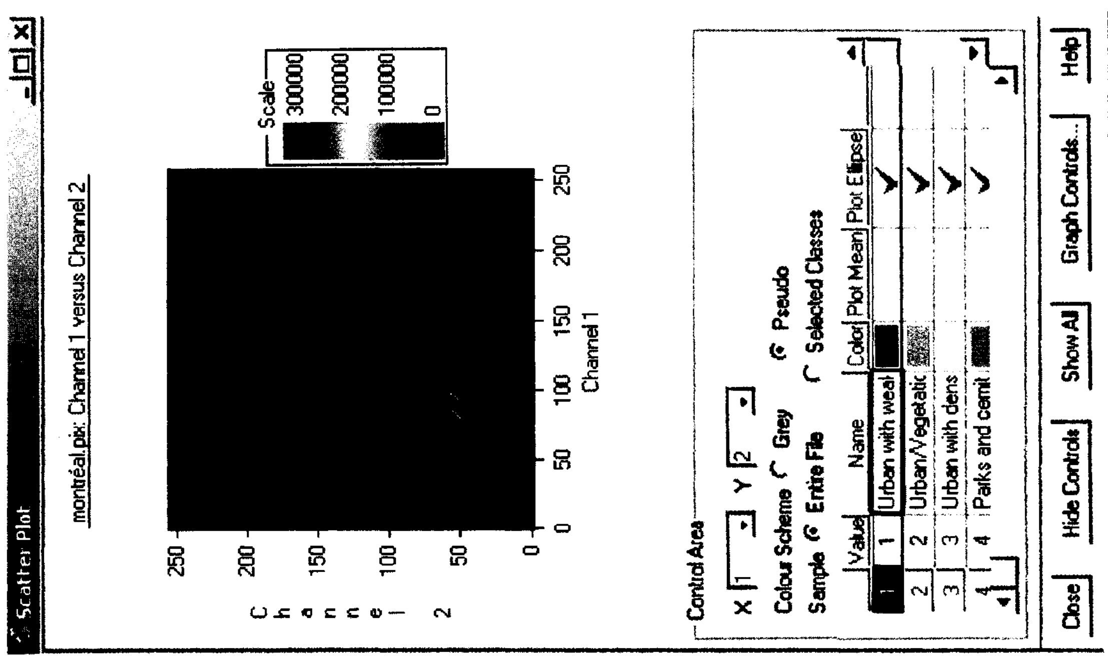

Signature Statistics
Value | Name | Color | Threshold | Bias
5 | 5 | Urban forest | 3.00 | 1.C
6 | 6 | Water | 3.00 | 1.C
7 | 7 | Large surfaces | 3.00 | 1.C
General | Matrices
Channel | Mean | Std.Dev
1 | 74.4241 | 3.14968
2 | 38.9891 | 2.16959
3 | 28.6421 | 2.12958
4 | 21.654 | 2.80841
7 | 0.0086785 | 0.462482
8 | 89.3456 | 4.34158
9 | 93.3322 | 2.08131
10 | 110.281 | 1.48578
Samples: 12675
Close | Separability | Save Report | New Panel | Help


Signature Statistics
Value | Name | Color | Threshold | Bias
5 | 5 | Urban forest | 3.00 | 1.C
6 | 6 | Water | 3.00 | 1.C
7 | 7 | Large surfaces | 3.00 | 1.C
General | Matrices
Channel | Mean | Std.Dev
1 | 135.064 | 10.2109
2 | 104.862 | 8.95808
3 | 90.9541 | 9.85061
4 | 140.716 | 26.8332
7 | 1.10092 | 5.73248
8 | 241.376 | 17.4523
9 | 107.725 | 15.1051
10 | 139.101 | 14.2571
Samples: 109
Close | Separability | Save Report | New Panel | Help


Signature Statistics
Value | Name | Color | Threshold | Bias
6 | 6 | Water | 3.00 | 1.C
7 | 7 | Large surfaces | 3.00 | 1.C
8 | 8 | Clouds | 3.00 | 1.C
General | Matrices
Channel | Mean | Std.Dev
1 | 241.453 | 20.61
2 | 204.284 | 30.5998
3 | 188.73 | 23.4832
4 | 249.811 | 13.1046
7 | 0.757271 | 3.74977
8 | 255 | 0.001
9 | 93.9597 | 11.2976
10 | 129.726 | 12.885
Samples: 894
Close | Separability | Save Report | New Panel | Help

APPENDIX E – Scatter Plot Results





APPENDIX F – The Post-Classification Algorithm

EASI Modelling

Input File: D:\Aysegul\RS\STUDIES\New\montréal.pix

```
if (%15=7 AND (%13=1 OR %13=2 OR %13=3)) then
%16=7
endif
if (%15=7 AND %13=0) then
%16=7
endif
if (%15=6 AND (%13=1 OR %13=2 OR %13=3)) then
%16=6
endif
if (%15=6 AND %13=0) then
%16=6
endif
if (%15=5 AND %13=4) then
%16=4
endif
if (%15=5 AND %13=5) then
%16=5
endif
if (%15=4 AND %13=1) then
%16=1
endif
if (%15=4 AND %13=2) then
%16=2
endif
if (%15=4 AND %13=3) then
%16=3
endif
if (%15=3 AND (%13=1 OR %13=2 OR %13=3)) then
%16=8
endif
if (%15=3 AND %13=0) then
%16=8
endif
if (%15=2 AND %13=7) then
%16=9
endif
if (%15=2 AND %13=4) then
%16=4
endif
if (%15=2 AND %13=5) then
%16=5
endif
if (%15=1 OR %13=6) then
%16=10
endif
if (%13=8) then
%16=11
endif
if (15=0 AND %13=0) then
%16=0
endif
if (%15=0 AND %13=4) then
%16=4
endif
if (%15=0 AND %13=5) then
%16=5
endif
if (%15=0 AND %13=6) then
%16=10
endif
if (%15=0 AND %13=7) then
%16=9
endif
```

APPENDIX G – Syntax File for Statistical Description of the Survey Data in SPSS

```
*DESCRIPTION OF THE SAMPLE.
*SURVEY DATA MONTREAL SUMMER 2002.
*****************************************************.
        GET FILE='enq_mtl.sav' .

*Profile of the respondents based on the first part of the questionnaire.
*****************************************************************************.

*For quantitative variables.
***************************
GRAPH
 /BAR(SIMPLE)=COUNT BY age
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=age
 /STATISTICS=MEAN MEDIAN MODE
 /ORDER=  ANALYSIS .

GRAPH
 /BAR(SIMPLE)=COUNT BY income
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=income
 /STATISTICS=MEAN MEDIAN MODE
 /ORDER=  ANALYSIS .


GRAPH
 /BAR(SIMPLE)=COUNT BY lghtrpl
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=lghtrpl
 /STATISTICS=MEAN MEDIAN MODE
 /ORDER=  ANALYSIS .

GRAPH
 /BAR(SIMPLE)=COUNT BY lghtrn
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=lghtrn
 /STATISTICS=MEAN MEDIAN MODE
 /ORDER=  ANALYSIS .
```

```
*For qualitative variables.
**************************
FREQUENCIES
 VARIABLES=sex
 /ORDER=  ANALYSIS .
GRAPH
 /PIE=COUNT BY sex
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=mtongue
 /ORDER=  ANALYSIS .
GRAPH
 /PIE=COUNT BY mtongue
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=mstatus
 /ORDER=  ANALYSIS .
GRAPH
 /PIE=COUNT BY mstatus
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=hsize
 /ORDER=  ANALYSIS .
GRAPH
 /PIE=COUNT BY hsize
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=wstatus
 /ORDER=  ANALYSIS .
GRAPH
 /PIE=COUNT BY wstatus
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=plofwrk
 /ORDER=  ANALYSIS .
GRAPH
 /PIE=COUNT BY plofwrk
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=educ
 /ORDER=  ANALYSIS .
GRAPH
 /PIE=COUNT BY educ
 /MISSING=REPORT.
```

```
FREQUENCIES
 VARIABLES=typres
 /ORDER=  ANALYSIS .
GRAPH
 /PIE=COUNT BY typres
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=occstatu
 /ORDER=  ANALYSIS .
GRAPH
 /PIE=COUNT BY occstatu
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=cperiod
 /ORDER=  ANALYSIS .
GRAPH
 /PIE=COUNT BY cperiod
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=pplres
 /ORDER=  ANALYSIS .
GRAPH
 /PIE=COUNT BY pplres
 /MISSING=REPORT.

FREQUENCIES
 VARIABLES=mtrsp
 /ORDER=  ANALYSIS .
GRAPH
 /PIE=COUNT BY mtrsp
 /MISSING=REPORT.

*Comparing the three neighborhoods.
**********************************.

CROSSTABS
 /TABLES=burrough  BY sex
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY sex BY burrough
 /MISSING=REPORT.

CROSSTABS
 /TABLES=burrough  BY age
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY age BY burrough
 /MISSING=REPORT.
```

```
CROSSTABS
 /TABLES=burrough  BY mtongue
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY mtongue BY burrough
 /MISSING=REPORT.

CROSSTABS
 /TABLES=burrough  BY mstatus
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY mstatus BY burrough
 /MISSING=REPORT.

CROSSTABS
 /TABLES=burrough  BY hsize
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY hsize BY burrough
 /MISSING=REPORT.

CROSSTABS
 /TABLES=burrough  BY wstatus
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY wstatus BY burrough
 /MISSING=REPORT.

CROSSTABS
 /TABLES=burrough  BY plofwrk
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY plofwrk BY burrough
 /MISSING=REPORT.

CROSSTABS
 /TABLES=burrough  BY educ
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY educ BY burrough
 /MISSING=REPORT.


CROSSTABS
 /TABLES=burrough  BY typres
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY typres BY burrough
 /MISSING=REPORT.
```

```
CROSSTABS
 /TABLES=burrough  BY occstatu
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY occstatu BY burrough
 /MISSING=REPORT.

CROSSTABS
 /TABLES=burrough  BY cperiod
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY cperiod BY burrough
 /MISSING=REPORT.

CROSSTABS
 /TABLES=burrough  BY lghtrpl
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY lghtrpl BY burrough
 /MISSING=REPORT.

CROSSTABS
 /TABLES=burrough  BY lghtrn
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY lghtrn BY burrough
 /MISSING=REPORT.

CROSSTABS
 /TABLES=burrough  BY pplres
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY pplres BY burrough
 /MISSING=REPORT.

CROSSTABS
 /TABLES=burrough  BY mtrsp
 /FORMAT= AVALUE TABLES
 /CELLS= COUNT .
GRAPH
 /BAR(GROUPED)=COUNT BY mtrsp BY burrough

 /MISSING=REPORT.
execute.
```

APPENDIX H – Syntax File for Subjective Quality of Place Index Calculation in SPSS

```
* SUBJECTIVE QUALITY OF PLACE INDEX CALCULATION
**********************************************************************************
GET FILE='SI.sav'
execute.
*SI calculations for every variable
***********************************************************************.
compute SIsize=((isize +1)/3)*(ssize+1-3).
        format SIsize (f5.1).
        variables label SIsize 'subjective index for the residence size'.

compute SIcond=((icond+1)/3)*(scond+1-3).
        format SIcond (f5.1).
        variables label SIcond 'subjective index for the residence condition'.

compute SImaint=((imaint+1)/3)*(smaint+1-3).
        format SImaint (f5.1).
        variables label SImaint 'subjective index for the residence maintanance'.

compute SIcomf=((icomf+1)/3)*(scomf+1-3).
        format SIcomf (f5.1).
        variables label SIcomf 'subjective index for the residence comfort'.

compute SIres=(SIsize+SIcond+SImaint+SIcomf)/4.
        format SIres (f5.1).
        variables label SIres 'subjective index for the residence'.

compute SIgreen=((igreen +1)/3)*(sgreen+1-3).
        format SIgreen (f5.1).
        variables label SIgreen 'subjective index for the green spaces'.

compute SIquiet=((iquiet +1)/3)*(squiet+1-3).
        format SIquiet (f5.1).
        variables label SIquiet 'subjective index for the presence of green spaces'.

compute SIsafety=((isafety +1)/3)*(ssafety+1-3).
        format SIsafety (f5.1).
        variables label SIsafety 'subjective index for safety'.

compute SIupkeep=((iupkeep +1)/3)*(supkeep+1-3).
        format SIupkeep (f5.1).
        variables label SIupkeep 'subjective index for upkeep'.

compute SIairq=((iairq +1)/3)*(sairq+1-3).
        format SIairq (f5.1).
        variables label SIairq 'subjective index for air quality'.

compute SIenv=(SIgreen+SIquiet+SIsafety+SIupkeep+SIairq)/5.
        format SIenv (f5.1).
        variables label SIenv 'subjective index for the environment'.
```

```
compute SIfire=((ifire +1)/3)*(sfire+1-3).
        format SIfire (f5.1).
        variables label SIfire 'subjective index for fire fighters'.

compute SIpolice=((ipolice +1)/3)*(spolice+1-3).
        format SIpolice (f5.1).
        variables label SIpolice 'subjective index for police'.

compute SIgarb=((igarb +1)/3)*(sgarb+1-3).
        format SIgarb (f5.1).
        variables label SIgarb 'subjective index for collection of garbage and recycling'.

compute SIroad=((iroad +1)/3)*(sroad+1-3).
        format SIroad (f5.1).
        variables label SIroad 'subjective index for road and sidewalk upkeep'.

compute SIsnow=((isnow +1)/3)*(ssnow+1-3).
        format SIsnow (f5.1).
        variables label SIsnow 'subjective index for snow removal'.

compute SIhealth=((ihealth +1)/3)*(shealth+1-3).
        format SIhealth (f5.1).
        variables label SIhealth 'subjective index for emergency health services'.

compute SIqwater=((iqwater +1)/3)*(sqwater+1-3).
        format SIqwater (f5.1).
        variables label SIqwater 'subjective index for quality of water'.

compute SIputrsp=((ipubtrsp +1)/3)*(spubtrsp+1-3).
        format SIputrsp (f5.1).
        variables label SIputrsp 'subjective index for public transportation'.

compute SIpub=(SIfire+SIpolice+SIgarb+SIroad+SIsnow+SIhealth+SIqwater+SIputrsp)/8.
        format SIpub (f5.1).
        variables label SIpub 'subjective index for the public services'.


compute SIcomm=((icomm +1)/3)*(scomm+1-3).
        format SIcomm (f5.1).
        variables label SIcomm 'subjective index for community life'.

compute SIpol=((ipol +1)/3)*(spol+1-3).
        format SIpol (f5.1).
        variables label SIpol 'subjective index for political life'.

compute SIecon=((iecon +1)/3)*(secon+1-3).
        format SIecon (f5.1).
        variables label SIecon 'subjective index for economic life'.

compute SIsocio=((isocio +1)/3)*(ssocio+1-3).
        format SIsocio (f5.1).
        variables label SIsocio 'subjective index for sociocultural life'.

compute SIinv=(SIcomm+SIpol+SIecon+SIsocio)/4.
        format SIinv (f5.1).
        variables label SIinv 'subjective index for the involvement in the neighborhood'.
```

```
compute SIov=((neighev2 +1)/3)*(neighev1+1-3).
        format SIov (f5.1).
        variables label SIov 'subjective index for neighbourhood evaluation'.

compute SIcstore=((icstore +1)/3)*(scstore+1-3).
        format SIcstore (f5.1).
        variables label SIcstore 'subjective index for corner store'.

compute SIsmark=((ismark +1)/3)*(ssmark+1-3).
        format SIsmark (f5.1).
        variables label SIsmark 'subjective index for supermarket'.

compute SIdrugst=((idrugstr +1)/3)*(sdrugstr+1-3).
        format SIdrugst (f5.1).
        variables label SIdrugst 'subjective index for drugstore'.

compute SIhrdwr=((ihrdwr +1)/3)*(shrdwr+1-3).
        format SIhrdwr (f5.1).
        variables label SIhrdwr 'subjective index for hardware'.

compute SIbank=((ibank +1)/3)*(sbank+1-3).
        format SIbank (f5.1).
        variables label SIbank 'subjective index for bank'.

compute SIrest=((irest +1)/3)*(srest+1-3).
        format SIrest (f5.1).
        variables label SIrest 'subjective index for restaurants'.

compute SIbtq=((ibtq +1)/3)*(sbtq+1-3).
        format SIbtq (f5.1).
        variables label SIbtq 'subjective index for boutiques'.

compute SIgpr=(SIcstore+SIsmark+SIdrugst+SIhrdwr+SIbank+SIrest+SIbtq)/7.
        format SIgpr (f5.1).
        variables label SIgpr 'subjective index for the goods and private services'.


compute SIclsc=((iclsc +1)/3)*(sclsc+1-3).
        format SIclsc (f5.1).
        variables label SIclsc 'subjective index for CLSC'.

compute SIhptl=((ihptl +1)/3)*(shptl+1-3).
        format SIhptl (f5.1).
        variables label SIhptl 'subjective index for hospital'.

compute SIschool=((ischool +1)/3)*(sschool+1-3).
        format SIschool (f5.1).
        variables label SIschool 'subjective index for schools'.

compute SIptrsp=((iptrsp +1)/3)*(sptrsp+1-3).
        format SIptrsp (f5.1).
        variables label SIptrsp 'subjective index for public transportation'.

compute SIpark=((ipark +1)/3)*(spark+1-3).
```

```
        format SIpark (f5.1).
        variables label SIpark 'subjective index for parks'.

compute SIse=(SIclsc+SIhptl+SIschool+SIptrsp+SIpark)/5.
        format SIse (f5.1).
        variables label SIse 'subjective index for the services'.


compute SIsocioc=((isocioc +1)/3)*(ssocioc+1-3).
        format SIsocioc (f5.1).
        variables label SIsocioc 'subjective index for sociocultural activities'.

compute SIsports=((isports +1)/3)*(ssports+1-3).
        format SIsports (f5.1).
        variables label SIsports 'subjective index for sports activities'.

compute SIleisr=((ileisr +1)/3)*(sleisr+1-3).
        format SIleisr (f5.1).
        variables label SIleisr 'subjective index for leisure activities'.

compute SIac=(SIsocioc+SIsports+SIleisr)/3.
        format SIac (f5.1).
        variables label SIac 'subjective index for the activities'.


compute SIovac=((acceval1 +1)/3)*(acceval2+1-3).
        format SIovac (f5.1).
        variables label SIovac 'subjective index for overall evaluation of accessibility'.

execute.
```

APPENDIX I– Syntax file for PCA of the data in the objective dimension in SPSS

```
*PCA on the integration of all variables.
******************************************************************************************************.
        GET FILE='Final_integration_20060221.sav'.


*Principal Component Analysis.
***************************************.
        FACTOR
                /VARIABLES  md_edu md_emer md_heal md_met md_recr oqpi per_hden
                                per_mden per_lden per_prk per_urbf per_gov per_comm
per_reso per_open
                                per_wat
                /MISSING LISTWISE
                /ANALYSIS md_edu md_emer md_heal md_met md_recr oqpi per_hden
                                per_mden per_lden per_prk per_urbf per_gov per_comm
per_reso per_open
                                per_wat
                /PRINT INITIAL EXTRACTION ROTATION
                /PLOT EIGEN
                /CRITERIA MINEIGEN(1) ITERATE(25)
                /EXTRACTION PC
                /CRITERIA ITERATE(25)
                /ROTATION VARIMAX
                /SAVE REG(ALL)
                /METHOD=CORRELATION .

*Cluster analysis.
**********************.
        *CLUSTER  fac1_1 fac2_1 fac3_1 fac4_1 fac5_1
                /METHOD CENTROID
                /MEASURE= SEUCLID
                /ID=ctid
                /PRINT SCHEDULE CLUSTER(5,10)
                /PLOT HICICLE(3,20,1)
                /SAVE CLUSTER(12).
        *FREQUENCIES
                VARIABLES=clu12_1
                /ORDER=  ANALYSIS .
        *MEANS
                TABLES=fac1_1 fac2_1 fac3_1  fac4_1 BY clu12_1
                /CELLS MEAN COUNT STDDEV  .

*Saving the file for ArcView.
********************************.
        *save translate
                /outfile=PCA_landuse_acces_oqpi.dbf
                /type=db3
                /keep=ctid        fac1_1 fac2_1 fac3_1 fac4_1
                /replace.
Execute.
```

APPENDIX J– Syntax file for PCA of the data in the objective and subjective dimensions in SPSS

```
*PCA on the integration of all variables.
*************************************************************************************************.
        GET FILE='Final_integration_20060221.sav'.

*Spatial scale.
****************.

        *Census tract selection for the CTs that have ASI values.
        select if (ctname = '0012.01' or ctname = '0013.00' or ctname = '0015.00'
                or ctname = '0021.00' or ctname = '0024.00' or ctname = '0025.00'
                or ctname = '0027.00' or ctname = '0028.00'
                or ctname = '0029.00' or ctname = '0030.00' or ctname = '0110.00'
                or ctname = '0111.00' or ctname = '0113.00' or ctname = '0115.01'
                or ctname = '0116.00' or ctname = '0120.00' or ctname = '0124.00'
                or ctname = '0125.00' or ctname = '0126.00' or ctname = '0127.01'
                or ctname = '0132.00' or ctname = '0143.00' or ctname = '0149.00'
                or ctname = '0150.00' or ctname = '0152.00' or ctname = '0155.00'
                or ctname = '0165.00' or ctname = '0172.00' or ctname = '0174.00'
                or ctname = '0176.00').


*Principal Component Analysis.
*************************************.
        FACTOR
                /VARIABLES  md_edu md_emer md_heal md_met md_recr asires asienv
                        asipub asiinv asiov asigpr asise asiac asiovac oqpi per_hden
                        per_mden per_lden per_prk per_urbf per_gov per_comm
                        per_reso per_open per_wat
                /MISSING LISTWISE
                /ANALYSIS  md_edu md_emer md_heal md_met md_recr asires asienv
                        asipub asiinv asiov asigpr asise asiac asiovac oqpi per_hden
                        per_mden per_lden per_prk per_urbf per_gov per_comm
                        per_reso per_open per_wat

                /PRINT INITIAL EXTRACTION ROTATION
                /PLOT EIGEN
                /CRITERIA MINEIGEN(1) ITERATE(25)
                /EXTRACTION PC
                /CRITERIA ITERATE(25)
                /ROTATION VARIMAX
                /SAVE REG(ALL)
                /METHOD=CORRELATION .

*Cluster analysis.
********************.
        *CLUSTER  fac1_1 fac2_1 fac3_1 fac4_1 fac5_1
                /METHOD CENTROID
                /MEASURE= SEUCLID
                /ID=ctid
                /PRINT SCHEDULE CLUSTER(5,10)
                /PLOT HICICLE(3,20,1)
                /SAVE CLUSTER(12).
```

```
*FREQUENCIES
        VARIABLES=clu12_1
        /ORDER=  ANALYSIS .
*MEANS
        TABLES=fac1_1 fac2_1 fac3_1  fac4_1 BY clu12_1
        /CELLS MEAN COUNT STDDEV  .

*Saving the file for ArcView.
********************************.
*save translate
        /outfile=PCA_landuse_acces_oqpi_asi.dbf
        /type=db3
        /keep=ctid      fac1_1 fac2_1 fac3_1 fac4_1
        /replace.
Execute.
```