

# **Modeling scale and effects of the modifiable areal unit problem on multiple deprivations in Istanbul, Turkey**

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March, 2011

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‘...are areal units entities or objects that can be studied or are they merely a variable that is proxy for geographical location?...?’

**Stan Openshaw, 1984**

To my late brother



## ABSTRACT

The analysis of multiple deprivations has posed a major challenge to researchers as well as decision makers. Features of this challenge have been the issues of scale with which to map deprivations and concerns regarding the modifiable areal unit problem's (MAUP) two main effects: the scale and zoning problem. The scale effect is defined by the range of varying results that can be generated when the same dataset is analysed at different levels of aggregation. The zoning effect is defined as the variability in results owing to the multitude of zoning systems that can be developed by merely adjusting the boundaries at a certain scale of analysis. Although spatial scale has attracted attention from researchers in recent discussions, there has been a missing link between analysis and the extent at which MAUP influences the mapped results as well as the statistical nature of multiple deprivations in Istanbul. Furthermore, based on the different levels at which analysis can be done coupled with a recent review of the administrative zones in Istanbul, MAUP is a practical issue of concern. This necessitates the understanding of deprivation and examining how their patterns operate at different scales.

This study uses household socioeconomic data at multiple scales to model how the scale and zoning problems influence the interpretation of multiple deprivations in Istanbul. Supplemental discussions with experts and policymakers were held to determine the units of analysis and implications of MAUP to urban policy. Specifically, the study looks at the influence of MAUP effects on statistical results and spatial patterns of deprivation. Results indicated that, although the choice of the appropriate unit of analysis is researcher dependent, it is highly determined by the scale at which data is available and the amount of detail required from the analysis. The study also revealed that MAUP and spatial scale has pronounced influence on representations of statistical as well as spatial patterns of multiple deprivations in the city. Spatial patterns of deprivation changed as indices were displayed at two different scales/ zoning systems. Levene's statistic for equality of variances confirmed the validity of these shifting patterns as significant differences on mean rates were found between the two scales/zones. Neighbourhood scale was seen to have more inter-area variability. Additionally, data aggregation not only masked deprivation by attenuating heterogeneity at small scales but also amplified the correlation and regression coefficients. This influence was seen to have relevant practical implications to urban policy and planning.

**Key words:** Multiple deprivations, scale, spatial scale, Modifiable Areal Unit Problem ( MAUP), Istanbul



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## LIST OF ACRONYMS

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BARD	Better Automated Redistricting
CSD	Census Sub Divisions
CT	Census Tract
DA	Dissemination Areas
ESRI	Environmental Systems Research Institute
GDD	General Deprivation Domain
GDP	Gross Domestic Product
GIS	Geographical information systems
GIT	Geographical information technology
GSS	General Social Survey
ILWIS	Integrated land and Water Information system
IMD	Index of Multiple Deprivations
IMM	Istanbul Metropolitan Municipality
IMP	Istanbul Metropolitan Planning
ISKI	Istanbul Water and Sewerage Administration
ITU	Istanbul Technical University
JICA	Japanese International Cooperation Agency
MAUP	Modifiable Areal Unit Problem
MCA/E	Multi Criteria analysis/Evaluation
METU	Middle East Technical University
NUTS	Nomenclature of Territorial Units for Statistics
SPSS	Statistical Package for the Social Sciences (now PASW -Predictive Analytics SoftWare)
TDHS	Turkey Demographic and Health Survey
TUIK	Turkish National Statistics Bureau
YTU	Yildiz Technical University



# 1. INTRODUCTION

*This chapter introduces the whole study by putting all the tasks into context. First, a background and justification is discussed followed by the research objectives and questions. The reader is also introduced to the research problem and conceptual framework showing the scope of the study and concepts applied. Lastly the research design on which the study is based describes the phases of the entire study.*

## 1.1. Background and justification

Over the last decades, problems linked to deprivation experienced by people and places have gradually intensified (Pacione, 2005). At the same time, urban neighbourhoods have been shown to suffer from not only one but several types of urban deprivation (Langlois & Kitchen, 2001). Most affected are vulnerable groups with high propensity to suffer from deprivation, economic and social disadvantage. Suffering is aggravated by such problems as low income, poor housing, unemployment and increased mortality, which are more concentrated in cities. In Istanbul, for example, most neighbourhoods suffer from acute shortage of housing and low level of services as a result of rapid population expansion of the city (Dokmeci et al., 1996).

Multiple deprivation has emerged as an important research theme in urban geography (Langlois & Kitchen, 2001). Urban geographers (Bailey et al., 2003; Baud et al., 2009; Gordon, 1995; Noble et al., 2010; Pacione, 2005; Schuurman, et al., 2007; Wong, 2006) have discussed it both as a concept and as a socio-economic problem. These discussions have recognized its multi-dimensional character focusing on multiple sources that poor households experience world over (Baud, et al., 2009; Baud et al., 2008). Therefore, an appropriate measure, able to take into account the multidimensional aspect of urban deprivation, should be useful in locating severely deprived areas and evaluate the degree to which these areas need help (Langlois & Kitchen, 2001). The use of indicators at certain geographical units e.g. micro (neighbourhood) or macro (district level) may be applied to examine its spatial dimension. Analysing indicators of poverty and deprivation together with their spatial representation has gradually become a vital tool with which to investigate and discuss environmental as well as socioeconomic problems (Henninger & Snel, 2002). Schuurman et al. (2007) sees deprivation indices as valuable measures of inequalities if analysed at medium or small spatial scales but warns that it is not easy to identify the exact number of individuals in need of help from medium averaged socio-economic data.

Poverty maps and indices have become important instruments that decision makers use to identify needy areas where they can prioritize services and infrastructure (Henninger & Snel, 2002). But the spatial unit at which these indices are calculated has significant influence on their values. Wong (2006) argues that geographical scales are important since the variability across different administrative areas tends to decrease at larger spatial scales (e.g. at district level), whereas larger areas tends to show more intra area variability. Large spatial units are seen as too large to capture problems like poor habitat conditions that may be concentrated in small pockets of deprivation smaller than the size of the unit. With this in mind, little attention has been directed towards addressing the influence of scale with more efforts being channelled towards how measures of poverty and deprivation should be constructed. The dire need of being perceptive of the MAUP and how it can be integrated within a GIS to curb the rising number of inconsistent analyses and their possibly costly ramifications on policy targeting need not be understated (Reynolds, 1998). The Modifiable areal unit can be associated to the analysis of multiple deprivations in Istanbul since analyses are reported by means of different administrative units over and over again. Core



questions in research relate to identifying an appropriate scale of analysis (Harris, 2006; Marceau, 1999) for a particular deprivation since areal units appropriate for one variable may not be appropriate for another (Manley et al., 2006).

This study aims at examining the effects of the modifiable area unit problem (MAUP) on multiple deprivations at different spatial scales in Istanbul. Multiple deprivations was chosen as the phenomenon of interest since it has been a centre of focus for many researchers in different areas (Baud, et al., 2009; Baud, et al., 2008; Brantingham et al., 2009; Pacione, 1995a, 1995b; Townsend, 1987). The rationale is that, the effects of MAUP have been of major concern in regards to the units of analysis of multiple deprivations. Socio-economic data from Istanbul is used to assess how MAUP affects the results when the same data is analysed at multiple scales. The relevance of this research is that, researchers working on multiple deprivations will be able to acknowledge that the results, which are computed from aggregated data for reasons of privacy or avoiding extreme outliers of point data, are subject to the effects of the modifiable areal unit problem. By acknowledging the effects of MAUP, policy initiatives will be alerted on their implications to policy intervention.

## **1.2. Research problem**

For several decades, researchers using deprivation indicators have concentrated on census based statistical data. As Bailey, et al., (2003) points out, this gives area based information which hardly distinguishes deprived and disadvantaged areas vis-à-vis deprived and disadvantaged individuals in the same areas. This form of area based analysis may be subject to the problem of ecological fallacy (Wong, 2006). For example, putting emphasis on results generated from a higher level of aggregation to a highly disaggregated level, such as the application of district level data to predict individual household deprivation can result in serious errors (Reynolds, 1998). One such error, ecological fallacy would be committed where it is assumed that individual household members of a particular district have the same average characteristics of the district at large. Indeed, a district classified as being highly deprived may have several better off individuals within its boundaries.

Wong (2006) sees some tension that lies with the mismatch between administrative geographies and the appropriate functional spatial scale in measuring a particular deprivation. Raising the idea that different aspects of disadvantage might require certain spatial scales of analysis in order to show variations in problematic areas. In doing so, the effectiveness of targeting can be improved. Dumedah et al., (2008) suggested that the distribution of resources whether public or social can be improved by incorporating scale sensitivity when measuring deprivation into spatial decisions. He adds that this may be of help to spatial analysts when choosing the size of areal units for their analysis.

The modifiable areal unit problem (MAUP) (Openshaw, 1984; Schuurman, et al., 2007; Wong, 2006) has attracted much attention from studies on poverty and deprivation. Hayward & Parent, (2009) showed that mapping poverty is highly sensitive to the changes of the spatial units for which data is aggregated. Changes in outcome due to changes in spatial units in the analysis of data highlight the effects of MAUP. Effects of the MAUP are more pronounced in analysis linked to spatial data since areal units of different configurations linked to the same data usually give rise to different results. When the boundaries of aggregated data are changed, the resulting analysis from the data may also be altered. Besides, a general solution is yet to be found despite there being several attempts to mitigate the effects of MAUP in urban analysis. This leaves room for researchers to seek solutions (P'aez & Scott, 2004). Indeed, studies focussing on deprivation and the link to MAUP are severely lacking in Istanbul. Thus the effects of the modifiable areal unit problem on the analysis of multiple deprivations would need to be studied. This calls for cross examining multiple deprivations at different spatial resolutions; at micro and macro scales, and analyzing the results that would arise thereof as a result of the scale alterations.

### 1.3. Research objectives

This study employs the use of qualitative and quantitative methods to examine the effects of the modifiable area unit problem when analysing socioeconomic phenomena at multiple scales using Istanbul as a case study. Here the main research objective and its specific objectives are listed.

#### 1.3.1. Main objective

To examine the spatial scale of multiple deprivation and effects of MAUP on the analysis of multiple deprivations at different geographical units of analysis using GIS and indicators in Istanbul, Turkey.

#### 1.3.2. Specific Objectives

- 1 To review the geographical units of analysis applied when mapping deprivation in Istanbul.
- 2 To examine the effects of the modifiable area unit problem (MAUP) on different forms of deprivation at different scales.
- 3 To find out and map the spatial units of analysis that are more appropriate for a particular aspect of deprivation.

### 1.4. Research questions

In this section, the research questions relating to each objective are listed.

**Objective one:** *To review the geographical units of analysis applied when mapping deprivation in Istanbul.*

- 1.1 What are the geographical units of analysis commonly used when mapping multiple deprivations?
- 1.2 At what scale do policy makers look at different deprivations?
- 1.3 What are the constraints that affect the choice of scale for a particular deprivation?

**Objective two:** *To examine the effects of the modifiable area unit problem (MAUP) on different forms of deprivation at different scales.*

- 2.1 What are the effects of MAUP on deprivation indicators?
- 2.2 How do inferences based on spatial analysis of multiple deprivation change when the same data are analysed using different scales?
- 2.3 What are the possible implications to policy intervention with regard to the effects of the MAUP?

**Objective three:** *To find out the scale of analysis that is more appropriate for a particular aspect of deprivation.*

- 3.1 What spatial scale is more suitable for what deprivation during analysis?
- 3.2 What influences the choice of a certain administrative boundary when mapping multiple deprivations?

### 1.5. Conceptual framework

The dependence on a single spatial unit in combining and visualizing multiple deprivation indicators may present a number of potential problems. This study analyses the spatial scale of multiple deprivation in relation to the problems associated with use of different scales using Istanbul as a case study. Inter and intra area variability as a result of changes in the units of analysis will also be shown. Multiple deprivations is conceptualized and analysed within its two main domains: material and social<sup>1</sup>. Analysing this invokes the use and computation of household survey data (a major source of data for the study). Expert and policy makers' knowledge and opinion on the geographical scales of analysis, forms of deprivation, the

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<sup>1</sup> Material deprivation is used to refer to measures relating to peoples access to goods or services such as ownership of household assets, educational, employment opportunities or community resources. Social deprivation means such measures like access to justice, rights of people in the society or family support e.t.c.

effects of MAUP and implications to urban policy and planning in Istanbul are sought through key informant interviews. Data is manually interpreted after which key variables are synthesized into indicators following the methodological framework of indicator development by Wong, (2006). Most of the analysis are done in statistical (correlation and regression analysis, descriptive statistics, *t* test and Levene's test) and GIS environments. GI techniques now supports the analysis of data using alternative zoning systems and thus examining the sensitivity of results obtained to modifiable areal units should become a routine (Fotheringham and Rogerson, 1993, cited in, Rogerson, 2006). The conceptual framework is based on the premise that analyzing multiple deprivations is scale dependent. Thus both the deprivation domains and Index of Multiple Deprivation will be tested in a framework of multiple scales to investigate the influence of scale and the MAUP. A diagrammatic representation of the conceptual framework is shown in Figure 1-1 below.

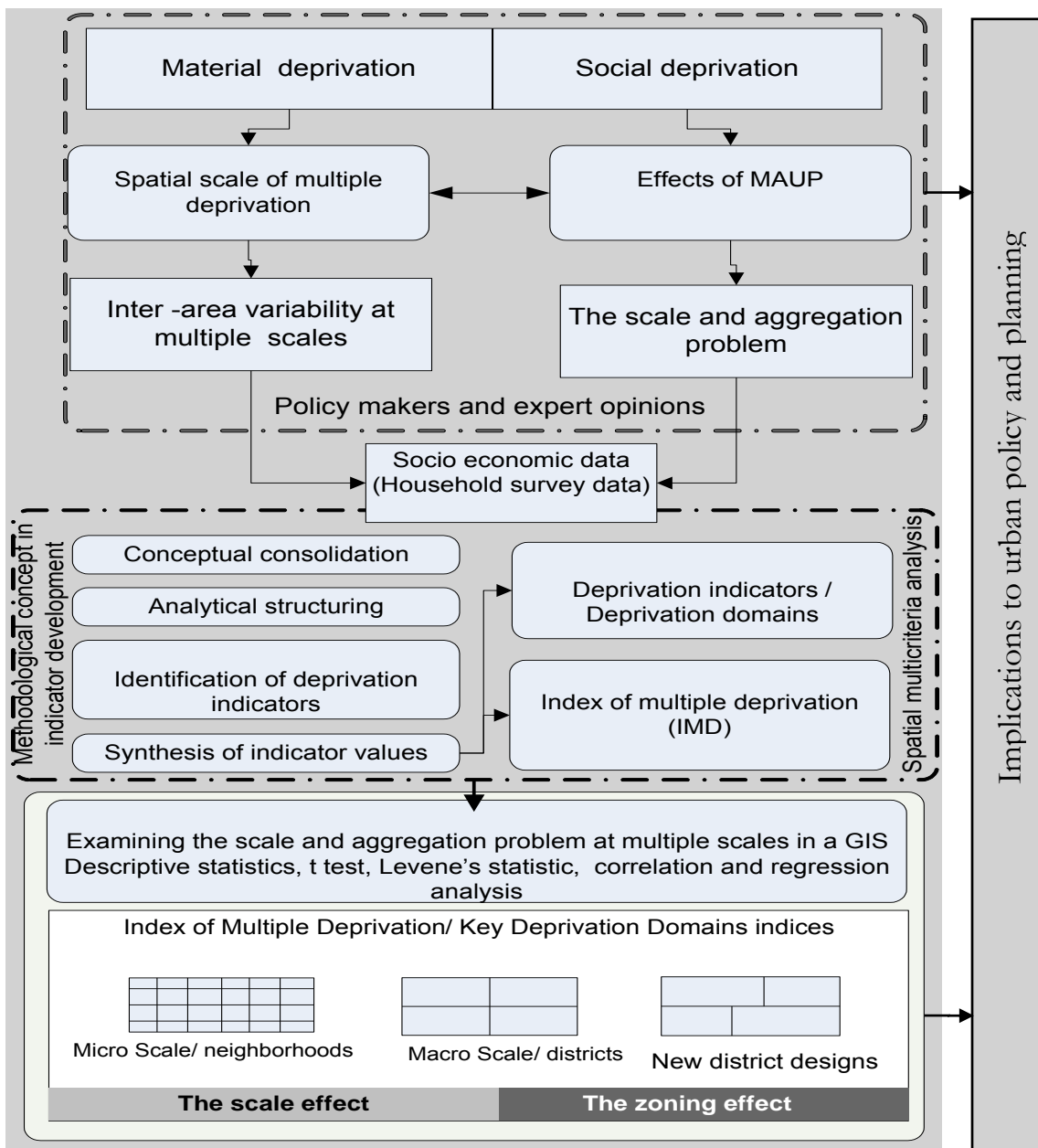


Figure 1-1 : Conceptual framework

*Methodological concept in indicator development adapted from Wong, (2006)*

## **1.6. Research design and procedures**

The study incorporates the following three phases. The complete research design is shown in Figure 1-2 below.

### **1.6.1. Phase I: Pre-field work**

The first phase encompasses defining the research problem, background information, justification of the study, formulation of research objectives and specific research questions. This is firmly backed by extensive literature review to identify research gaps and put the study into context with existing research. This is collected from published books, book chapters, journal papers and web pages. Methods and data needed to answer each research question are identified in this phase. The research matrix showing research objectives, research questions and methods designed at this phase is presented at the end of this report on appendix 1.

### **1.6.2. Phase II: Data collection**

After defining the data needs, primary and secondary data collection through a fieldwork exercise were the main tasks here. Primary data is sought by way of key informant interviews. Secondary data in form of administrative and demographic household survey data from Istanbul Metropolitan Planning (IMP) is also collected.

Key informant interviews with policy makers in Istanbul municipality are conducted with the aim of obtaining in-depth information on concepts, perceptions and ideas on the spatial scale of multiple deprivations towards answering research questions and meeting data needs as described in the research matrix. Experts and knowledgeable persons in the field of urban poverty and deprivation who are identified as key informants are also interviewed.

### **1.6.3. Phase III: Post-field work**

Here data was processed and analysed using geo information technology and statistical techniques. It is through this that indicators will be constructed and summarized to composite indices after which the findings and results were examined, evaluated and discussed. Visualization by means of maps, graphs and tables were done in this phase. Finally, results were presented followed by conclusions and recommendations for further research.

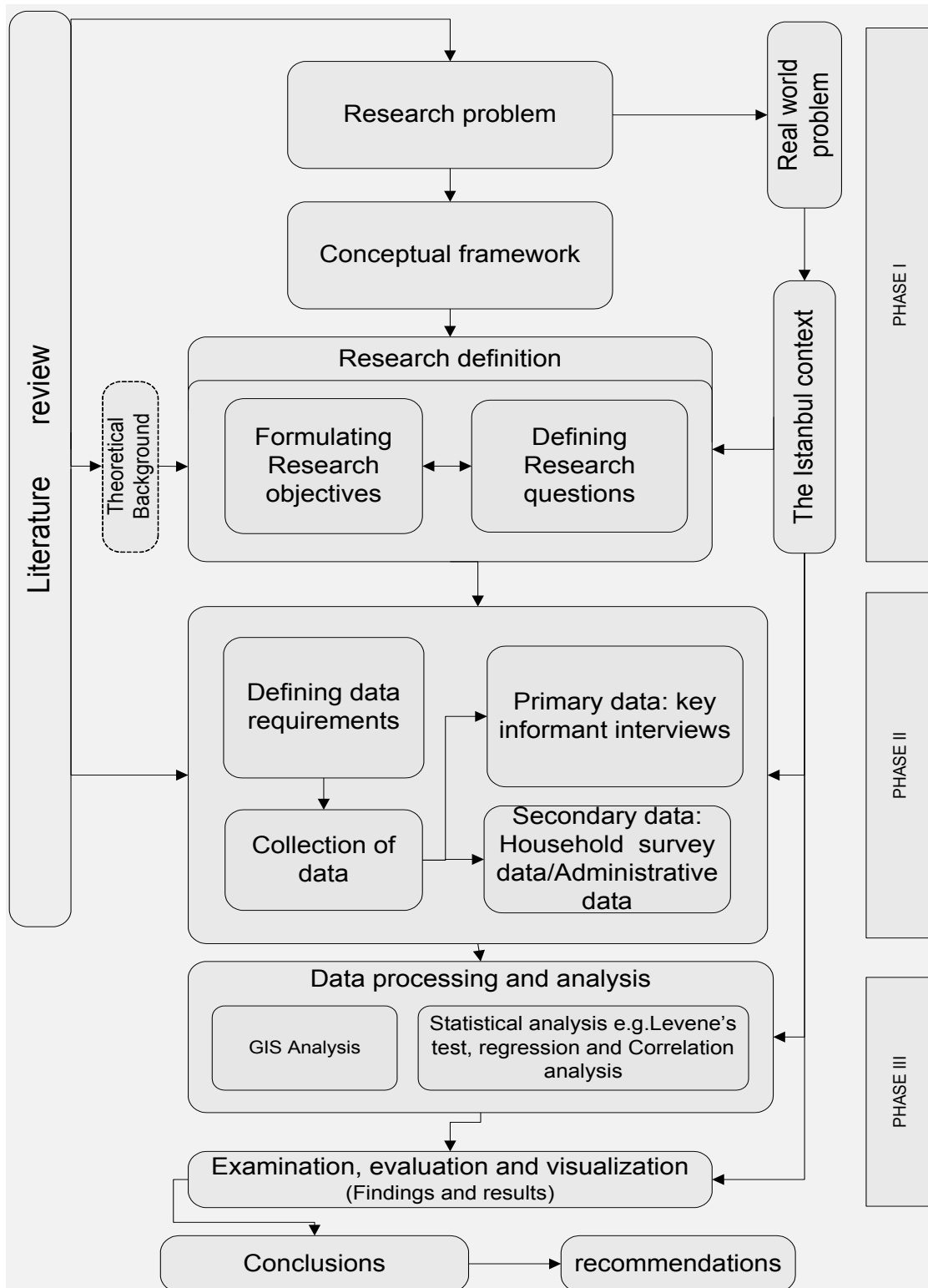


Figure 1-2: Research design

## **1.7. Thesis outline**

### **Chapter one: Introduction**

This chapter gives the introduction, research problem, background and justification of the study. It also describes the research objectives, research questions for each sub-objective, conceptual framework and the research design of the research.

### **Chapter two: Literature review**

This chapter presents a short literature review on multiple deprivations and the modifiable areal unit problem (MAUP). The two effects of MAUP are defined with illustrations based on previous studies of the scale, zoning effect and ecological fallacy. Suggested methods used in examining MAUP are also discussed.

### **Chapter three: Study area**

This chapter briefly describes the background of Istanbul city including geography and location, socioeconomics and finally introduces the general deprivations and environmental conditions of Istanbul.

### **Chapter Four: Research methodology**

This chapter presents a rationale for the case study area, followed by a description of the datasets. Primary data collection methods are also outlined here. Finally it discusses the research methods used for meeting the research questions under each objective followed by an illustration on how the index of multiple deprivation was developed.

### **Chapter five: Results and discussion**

This is the core chapter of this work. It starts by giving a detailed description of the effects of scale and zoning effects of MAUP then followed by a discussion of the results of analysis. It finally presents the suggested possible ways of mitigating MAUP effects in Urban analysis.

### **Chapter six: Results and discussion**

This chapter extends the discussion of results. Results here are based on interviews and literature review. The chapter starts by describing the geographical units of analysis and the implications of the modifiable areal unit problem to policy and planning in Istanbul. A discussion is also presented on the appropriate units of analysis.

### **Chapter seven: conclusion and recommendations:**

This chapter concludes by giving a summary of the main findings under each objective. Finally, further improvements for this study based on the limitation encountered and ways in which the study could be appreciated are recommended.



## 2. MULTIPLE DEPRIVATION AND THE MODIFIABLE AREAL UNIT PROBLEM

*This chapter presents a literature review of the effects of data aggregation on mapping multiple deprivation as well as the different aspects of the modifiable areal unit problem. More specifically, the chapter provides a description with a diagrammatic demonstration of the zoning and scale effect of the MAUP. Previous studies and the analytical techniques within which they attempted to deal with the MAUP in their respective disciplines are also discussed.*

### 2.1. Conceptualizing multiple deprivation

As much as it has been regarded by some researchers,(Noble et al., 1999) as an exceedingly difficult concept to define and examine, measuring multiple deprivation has been valuable for its focus on the inadequacy of commodities, social relations or poor physical and social environment which results from a lack of monetary resources (Bailey, et al., 2003). Quantifying deprivation is necessitated by intervention programmes initiated by politicians and motivated by urban planners who need knowledge on its sources and spatial patterns (Baud, et al., 2009). Measures of deprivation are typically done using data collected and reported at predefined geographical units.

The choice of the units of analysis highly influences the results and the apparent intensity of deprived conditions (Harris & Longley, 2002). Therefore, when conducting spatial analysis for any dimension of deprivation, the analyst should not ignore the spatial units that data are aggregated into and the consequent impacts of this choice on the interpretation of the findings and results (Rengert & Lockwood, 2009).

Multiple deprivation is usually analysed based on its two major constructs that define disadvantage according to social position and material access (Schuurman, et al., 2007). Material deprivation is a measure that concerns population's ability to access goods or services: educational, health, employment opportunities, community resources, physical assets e.g. the ability to get suitable housing. On the other hand, social deprivation is defined by the collective functions encompassing the social environment, for example the degree of society or individual family support, peoples rights in the society or the influence of conditions behind labour environments (Ibid). Other researchers, e.g. Townsend, (1987) sees it as a state of observable and demonstrable disadvantage relative to the local community or the wider society to which an individual, family or group belongs. He adds that multiple deprivations applies to conditions (that is, physical, environmental and social states or circumstances) rather than resources and to specific and not only general circumstances, and therefore can be differentiated from the concept of poverty.

The Identification and understanding of the spatial patterns; along with analysing the nature and distribution of deprivation calls for knowledge on its sources. The following section briefly describes sources of multiple deprivations

#### 2.1.1. Sources of multiple deprivation

For Pacione (2009), the main cause of deprivation is economic and comes from three sources: low wages earned by persons working with declining traditional industries or employed on a part time basis in newer service based industries. The other source is unemployment experienced by those marginal to the job market (such as single parents, the elderly and the never employed school leavers). The final source is concerned with reductions in welfare expenditure in most western countries due to increasing demand and economic crisis. Thus it can be argued that in many cities of the world, unemployment, low income, poor



housing e.t.c. are more common in deprived areas. This explains why people in these areas lack the types of diet, clothing, shelter and environmental, educational, working and social conditions, activities and facilities which are customary, or at least widely encouraged and approved, in the societies where they reside (Townsend, 1987).

### **2.1.2. Multiple deprivation indicators**

Census based deprivation indicators were first used in the UK in early 1970s and have since been developed in Canada, the US, New Zealand, and other places (Bell et al., 2007). Indicators are used to quantify and monitor deprivations in an area. They can inform policy makers about where to target first, and how much – or to which proportion (Martínez, 2009). However, the change over time in their construction and use can be described as the most mature as well as the most politicized (Wong, 2006). This may be attributed partly to their long history of development and partly to their practical use in informing resource allocation. In this regard, Gordon (1995) asserts that the construction of census based deprivation indicators is among the most economically important uses of social statistics. They are also practical measures since they tend to utilize census socioeconomic data that are available in different administrative areas.

For purposes of targeting, several indicators may be synthesized into composite indices, some of which are known in literature as area based deprivation indices. Recently, they have been frequently used as tools for investigating the spatial patterns and degree of inequalities (Schuurman, et al., 2007), moving away from a narrow focus on living standards to encompass a wider range of problems associated with concentrations of deprivation or seen as related problems which policy should address.

While area based indices target geographical areas where deprivation can be identified, on the other hand, they form the basis for area based policies. Martínez (2009) explains that area-based policies are one of the tools that have been applied since the 1990s to improve the quality-of-life of the people inhabiting deprived areas.

### **2.1.3. Composite multiple deprivation indices**

Many studies, (Bailey, et al., 2003; Baud, et al., 2008; 2009; ODPM [Office of the Deputy Prime Minister], 2004) have examined urban deprivation for targeting by policy makers. For city-wide level, they have used an index of multiple deprivations. An index of multiple deprivation is designed by aggregating indicators ostensibly to measure a range of deprivations in an attempt to capture problematic socioeconomic circumstances of urban areas (Deas et al., 2003). Weights are introduced during aggregation to reflect the relative importance of the variables used (Booyesen, 2002; Wong, 2006). This makes the index more invaluable in terms of its ability to simplify complex measurement constructs, to focus attention and to catch the eye, thus enhancing its political appeal (Booyesen, 2002) in decision making. A prominent advantage of composite indices is that they are intuitive and easy for even non researchers to understand; and besides, it's an approach that doesn't require advanced statistical know how (Henninger & Snel, 2002). They have the first impression of capturing the multidimensional character of inequalities which makes poverty and deprivation studies widely apply them widely.

As Matern et al., (2009) explains, a deprivation index highlights the measure of deprivation in a number of ways compared to existing measures:

1. Communicates a dominant and undeniable picture of deprivation to the public;
2. Reflects tangible standard of living in an area;
3. Its known to capture dimensions of poverty that income does not, for instance illiteracy;
4. Reflects the actual rate of deprivation and not as arbitrary decisions made by experts;

5. Monitors government investment in services and in-kind benefits i.e. if government invests in affordable housing, we should see a reduction in the deprivation index;
6. Although it complements existing income measures, it does not however replace them.

Schuurman, et al.,(2007) used what he called the Vancouver Area Neighbourhood Deprivation (VANDIX) and Socio-economic Factor (SEFI) deprivation indices at Dissemination Area (DA), Census Tract (CT), and Census Subdivision (CSD) administrative units to assess how composite indices on population health are influenced by data aggregation in analysis. Researchers using multiple deprivation indices should account for ways in which the selection and design of the spatial scale of analysis shapes the emergent results.

However, composite indices have been critiqued for their relative measuring nature in that the scores that each area achieves do not reflect the absolute number of people who are multiply deprived (Bailey, et al., 2003) especially when the total population per area varies. A major critique is founded on the weighting scheme of the variables used which may be subjective and theoretically unstable (Henninger & Snel, 2002). They are highly sensitive to the weighting system used. A slight change could lead to a rank reversal of areas ranked as highly deprived.

## **2.2. Relevance of spatial scales in context of multiple deprivation**

Techniques for the delimitation of areas for analysis have fascinated much attention in recent decades especially in relation to area based policies (Johnston et al. 2003). Analyses of multiple deprivations have been dependent on geographic scale as well as the selection of their boundaries. Boundaries are selected for aggregation of individual level data since it's sometimes inefficient to analyze and display individual level data in geographic research. Reasons for this include privacy concerns regarding the display of highly disaggregated data, extreme outliers that may render individual attribute analysis problematic or the magnitude of computational complexity in handling vast data points (Hayward & Parent, 2009; Noble, et al., 1999; Reynolds, 1998). Aggregation however comes at a cost. For instance, grouping individual spatial data points into geographical units inherently dissolves the finer resolution at which analysis of multiple deprivation can take place amounting to loss of detail (Hayward & Parent, 2009).

Averaging data could mask severely deprived individuals. Decision makers have raised concerns when targeting interventions to multiply deprived individuals; with spatial variation of poverty posing great challenges since clusters of the poor are found in particular places (Henninger & Snel, 2002). Addressing the question of "what is the appropriate spatial unit of analysis?" is very crucial in clarifying the issues that decision makers consider to be most relevant for policy targeting (Wong, 2006) of deprived areas. Spatial scales are seen as important entities if measures of area deprivation are to be in a position of quantifying deprivation well enough for policy makers to target resources effectively (Noble et al., 2006).

## **2.3. Ecological fallacy**

This study is concerned with the problems that occur when data is aggregated into different scales. The Modifiable Areal Unit Problem, (MAUP), is probably among the most widely recognized forms of ecological fallacy (Harris, 2006). As such, errors are made when thinking that relationships observed for groups necessarily hold for individuals. Ecological fallacy occurs when it is inferred that results based on aggregate zonal or grouped data can be applied to the individuals who form the zones or groups being studied (Openshaw, 1984). It is also agreeable that, the assimilation of results based on statistical analysis consequential from a certain level of spatial resolution to a higher resolution such as district level data, being used for reporting household information may be problematic, thus bringing forth serious errors (Reynolds, 1998). Some studies (Naoto & Atsuyuki, 2002; Pawitan & Steel, 2006; Tranmer & Steel, 1998)

have pointed out that using aggregated data in spatial analysis may lead to limitations on results reported due to such issues as ecological bias and the modifiable areal unit problem. This brings forth serious concerns. Because of ecological fallacy, policy makers may direct resources to areas in which a substantial proportion of the residents do not need public assistance (Pacione, 2009).

Martinez (2009) sees ecological fallacy especially of area-based policies as a problem that can be overcome. He suggested that, while derived need through individual indicators and an index of inequalities can catch the predominant aspects of inequality, the use of self expressed needs can depict the individual cases that are in need and might be “hidden” or homogenized in a well-off area viz. the inclusion of expressed need can help to detect those individuals that might be left out from compensatory policies based on geographical areas.

## **2.4. The Modifiable Areal Unit Problem (MAUP)**

With many areal data, the spatial objects only exist after data collected for one set of entities are aggregated to produce a set of spatial units (Openshaw, 1984). Spatial units chosen for analysis are modifiable. Analysis is often conducted using aggregated geographical data which in many cases is data reported for pre-defined areal units such as census tracts or traffic analysis zones (Páez & Scott, 2004). As much of the data are collected for essentially non-modifiable units, for instance, people or households, they are mapped based on modifiable area units: wards, counties or districts. Normally, areal units are arbitrarily determined and modified to form units of different sizes. Hence this forms the crux of the modifiable area unit problem (Dark & Bram, 2007; Jelinski & Wu, 1996; Manley, et al., 2006; Openshaw, 1984). Schuurman, et al., (2007, p.595) define MAUP as:

*“...the problem that occurs when inferences based on spatial analysis change when the same data are analysed using either variations in administrative zoning or through different scales”.*

Even though there are almost infinite number of ways in which geographical areas of interest can be spatially divided, data are only collected and analysed for a particular set of units. The choice of this units is rather haphazard and there is uncertainty about the nature and the best possible spatial units of study to be chosen when analyzing data or mapping deprivation. In this regard, the MAUP is today one of the most important unresolved problems left in spatial analysis. A fact is that there has been very little research to the MAUP compared with that afforded to many far less significant problems. While it appears like primarily a technical problem, it is also a major conceptual problem that is central to many aspects of geographical study (Openshaw, 1984).

The seriousness of MAUP has been demonstrated by the wide range of techniques whose outcome has been suggested to be affected by it (Páez & Scott, 2004). Some of the techniques suggested include correlation and regression analysis (Amrhein, 1995; Openshaw, 1984; Páez & Scott, 2004) and the representation of the spatial patterns of the phenomena in a GIS; especially when used to produce maps (Hayward & Parent, 2009; Henninger & Snel, 2002; Schuurman, et al., 2007).

There are two problems of concern related to the MAUP: the scale effect and the zoning effect (Amrhein, 1995; Dark & Bram, 2007; Hayward & Parent, 2009; Oliver, 2001; Openshaw, 1984; Schuurman, et al., 2007). In the following section, the two effects of MAUP are discussed with illustrations.

### **2.4.1. The scale effect**

The trend for varying results to be generated when the same dataset is summed up at different spatial scales in a system where spatial units are modifiable defines the scale effect (Jelinski & Wu, 1996; Manley, et al., 2006; Openshaw, 1984; Páez & Scott, 2004; Schuurman, et al., 2007) e.g., post codes,

neighbourhoods, regions and districts. It is attributed to the variation in numerical results owing firmly to the number of areal units used in the analysis of a given area (Dark & Bram, 2007).

That it has been regarded by many researchers (Dusek, 2005; Hayward & Parent, 2009; Oliver, 2001; Openshaw, 1984; Schuurman, et al., 2007; Yang, 2005) as a major problem of the MAUP is not in doubt. The scale effect has been described as how changing the number of areal units imposed on a map can affect the interpretation of a geographical phenomenon (Hayward & Parent, 2009) and explains also the change in statistical results as data aggregation occurs. The processes operating at different spatial scales explains the variations in statistical outcomes dues to individual level and aggregate level effects (Manley, et al., 2006). Figure 2 below shows a diagrammatic representation of the scale effect of MAUP.

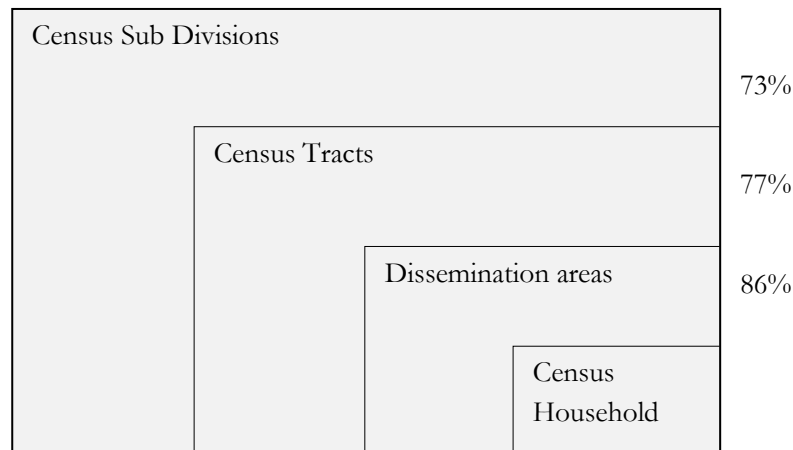


Figure 2 : Scale sensitivity measure<sup>2</sup> for Deprivation Index across three census scales  
Adapted from: (Dumedah, et al., 2008)

Figure 2-1; a and b is an example showing the influence (change) to the means that happens when smaller units are aggregated into larger units. When nine units are aggregated to three units, the mean changes from 8.88 to 8.33.

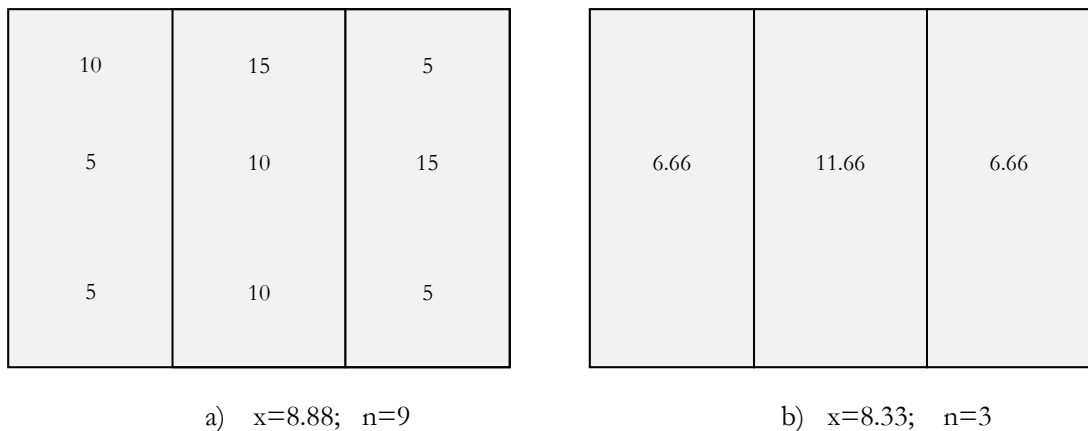


Figure 2-1 (a and b): Modifiable area unit problem: Demonstration of the scale effect  
Adapted from (Oliver, 2001)

Martinez (2009) demonstrated the sensitivity of the problem of overcrowding to scale and how it became more evident when the indicator was disaggregated at different levels of administrative units in Rosario,

<sup>2</sup> It's the accuracy when expressed as a percentage of estimating deprivation index at three scales. It's used as an indication of scale distortion as characteristics of deprivation are shown across the three scales.

Argentina. At the city level, Rosario had an overcrowding of 6 % while when analysed at the district level, more inequalities emerged. At the lowest administrative area, intra-area variability between best off and worst off neighbourhoods becomes clear (see Figure 2-2).

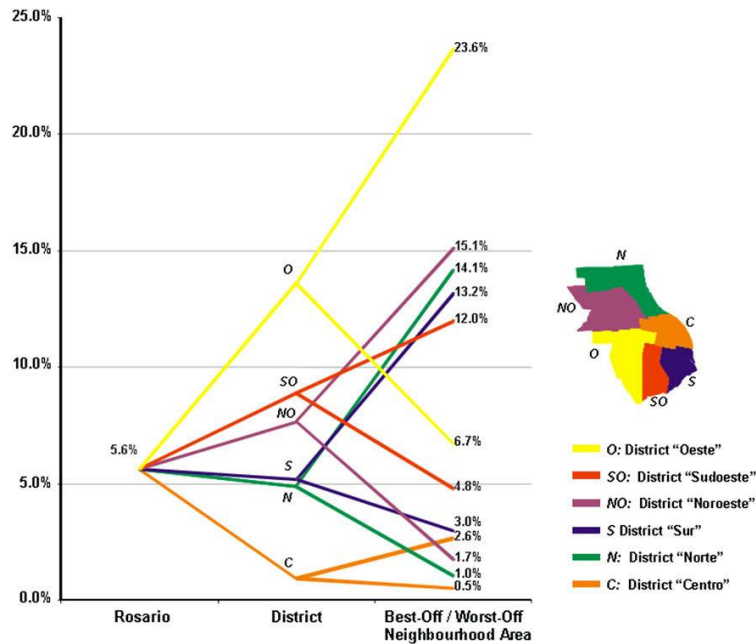


Figure 2-2: Scale sensitivity to overcrowding at city, district level, and the gap between worst-off and best-off neighbourhood area in Rosario, Argentina.

Source: (Martínez, 2009)

Schuurman et al.,(2007) demonstrated the influence of scale on population health indices against Vancouver using both Dissemination Areas and Census Tract boundaries where a small scale map showed an averaged picture of socioeconomic characteristics whereas the large scale map on the left (Figure 2-3) showed detailed characterization of small areas.

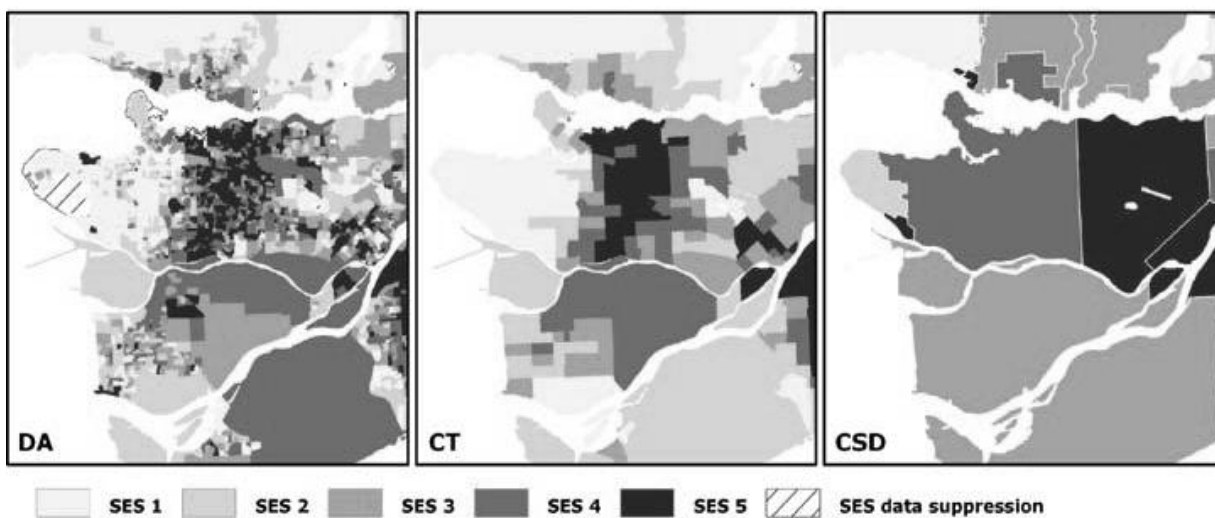


Figure 2-3: Greater Vancouver socio-economic status quintile rankings using the VANDIX deprivation index on dissemination area (DA) Census Tract (CT) and Census Subdivision (CSD) administrative units (1= least deprived)

Source: (Schuurman, et al., 2007)

**2.4.2. The Zoning effect**

The zoning problem occurs when partitioning of space within a map happens, while simultaneously maintaining the same number of areal units i.e. rezoning into different arrangements, thereby influencing the interpretation of a geographical phenomenon (Harris, 2006; Hayward & Parent, 2009; Manley, et al., 2006). Other researchers see it as the unevenness in results generated within a system of modifiable areal units as a result of the various ways in which the units can be grouped i.e. at a given scale and not due to changes in the size of those areas (Schuurman, et al., 2007). It results from the multitude of zones that could be constructed and used at any given scale with different results being obtained by simply altering the boundaries of the zonations at a certain level of analysis (P’aez & Scott, 2004; Schuurman, et al., 2007). Attributed to the zoning problem are the changes in numerical results owing strictly to the way in which a larger number of smaller areal units are grouped into a smaller number of larger areal units (Dark & Bram, 2007). A demonstration is shown in Figure 2-4 below.

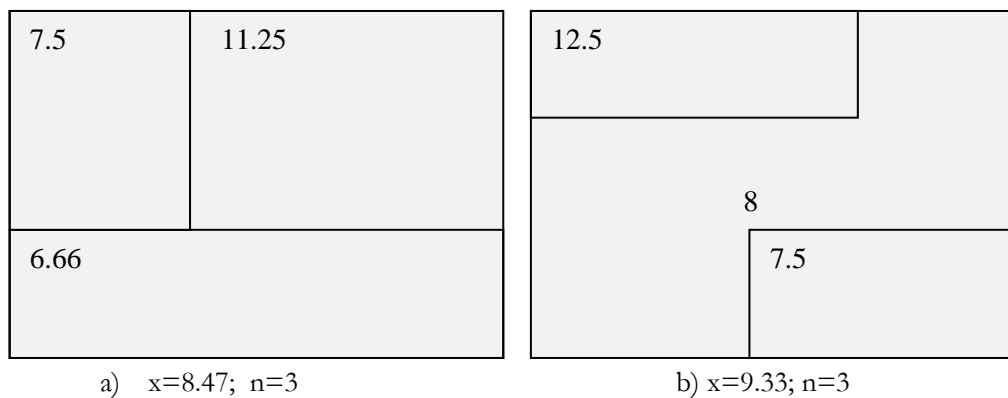


Figure 2-4: Modifiable area unit problem: Demonstration of the zoning effect  
Adapted from: (Oliver, 2001)

Figures 2-5 a and b, above shows a demonstration of the zoning effect and how it affects the results of descriptive statistics (mean). With the original zones in a, the mean is 8.47 which is shown to change to 9.33 after rezoning in b.

In Figure 2-5, Dark & Bram (2007) shows the zoning influence when the units are aggregated into different zones with varying orientations. For d and e there is no change in the mean, however, the variance is shown to change substantially. What can be observed is that, unlike in Figure 2-4 where the variance is not shown, doing a comparison of Figure 2-5 d to f, and with the number of zones being held constant at the same time, the mean and variance are significantly affected.

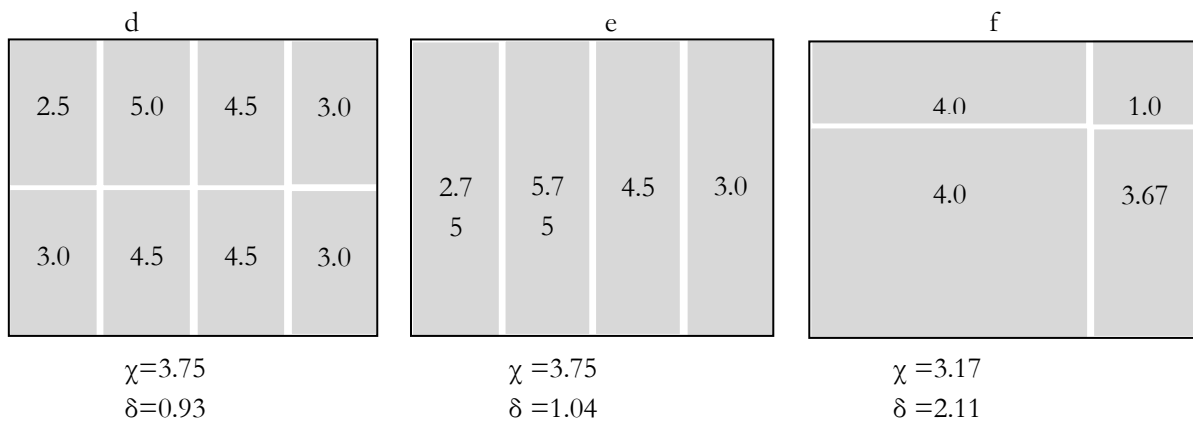


Figure 2-5: The influence of the zoning issue

Source: (Dark & Bram, 2007)

A practical example was that by Schuurman, et al. (2007) who investigated the influence of the zoning effect on the patterns of population health using socio economic factor index in Vancouver, Canada. As shown in Figure 2-6, he observed that after modifying the original census tracts, the zoning problem was apparent in new adjusted areal units. There were clear differences in the spatial patterns from those recognized in the actual census tract map.

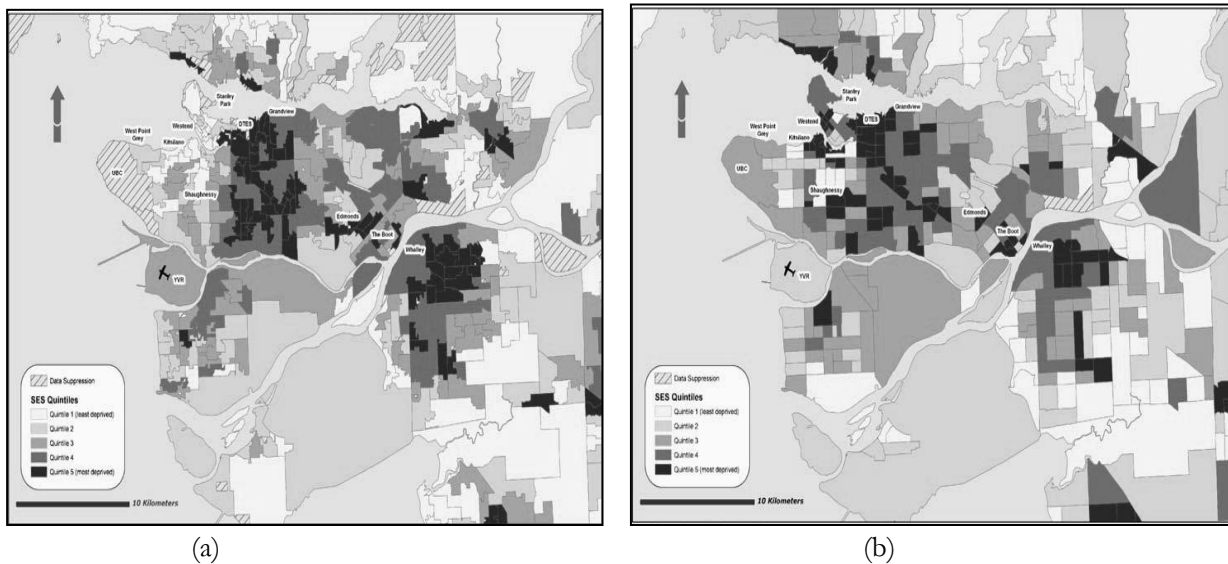


Figure 2-6: Zoning effect; (a) socio economic factor index quintiles using adjusted Census Tract administrative boundaries; (b) socio economic factor index quintiles using the original Census Tract administrative boundaries

Source: (Schuurman, et al., 2007)

### 2.4.3. Previous studies on MAUP

Among the earliest studies to unearth the effects of MAUP on measurements based on aggregated data was that by Openshaw (1984). He observed that, it's a major problem whose ramifications need to be well appreciated by those interested in analyzing spatially aggregated data. Some more recent discussions (Hayward & Parent, 2009; Hui, 2009; Pawitan & Steel, 2009; Schuurman, et al., 2007) have centred on issues like the aggregation process, aggregation effect, zoning problem, scale problem, and ecological fallacy. They endeavoured to study the sensitivity of the analysis of spatial phenomena to the scale and zoning problem regarding the mapping unit.

Significant attention has been received from disciplines as diverse as human geography, landscape ecology, spatial statistics and public health. For example, in landscape ecology, Jelinski & Wu (1996) conducted several autocorrelation analyses based on NDVI (Normalized Difference Vegetation Index) to show how the MAUP may influence the results of landscape analysis. Using such methods as spatial autocorrelation and focusing the study on scales was suggested as the procedure to deal with the MAUP.

Fotheringham et al.,(2002) briefly examined the way Geographically Weighted Regression (GWR) results were sensitive to the scale of aggregation of the spatial data being used in the calibration of the regression models. London house price data at three levels was used: at the individual property, enumeration districts and wards. However, he warns that "...GWR still suffers from its own form of the modifiable areal unit problem in that the results are dependent on the bandwidth used, which is a measure of spatial scale..." p.158.

In the field of public health (epidemiology), Swift et al.,(2008) evaluated aggregation bias on correlation statistics between water quality data and gastrointestinal (GI) illness events by looking at two spatial distribution scenarios in the context of waterborne diseases. Their research demonstrated the potential for MAUP to cause large bias in correlation and regression statistics (in a controlled simulation experiment) which indicated how heavy the MAUP bias can be when point patterns are aggregated.

#### **2.4.4. Scale and zoning design in MAUP analysis: what are the methods?**

Scale effect is examined by analysing data at different levels of spatial resolution. Schuurman, et al. (2007) analysed scale using illustrations at Dissemination Area, Census Tract, and Census Subdivision administrative boundaries while (Hayward & Parent, 2009) used county and census tract scales in Vancouver and Pennsylvania respectively.

The zoning effect is analysed by designing diverse zoning systems for a particular scale through automated zoning design techniques. The strategy may require aggregating source base areal units which in principle should be of lower spatial scale. The design of the zoning system can be controlled to ensure stable aggregation of data in urban analysis. Automated procedures call for designing of a variety of zones by controlling the zoning boundaries through statistical or geo information technology (GIT) design rules. For example, Better Automated Redistricting<sup>3</sup> (BARD) (Altman & Macdonald, 2009) makes it possible for users to design different zoning systems; a process referred to as redistricting. Different procedures are offered by BARD that can be used to produce district designs (Hayward & Parent, 2009). It uses processes like closeness and contiguity to combine areal units into random districts. Districting add on extension in ArcGIS allows the user to define various aggregates of data such as census tracts or post codes into a zoning design (ESRI (Environmental Systems Research Institute), 2010) (see also section 4.5.2). Zoning designs are created by selecting base data and grouping by selecting them in ArcMap. Such designs could be zoned by putting into consideration equal population size or random aggregation based on contiguity or closeness of areal units or a combination of both procedures.

Methods and techniques of scale and zoning designs are of relevance to this study. A range of different spatial scales and zoning systems were designed with socio-economic data being ascribed to those areal units. This ensured analysis of data in a framework of modifiable areal units by checking their sensitivity to the areal unit definition.

## **2.5. Summary**

This chapter presented a review of the general definitions of multiple deprivation and concepts regarding spatial scale. We defined ecological fallacy, MAUP, scale and zoning effects as they were described by different authors in previous researches. The definition and understanding of these concepts helped a great deal in building the conceptual framework for this study.

While this study was concerned with spatial scale and MAUP and how it affects the analysis of multiple deprivation, it was believed that a brief review on the different aspects of MAUP and the concept of deprivation, a range of statistical and GIS techniques applied in related studies; to design zoning systems and test MAUP were pertinent in building and developing methodology for the current study. The review highlighted the importance of GIS and statistics in analysing the modifiable areal unit problem.

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<sup>3</sup> BARD is a R statistical analysis software extension. BARD is a publicly available freeware extension





### 3. BACKGROUND TO THE STUDY AREA: ISTANBUL CITY

*This chapter gives a brief background of the study area. The geography and location, administrative structure, land use patterns, demographics, socio economic background of Istanbul city are described here. Finally, the general deprivations and environmental conditions of the city are discussed.*

#### 3.1. Geography

Istanbul is the biggest metropolitan centre in Turkey. It is located between the coordinates 28° 01' and 29° 55' East longitudes and 41° 33' and 40° 28' North latitudes, lies next to the Marmara Sea in the South, soaring peaks of Kocaeli mountain Ranges to the East, and the waterline of Ergene Basin to the West; the Istanbul Straits penetrates through the Asian and European Continent by cutting across Istanbul City thereby connecting Black Sea and Marmara Sea (Istanbul Metropolitan Municipality, 2008a). By being defined as the only world city which is effectively identified as one of the Balkan states, as well as the eastern Mediterranean, the Middle East, and Central Asia, Istanbul is a unique city in its own way (IMM & JICA, 2008).

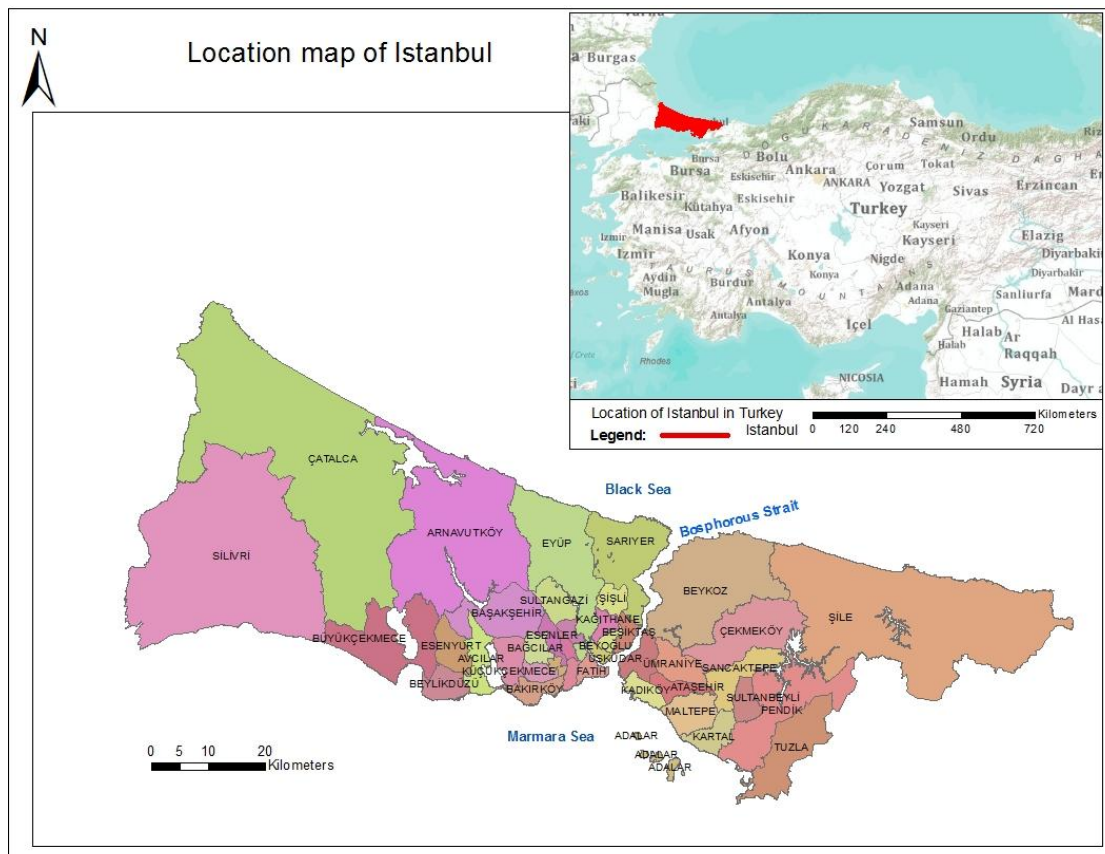


Figure 3-1: Location of Istanbul displaying the names of the thirty nine districts

#### 3.2. Administrative structure

The city of Istanbul (also known as the province of Istanbul) is divided into 39 districts (see Figure 3-1) whereby each has a district centre, a local municipality and an elected mayor. The city is comprised of

what are referred to as villages (155) and a total of 841 neighbourhoods. The city is under the jurisdiction of Istanbul Metropolitan Municipality comprising of the metropolitan mayor, metropolitan council and the metropolitan executive committee. The metropolitan city is found on the decayed plateaus of Kocaeli and Catalca Peninsulas(Istanbul Metropolitan Municipality, 2008a).

### 3.3. Land use patterns

The land use in Istanbul can best be described as mixed land use: residential, commercial and office e.t.c. This occurs either in one street or in a building. Istanbul is often described as a compact city with very high population density. However, in the peripheral areas, evident is the sprawling of housing and urban areas represented by squatter settlements locally known as *gecekondu*.

### 3.4. Demographics

From the address based population registration system by the Turkish Institute of Statistics, the population of Istanbul had reached 12,573,000 people with an average population growth rate of 3.45% a year (from the release of 2007 official census data). In the last seven years alone, population has increased by 2.5 million. The most populous district is Gaziosmanpaşa, with 1,013,048 people followed by Ümraniye, with 897,260 people. The European part currently has 8,156,696 people residing there with the Anatolian side having 4,416,867 people. The sum of the female population of the city amounts to 6,283,073, while that of the male population is 6,291,763 (Istanbul Metropolitan Municipality, 2008a).

Industry-based urbanization stimulated the influx of population into Istanbul through in-migration. This greatly expanded the urban areas outward. Istanbul then expanded from a city of three million in the 1970's to a huge city of ten million in 2000, while at the same time increasing its population and share in Turkey from 8.5% in 1970 to 15.9 % in 2005. This can be seen from the graph (Figure 3-2) and Table 3-1 below.

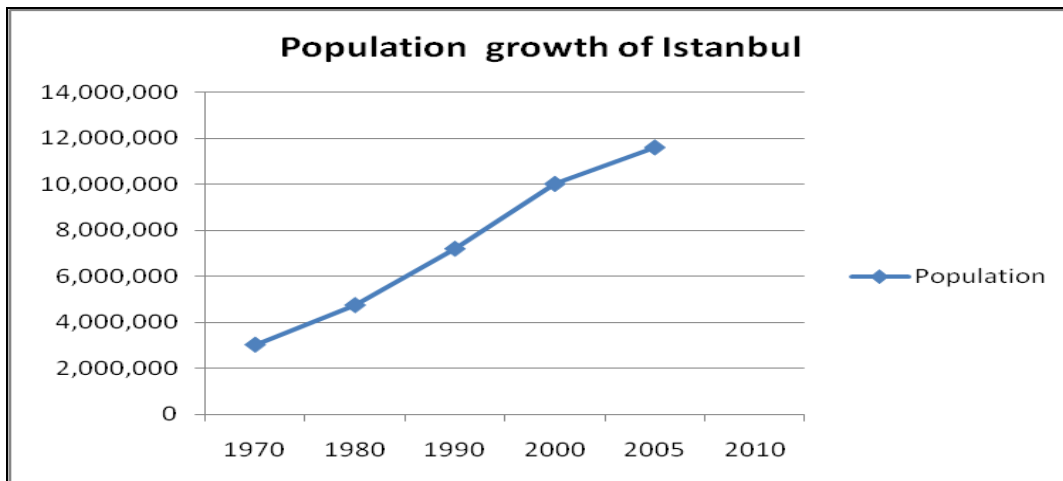


Figure 3-2: Population growth trends for Istanbul  
(Source: IMM & JICA, 2008)

It should also be noted that the city's population trend has been in a steadily declining annual growth as shown in Table 3-1.

Table 3-1: Istanbul's % population share to Turkey &amp; annual growth rate

	1970	1980	1990	2000	2005
Population	3,019,032	4,741,890	7,195,773	10,018,735	11,606,341
Share to turkey (%)	8.5	10.6	13	14.8	15.9
Annual population growth rate %		1970-80:4.6	1980-90:4.3	1990-00: 3.4	2000:05-3.0

(Source: IMM & JICA, 2008)

### 3.5. Socio-economic background

Trade is the second most important sector in Istanbul after industry giving it a central importance in both domestic and international trade. Istanbul makes 27% of the general added value within the commercial sector in Turkey (Istanbul Metropolitan Municipality, 2008a). Furthermore, head offices, tourism, finance, and the banking sector have emerged as the new sectors substituting the industrial sector in modern times (ibid). Istanbul forges ahead in becoming a financial centre, more so in the domains of leasing, factoring companies, private financial institutions etc.

Istanbul's share in GDP by sector and international trade indicates its greater importance in the overall national economy especially in financial, professional and international trade, whereby international trade shares more than 40% followed by commercial at 35.5 % as of 2004 (IMM & JICA, 2008) . However, despite the evident economic prowess, and it being one of the largest urban centres in Turkey, Istanbul was hit by the global economic meltdown. The result of the economic slowdown being lower incomes and higher unemployment which has affected the lives of the majority of families (TEPAV, 2009). It must also be noted that Istanbul is one of the most central tourist areas in Turkey having hundreds of hotels and tourist oriented industries which caters for all tourists and visiting professionals.

### 3.6. Public services

Education is a prominent service in Istanbul. This is where some of the finest institutions of higher learning (more than twenty public and private universities) in Turkey are found. There are also numerous libraries, many of which have great collections of historic documents from the roman to the ottoman periods.

Access to healthcare is through numerous public and private hospitals, different clinics and laboratories attached to numerous medical research centres. Much of these facilities have advanced technology equipment. Health service (surgeries, clinics, physiotherapy halls and maternity hospitals) is provided through the Istanbul Metropolitan Municipality Health department by Istanbul Health Enterprise (Istanbul Metropolitan Municipality, 2008b).

Government agency (ISKI, 2007) manages sewerage and water supply. Together with the private sector, they supply clean water to the residents. Electricity distribution services are provided by the state. Diverse transport infrastructure connecting different parts of Istanbul enhances the availability of different transport services for people and goods. Two international airports, commuter ferries, trains, trams, metros and buses are major means of transport in Istanbul.

### 3.7. General deprivations and environmental conditions of Istanbul

Despite having a vibrant economy, infrastructure, utilities and services, some of which are described above, Istanbul suffers from a myriad of problems which is known to affect the quality of life and that of the environment. For instance, separations in geographical conditions of Istanbul together with

insufficient road network capacities and narrow access roads (Gerçek & Demir, 2008) has generated constraints of the transportation system in regard to access to services by the public. Urban road network and village roads in Istanbul are not sufficient thus causing major traffic problems.

Private vehicles on the other hand have created major traffic congestion problems and environmental pollution which often cause smog conditions in the urban centres (ibid.). Most of the congested areas have already registered high saturation levels and are plagued with environmental deterioration thereby hindering the healthy and functional living and activities of the city. Health problems caused by pollution have been increasing more so in winter as the combustion of heating fuels increase.

There are risks of earthquakes taking place especially in the south side of Istanbul of the Marmara sea where an active fault, a branch of the North Anatolia faults runs East-west direction (IMM & JICA, 2008). Illegal residential areas in or near geologically hazardous zones create serious problems for the City as they are situated in dangerous seismic zones. Buildings in geologically hazardous zones expose households to high mortality risks and loss of property in case of an earthquake.

Ercan (2010) citing Dinçer (2009) adds that the changing urban environment in Istanbul has matched the changes in the socio-spatial structure, strengthening urban segregation and social exclusion. This is more evident where by low income groups live in established gecekondu (informal houses) with the affluent living in new luxurious, introverted, multifunctional and highly secured neighbourhoods.

In terms of employment, as compared with the average rate of 0.33 employments per population of Istanbul, the east section has a lower rate of 0.27 for the year 2005. This implies lack of employment in the East section with a number of residents commuting daily from the East section to either the North or the West section by crossing the Bosphorus strait for work. This is shown in the Table 3-2.

Table 3-2: Employment growth and rates in Istanbul by section

Section	Employment at work space						Employment at home		
	Number			share%		Ratio of employment/pop		Number	Work place/home
	1996	2005	Growth %	1996	2005	1996	2005		
East section	661,553	1,081,535	5.6	26.2	28.9	0.2	0.27	1,328,140	0.81
North section	538,206	657,527	2.2	21.4	17.6	0.45	0.49	459,806	1.43
West section	1,317,267	2,119,925	5.4	52.3	56.7	0.27	0.34	2,038,314	1.04
1996 study area	2,520,311	3,736,355	4.5	100	100	0.27	0.33	3,759,826	0.99
2005 study area	-	3,862,821	-	-	-	-	0.33	3,831,347	1.01

Source: 1996 and 2005 IMP Transport Master Plan study in (IMM & JICA, 2008)

## 4. RESEARCH METHODOLOGY

*This chapter discusses the methods used to answer the research questions defined to meet the research objectives of the study. In order to achieve the main objective, the city of Istanbul was selected as the case study. Reasons for choosing Istanbul are presented. Criteria used in collecting secondary and primary data are as well detailed. Both quantitative and qualitative techniques were used. The chapter winds up with a description of the methods used to achieve each research objective.*

### 4.1. Rationale for Istanbul case study

A case study approach was adopted in order to enable the researcher to closely collect and review primary and secondary data in the context of multiple deprivations. The final goal was to evaluate how the analysis of multiple deprivations is influenced by MAUP in Istanbul. The aim was to make it more realistic with the adoption of a case study approach. Zainal, (2007) recommends that its role as a method in research is more prominent when issues with regard to education, poverty, unemployment, drug addiction and illiteracy are raised. Thus, it would be scientifically sound to make analysis and generalizations that can be applicable to different cases of the same nature.

It is clear from literature that Istanbul faces different kinds of deprivations ranging from overcrowding, unemployment to poor access to transport services. For example, Bolen et al. (2005) notes that indicators like high population growth rate, unbalanced income distribution, low income per capita, all point to the existence of problems in Istanbul. However, little has been done in regards to both mapping deprivation and analyzing its spatial characteristics. Research on the effects of MAUP on urban socio-economic phenomena in Istanbul has so far not been identified. At the backdrop of these research gaps, Istanbul was also chosen due to availability of data at different spatial scales i.e. at the neighbourhood (Mahalle) and district level (Ilce). A series of interviews with experts (scientists, decision makers, etc.) needed to be conducted too.

### 4.2. Data collection

#### Overview of Fieldwork activities

Data collection was done through a 21 day fieldwork exercise in Istanbul with technical and logistical support from IMP. The following activities were planned and executed.

- 1) Collection of secondary data.
- 2) Collection of primary data.
  - i. Making arrangements and appointments for key informants.
  - ii. Pilot testing of the key informant questionnaire.
  - iii. Administering key informant personal interviews.
  - iv. Administering key informant mail interviews.
  - v. Transcription of recorded interviews.

#### 4.2.1. Secondary data collection

Acquisition of secondary data was a major task for this fieldwork. The main data items to be elicited were socio-economic variables found mostly on national population censuses. However, after putting significant efforts to obtaining it including paying for its dissemination, it was realized that census data for Istanbul could only be given at a much aggregated provincial level. Therefore, there was need to look for other sources of socio-economic data. A household survey from IMP done for developing a transport

master plan in 2006 sufficed, albeit having limited socioeconomic variables. This was used for developing the indicators to be used in meeting the research objectives. Other options of getting significant data for Istanbul, disaggregated at neighbourhood level were also explored. This included a UN-Habitat Turkey Demographic and Health Survey (TDHS) 2003. However this survey data was not used for two reasons: it was older compared to the IMP household survey of 2006 and more crucial was that it was a survey done for the whole of Turkey and that data was only available at provincial level based on the Nomenclature of Territorial Units for Statistics (NUTS).

Administrative boundary data (both the new and old) district and neighbourhoods boundaries for the province of Istanbul were acquired in Arc GIS shape file format. Table 4-1 gives a summary of the acquired secondary data.

Table 4-1: Secondary data acquired from fieldwork

<b>Data</b>	<b>Unit of aggregation</b>	<b>Year</b>	<b>Format</b>	<b>Attributes</b>	<b>Source</b>
Household Survey	District Neighbourhood	2006	SPSS Excel	Demographic and Socio economic variables with a sample size of 255,403	IMP
New and old district layers	District	-	ArcGIS	-	IMP
New and old neighbourhood layers	Neighbourhood	-	ArcGIS	-	IMP
Census data	Provincial	2008 2009	Excel	Demographic and Socio economic variables	Turkish Institute of Statistics
Demographic and health survey for Turkey	District	2004	SPSS	Demographic Socioeconomic variables	UN-Habitat

#### 4.2.2. Primary data collection

Primary data collection included making arrangements and appointments for the key informant interviews, pilot testing of the key informant questionnaire, administering key informant personal and mail interviews. A series of nine interviews with experts and policy makers were carried out. Specifically, Table 4-2 shows the experts, their field of expertise, language and nature the interviews administered.

Table 4-2: Key informant interviews

<b>No</b>	<b>Informant</b>	<b>Institution</b>	<b>Language</b>	<b>Type of interview</b>	<b>Data capture</b>
1	Expert	YTU	English	Face to face	Recording Shorthand notes
2	expert	ITU	English and Turkish	Face to face	Recording Shorthand notes
3	Expert	IMP	English	Face to face	Recording Shorthand notes
4	expert	IMP/ ITU	English	Face to face	Recording Shorthand notes

No	Informant	Institution	Language	Type of interview	Data capture
5	Expert	IMP/ ITU	English	Face to face	Recording Shorthand notes
6	Expert	YTU	English	Email	Email
7	Expert	METU	English	Email	Email
8	Policy maker	IMM	Turkish	Face to face	Recording
9	Policy maker	IMM	Turkish	Face to face	Recording

#### 4.2.2.1. Key informant interviews

Discussions with key informants regarding the modifiable areal unit problem and its effects on the analysis of multiple deprivations were executed. Given the nature of the geography of urban deprivation and MAUP, the experts and policy makers were carefully identified and selected. Agreed on by the researcher were literature review and looking through websites of such university departments as urban, regional planning and, architecture. Criteria applied looked at areas of research, scientific publications and research interests of the experts.

Snowballing approach was also applied where initial interviewees were asked to make recommendations for subsequent key informants. They included senior university lecturers, university professors, research consultants and professionals researching or working on socio-economic domains, quality of life, urban inequities, spatial statistics or census geographies. Key Informants at IMP and Istanbul Metropolitan Municipality were identified through recommendations by contact persons.

Appointments for interviews were done through emails and telephone calls. Techniques used to obtain information from the key informants relied heavily on their availability and logistical feasibility as well as their preferred choices. Based on this, either Face to Face or email interviews were administered.

Discussions were held with researchers from Istanbul Technical, Yildiz Technical and Middle East Technical universities. This sought to answer questions related to Istanbul urban deprivation and the modifiable areal unit problem. However, due to logistical problems, responses from Middle East Technical University were through email correspondence (see Table 4-2). From these discussions, the main urban deprivations in Istanbul and geographical units of analysis used in analyzing urban phenomena were elucidated.

At IMP, three urban planners were interviewed, two of them being researchers attached to Istanbul Technical University. The aim was to collect data on work done by the planning authority in regards to urban inequalities in Istanbul or urban deprivation; geographical units of analysis used; the general planning scales; and the general structure of the planning system in Istanbul.

Discussions with two senior urban planners from Istanbul Metropolitan Municipality were also held. The idea was to establish policymakers' views and roles in the choice of certain geographical units of analysis for certain socioeconomic dimensions. More crucial was their opinion on the possible implications to policy intervention with regard to the problems that occur when interpretations based on spatial analysis change when the same data is analysed at different geographical units.



Pilot testing of the key informant questionnaire was done to check for errors the respondents would make due to the manner in which the questions were presented besides improving the quality of data collected. After testing, it was found necessary to unify related questions into one. Notably, interview schedules had related questions and only some parts were modified to reflect the role of the interviewee where it mattered e.g. policy makers. For example, some questions addressed to experts would be modified in the policy makers' questionnaire in order to reflect their role (see Appendix 3)

### **Transcription of recorded interviews**

All interviews conducted were recorded while simultaneously taking short hand notes. Transcription was done to fill in the gaps on the notes taken with the help of a translator in cases where the interview was in Turkish.

### **4.3. Data validity and quality control**

Due to language issues, some of the interviews were done in Turkish. Datasets were in Turkish too. This needed translation to English for the purposes of future analysis and ease of reference. Hence three research assistants were hired to facilitate much of the translation work at IMP.

During the preparations for the interviews, the key informant questionnaires were discussed with colleagues and supervisors whereby later versions were amended depending on their comments and criticisms. In other cases, some shorthand notes done during interviews and recorded responses were transcribed and the compiled write-ups sent to the interviewees for proof reading to ascertain if it reflected the issues discussed.

Greater benefits of the primary data collection accrued with the presence of one of the thesis supervisors on the ground. Even though for a short period of time, his advice and critical comments especially during and after the pilot interview helped a great deal in reshaping the subsequent discussions with experts.

### **4.4. Fieldwork limitations**

Through out the fieldwork phase, a number of limitations were experienced. These are listed in the following paragraphs.

- Language in itself was a major barrier in this study especially during fieldwork phase. All the datasets obtained were originally in Turkish, as were the literature materials.
- Soliciting for respondents was difficult. Many declined even after hitherto agreeing and assured of a translator on grounds that they would be constraint by language.
- Making telephone contacts and/or interviews was sometimes difficult particularly where recipients could not speak English. This demanded enlisting the services of bilingual research assistants for translations from Turkish to English. Limitations were evident when conducting a telephone interview in Turkish through a translator while simultaneously transcribing to English.
- The originality of the response from interviewees might have been susceptible subject to the translator's understanding of the issue.

### **4.5. Data analysis**

While it has been shown that most studies on urban deprivation use census data, General Social Survey (GSS) is also a potential source of data (Langlois & Kitchen, 2001). As such, the IMP household survey of 2006 (see Table 4-1) is adopted for this study for two reasons. It was hitherto the largest household survey done for the city of Istanbul with a huge sample size of 255403 cases. Secondly, it has important socio-economic variables from which indicators on multiple urban deprivations can be constructed to test MAUP. Finally, data is available at two levels of aggregation: at neighbourhood and district scales.

#### 4.5.1. Processing the indicators: Rationale behind choice of items

Data preparations on the selected socio-economic and demographic variables were performed. The variables were conceptually grouped into five main domains i.e. income, demographic, education, assets and employment. It's from these domains that indicators for Istanbul urban deprivations were identified and defined. However, besides seeking to analyze multiple deprivations using aspects generated from discussions with experts and policy makers, the operational definitions and final selection of the indicators described below were also adapted to the data sources available locally. Martinez (2009) advances that data availability is one of the criteria for selection of indicators, in addition to policy relevance. These are shown in the Table 4-3 :

Table 4-3: Dimension of multiple deprivation and definition of selected indicators

Dimension	Variables	Definition of indicators
1 Income	MHINCOME	Median household income in Turkish Lira
	LHINCOME	Proportion of all households living below the median income
2 Demographic	VERYOUNG	Proportion of people aged 15-25 years
	VERYOLD	Proportion of people aged 65 years and over
3 Employment	YOUNGUNEMP	Proportion of young people aged 15-25 unemployed
	MALEUNEMP	Proportion of males aged 15 years and over who are unemployed
	FEMALEUNEMP	Proportion of females aged 15 years and above who are unemployed
4 Education	EDULOW	Proportion of the population 15 years and over whose level of education is primary, intermediate or elementary school
	ILLITERATE	Proportion of people aged 15 years and over who cannot read or write
5 Assets	RENTERS	Proportion of household occupants who are tenants
	NOCAR	Proportion of people with no car

The two incomes related variables are median income (MHINCOME) and low income (LHINCOME) which represent direct measure of deprivation. The demographic dimension includes the youth (VERYOUNG) and the aged population (VERYOLD) which were selected because this part of the population are more susceptible to the effects of economic and urban change (Langlois & Kitchen, 2001) and thus they are more vulnerable to deprivation. In the employment domain, three variables were included: unemployed youth (YOUNGUNEMP), unemployed male (MALEUNEMP) and unemployed female (FEMALEUNEMP) which are vivid measures of urban deprivation. Unemployment subjects people to circumstances in which they cannot generate income resulting to poor standards of living.

People with low levels of education (EDULOW) and those considered illiterate (ILLITERATE) were also considered as they show a more direct measure of deprivation. People with low levels of education also are more prone to suffer from deprivation. Adult literacy is also a good indicator of the usefulness of public participation, thus an important indicator of governance (UN-Habitat, 2004). Uneducated people

hardly understand and communicate local issues which are vital in influencing the outcome of decision making. It is also true that, people who are under educated or illiterate hardly find economically sustainable jobs hence they have low or no income. For assets, people who are not owner occupiers and therefore renting houses (RENTERS) are chosen since they tend to have low incomes and have very few alternatives with respect to place of habitation. In other contexts they might be more prone to evictions as a result of lack of tenure security. Ownership of assets is also an indicator of deprivation. People who own a car means that they have disposable income where as those without (NOCAR) have limited mobility and have to depend on public transport which is inefficient in many countries.

#### **4.5.2. Meeting the research objectives**

This section addresses the methods applied to meet each research objective.

##### **Objective one: To review the geographical units of analysis applied when mapping deprivation in Istanbul.**

The geographical units of analysis commonly used when mapping multiple deprivations were identified through literature review and key informant interviews. Answers to the research questions of what scale policy makers look at different deprivations and the constraints that affect the choice of scale for a particular deprivation were also determined from both existing literature and key informant interviews. The key informant questionnaire had open ended questions to give key informants opportunity to give explicit answers (see annex for questionnaire) towards answering the research questions.

##### **Objective two: To examine the effects of the modifiable area unit problem (MAUP) on different forms of deprivation at different scales.**

The above indicators defined in Table 4-3 were used to develop a conceptual model for the general deprivation domains index (GDD) and an Index of Multiple Deprivation (IMD). The conceptual model illustrated in Figure 4-1 was executed in a multi-criteria analysis framework at the neighbourhood, actual Istanbul districts and the newly designed districts using ILWIS GIS version 3.7.1 (see Appendix 5). A dbf file containing all the indicators was linked to the boundaries (neighbourhood, actual Istanbul districts and the newly designed districts) through a primary key. In ILWIS, an attribute map of all the indicators was prepared with its spatial distribution across each boundary. Interval standardization of the attribute maps was done to transform the values to a score ranging from 0 (low deprivation) to 1 (high deprivation). During standardization, all the variables were treated as benefits except MHINCOME which was treated as a cost.

For the final production of the maps, the standardized indicator maps were aggregated through weighted summation by assigning equal weights to all indicators within a certain domain and all the domains for the final index map. Running the spatial multi-criteria analysis in ILWIS involved combining indicator maps into a composite index map in which bad performance on one criterion could be compensated by good performance on another, resulting in average deprivation levels (Baud, et al., 2008) across all three boundaries: Neighbourhood, actual districts and new district designs. Finally, particular indicators were synthesized into a general deprivation domain index map and then all deprivation domains synthesized and aggregated into the final index of multiple deprivations.

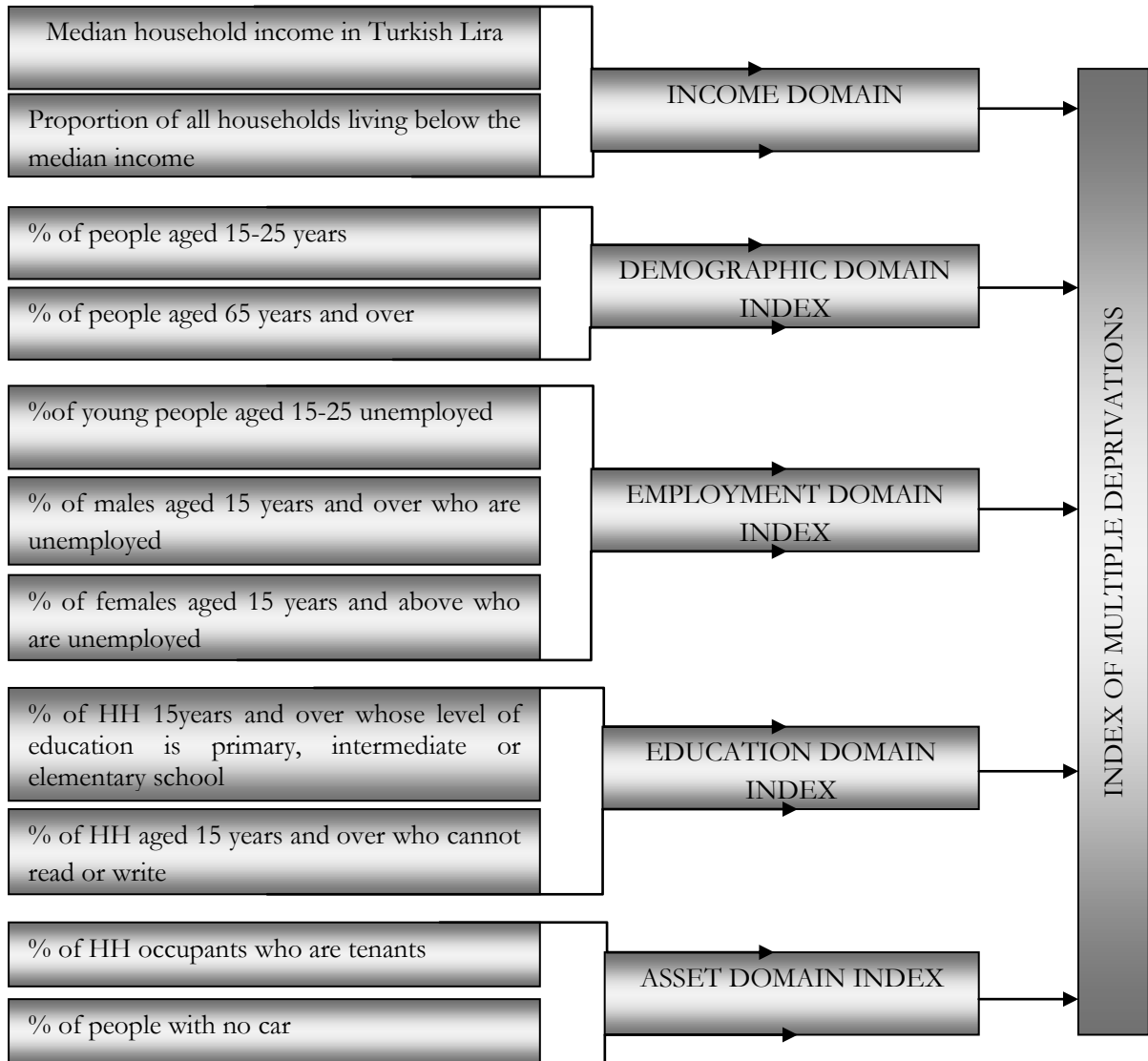


Figure 4-1: Conceptual model processed in multi-criteria evaluation framework for developing general deprivation domains indices and the IMD

The IMD is undoubtedly a valuable guide for informing the targeting of resources and policy initiatives to areas of particular need. It is extensively used for this purpose both by government departments and by many local authorities (Deas, et al., 2003). The index can also catch the concentrated and predominant aspects of inequality (Martínez, 2009) in an area. Here, GDD and IMD are devised to study the spatial patterns of multiple deprivations and how it is influenced by MAUP. Figure 4-1 shows how the GDD and IMD were developed and used.

Analysis of the data was done through a number of statistical techniques which included correlation and regression analysis, descriptive statistics, *t* test and Levene’s test. More precisely, in order to examine the impact of the modifiable areal unit problem (scale and zoning effect), the following steps were followed.

**The scale effect** was examined by analyzing household survey data in SPSS through statistically testing the mean of the data by computing a *t* test, variance by Levene’s test and regression coefficients at two different scales: neighbourhood and district. Levene’s test for equality of variances was used in the same manner as Hayward & Parent, (2009). The scale effect was also tested by producing choropleth maps using the general deprivation indices and the IMD at multiple scales in ILWIS 3.7.1 environment. For

accurate comparisons between the scales, proportionate classification schemes (quartile rankings) for all the index maps were applied by slicing (see Appendix 6) them into the following classes:

- Least deprived
- Moderately least deprived
- Moderately highly deprived
- Highly deprived

Investigating the influence of **the zoning effect** on the interpretation of multiple deprivations was achieved by comparing the real Istanbul old district (*Ilce*) maps against alternative new district designs that were created and analysed using Districting extension on Arc Map 10. The criteria for designing the new districts were based on random assignment of neighbourhoods to form a particular district design.

Districting is a freeware add-on extension to ArcGIS 10 software. The Districting for ArcGIS add-on allows you to create defined groupings of spatial data, such as census tracts, and neighbourhoods by creating a districting plan (ESRI (Environmental Systems Research Institute), 2010). It presents a simplified user interface for swift configuration of geographic representation and analysis of those configuration alternatives. The foundation for creating the new district designs was source boundaries and source attributes. Source boundaries are spatial data used for assigning units into districts whereas source attributes are the attributes that are associated with the source geography. The source geography and source attributes can be stored in separate files or contained within the same file. Istanbul neighbourhoods together with their attributes were used as the base data and grouped based on random aggregation to form the new district units. This was done by simply selecting them in Arc Map 10 and aggregating to 32 districts of different configurations from those of the actual Istanbul old districts. The Districting for ArcGIS add-on then assisted in analyzing the variables and recalculating the indicators. In total three new different district configurations were designed. However in the analysis, only one district configuration that was seen to have distinct zoning systems from the actual districts was used.

Here also statistical techniques: mean and *t* test, variance and the Levene's test, and correlation and regression analysis were also used. Composite maps at multiple scales in ILWIS 3.7.1 environment were produced too, to assess the influence of the zoning effect on the spatial dimensions of multiple deprivations. In order to make accurate comparisons between the scales, proportionate classification schemes for all maps were applied in the same way as in the scale effect.

Responses from key informant interviews were synthesized to unravel the implications to urban policy and planning by the zoning and scale effect of MAUP. Answers to this question were also supported by literature review.

**Objective three: To find out the scale of analysis that is more appropriate for a particular aspect of deprivation.**

This question was answered through responses from key informants as well literature review to single out recommendations for appropriate units of analysis for aspects of multiple deprivations. This was supported by cross-examining the results of objective two.

Factors influencing the choice of a certain administrative boundary when mapping multiple deprivations were determined from the key informant interviews. The rationale for investigating this was to get a general understanding of the reasons as to why researchers would choose a particular boundary for instance, a district and not the whole province when mapping multiple deprivations. Respondents were asked to discuss various reasons to answer this research question.

## 5. MULTIPLE DEPRIVATION AND EFFECTS OF MAUP

*This chapter provides the dimensions of multiple deprivations identified in Istanbul. It also presents in depth results on the influence of the scale and zoning effect on spatial patterns of multiple deprivation, descriptive statistics and regression analysis. Results of independent t test and Levene's statistic testing the influence of the MAUP on the mean and variance and whether or not the differences in descriptive statistics by scale or district design are significant are described. Finally discussions of the results of analysis are made.*

### 5.1. Identifying multiple deprivation

#### 5.1.1. Dimensions of multiple deprivations in Istanbul

In Istanbul, a basic distinction was made between social and material deprivations, and so are the aspects within these concepts. This helped in explaining social conditions and the existence of deprivation. A questionnaire was developed with a list of 24 deprivation aspects (see Appendix 2) which were taken from already existing studies. For example, building on Townsend's (1987) work, the questionnaire was dichotomized into material and social deprivation with a list including material needs but also aspects that are a form of social deprivation.

Experts and policy makers were asked to identify from a list on the questionnaire, aspects of deprivation that occur in Istanbul or which they researched on. Based on the level of consensus and the level of discussion generated, particular aspects were eliminated, added or kept. Ultimately, the following deprivations were identified:

#### Material deprivation

- Overcrowding
- Environmental degradation
- Industrial pollution
- No recreational facilities
- No broadband services
- Poor access to public transport
- No car ownership
- Inadequate housing and informal houses (*gecekondu*s)

#### Social deprivation

- Illiteracy
- Low income
- Low levels of education
- Young unemployment
- Male and female unemployment

The above items were recommended as valid in the sense that they reflected conditions, standards and activities of multiply deprived individuals in Istanbul. It was believed that some of the aspects listed on the questionnaire did not reflect local characteristics. As such, aspects like no telephone or no television could not be used as a measure of deprivation since almost every household in Istanbul owned one. Thus, as an expert<sup>4</sup> explained, more specific measures of deprivation needed to be included for the Istanbul case:

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<sup>4</sup> Discussions with an expert from a University, Istanbul, October 2010

*“Connection to the internet and also those types of broadband or wireless communication technologies is a more important measure of deprivation that makes the society go further or go beyond for economic purposes unlike measures relating to ownership of a telephone or refrigerator. Transportation infrastructure issues in Istanbul are not a problem but accessibility to public transport is really an important factor for measuring deprivation as well”.*

Although listed on the interview schedule, some significant measures of social deprivation were not identified as important aspects in the above list. For instance, no paid holiday was eliminated since it was rendered obsolete; all holidays in Turkey are paid.



Figure 5-1: An environmentally deprived part of a neighbourhood in Beyoglu, Istanbul

There was a general consensus that overcrowding, industrial pollution, environmental degradation (Figure 5-1 shows a form of degradation to the quality of the environment) and high unemployment levels were major problems. Illiteracy and low levels of education mostly among immigrants were also emphasized as the major forms of deprivations in Istanbul.

A list of eleven indicators was developed to reflect the types of deprivations in the above list. These are deemed key indicators of concrete living standards in the sense of existing patterns in Istanbul whose absence indicates a form of deprivation. However, to ease testing the issues of MAUP, the list was adapted to the local data available from Istanbul. From these indicators, general deprivation domains and an index of multiple deprivations is constructed.

### 5.1.2. General deprivation domains (GDD) and the Index of Multiple Deprivation (IMD)

The general deprivation domains and the Index of Multiple Deprivation (IMD) are developed to capture and synthesize the above deprivations into one index score for Istanbul. Most other studies (Bailey, et al., 2003; Baud, et al., 2009; Baud, et al., 2008; Eroğlu, 2007; Harris & Longley, 2002; Langlois & Kitchen, 2001; Noble, et al., 2010; Noble, et al., 1999; Schuurman, et al., 2007) also developed an index of multiple deprivation in their socio-economic analysis of problematic areas for area targeting. IMD allows better insight into poverty with better targeting possibilities for policy-makers (Baud, et al., 2008). In this study, IMD is developed in a similar sense to that used in these studies to refer to the inadequacy of certain standards of living perceived to be central to household well-being (Eroğlu, 2007).

Objectively, this study adopted the general deprivation domain indices and the Index of Multiple Deprivation against the backdrop of the above highlights and the fact that it has been a major tool in the analysis of multiple deprivations, as such for testing the influence of the scale and zoning problem of MAUP.

## 5.2. The modifiable area unit problem

This section presents results of analysis on the effects of MAUP on IMD and asset, education, income, employment and demographic deprivation domains indices.

### 5.2.1. The scale effect on the index of multiple deprivation

Figure 5-2 demonstrates the impact of the scale effect of MAUP using an index of multiple deprivations (IMD) constructed for the case of Istanbul at two different spatial scales: the neighbourhood and district boundaries. The neighbourhood boundaries are the smallest units through which socio-economic data is available to the public in Istanbul.

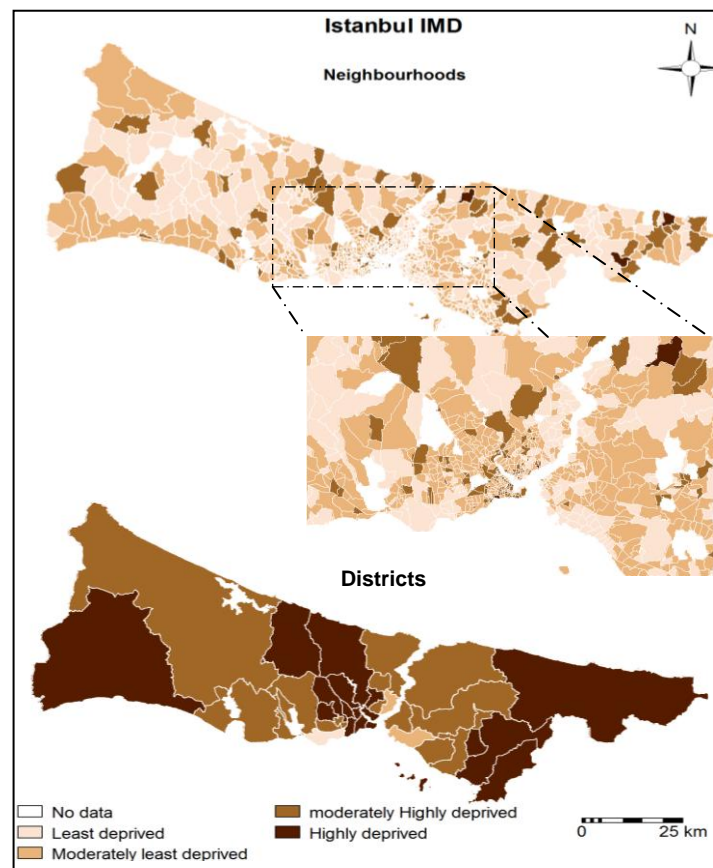


Figure 5-2: Scale effect of MAUP: Istanbul deprivation quartile rankings using the Index of Multiple Deprivation (IMD) on neighbourhood and district boundaries

By doing multi criteria evaluation overlays using the district and neighbourhood layers of Istanbul, maps of different deprivation indices were produced. The resultant map of the index of multiple deprivations shows the spatial variation of deprivation when examined at both scales. Light colour indicates least deprived whereas dark colour represents highly deprived areas. Evidently, Figure 5-2, shows that in Istanbul, spatial concentration of deprivation is well depicted at the neighbourhood level. It can be observed from the zoomed in area that there is more heterogeneity at the neighbourhood scale. As such, in wards which are highly deprived from the rest can be delineated. Here also hotspots of multiple



deprivations can be clearly identified. However, more interestingly, these deprived neighbourhoods and the heterogeneity that emerge when working at lower levels of aggregation seem to disappear when the indices are constructed and analysed at the district scale. Spatial patterns manifested at the neighbourhood scale begin to wane. Clearly, districts have a homogenizing effect to deprivation. For instance, the neighbourhoods at the eastern part of Istanbul have varying classes of deprivation ranging from least deprived to highly deprived in regards to the IMD. But after aggregation, they are averaged with the district becoming highly deprived thereby losing all the other classes.

The differences in the geographical patterns of multiple deprivations between the neighbourhood and district units are also examined for the asset, education, income, employment and demographic deprivation domains indices. This is presented in the sections below.

**5.2.2. The scale effect on material and social deprivation**

As shown in Figure 5-3, the nature of the areal unit in the visualization of a particular deprivation domain is a key factor owing to the influence of the scale effect. The asset and education deprivation domain index maps, exhibit spatial patterns not so different from those by the IMD at both scales. For the education and to a lesser extent, the asset domain index map, spatial variations emerges to be so small at the district scale. A higher number of districts get comparatively the same classification: moderately highly deprived. This shows the opposite when analysis is done at the neighbourhood level since differences in socio economic status can be seen across different units. On both maps of the asset and education deprivation domain indices, the small scale map below explains a generalized picture of deprivation, but the large scale map on top demonstrates a more detailed description of small areas.

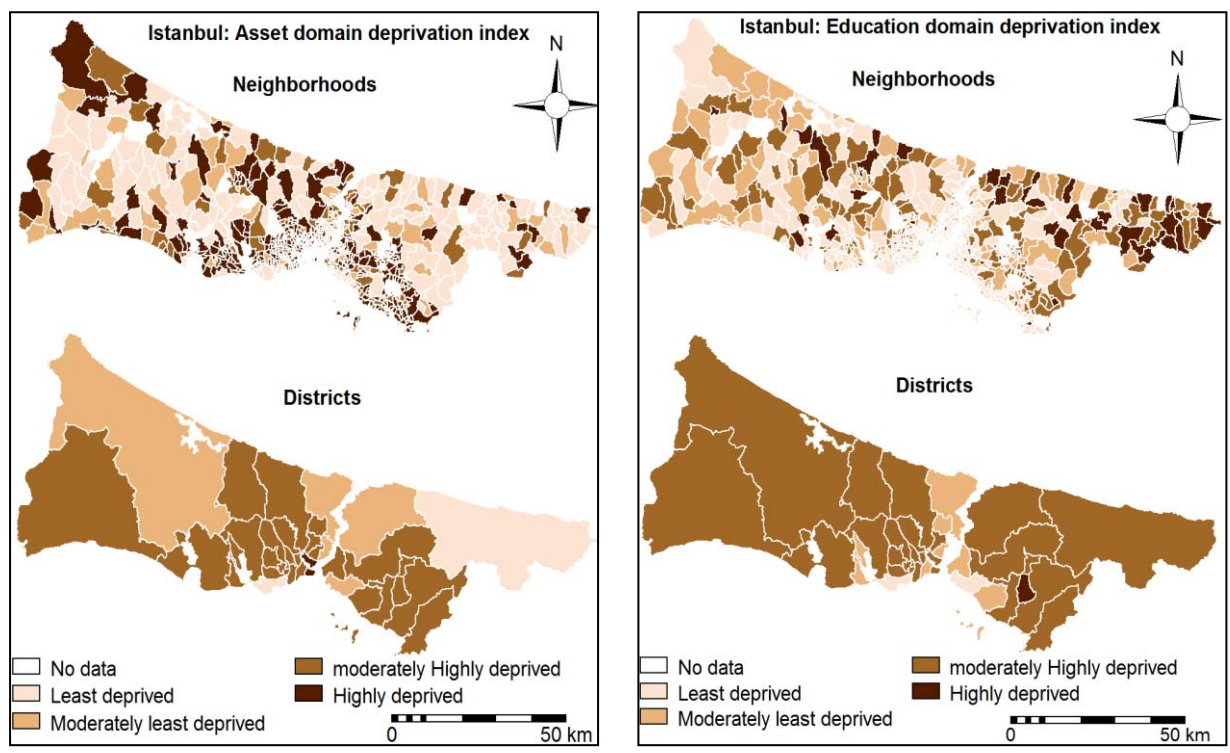


Figure 5-3: Scale effect of MAUP: Istanbul deprivation quartile rankings using the asset and education deprivation domain indices on neighbourhood and district boundaries

The education domain map shows a unifying effect at the district level. All the districts except those lying on the central part of Istanbul are moderately highly deprived whereas the corresponding units at the neighbourhood scale show a clear deprivation differentiation. These neighbourhoods have distinct

deprivation classes. All these results highlight the influence of the scale problem on the understanding of the spatial patterning of multiple deprivations.

The benefits of using geographical information systems and multi-criteria analysis to construct deprivation indicators into composite indices are also clearly apparent in the figures below. It made it easier to illustrate the scale effect on analyzing deprivation at multiple scales for all deprivation domains. Figure 5-4 maps the potential problems of the scale effect. Dissimilar to the neighbourhood scale map of the income domain in which some neighbourhoods to the west of Istanbul are moderately least or highly deprived, the corresponding larger units in the district scale are only moderately highly deprived. While the district to the East of Istanbul is the least deprived, the aggregated neighbourhoods for the same district have nearly all the commensurate classes whereby only two are highly deprived. The employment deprivation domain map illustrates the same averaging pattern. Whereas there are no neighbourhoods which are highly deprived to the East, certainly one district becomes highly deprived on the district scale for the same areal units to the East. A significant number of the other districts are moderately least deprived whereas some of their constituent neighbourhoods are least deprived.

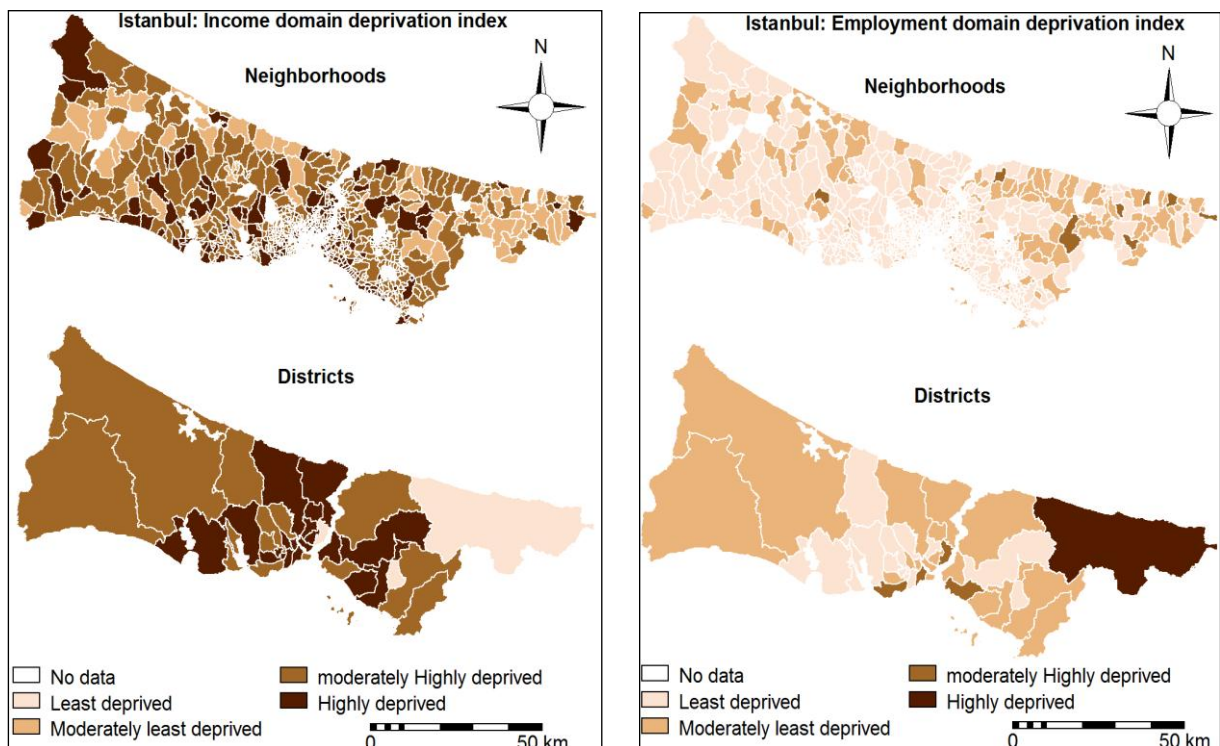


Figure 5-4: Scale effect of MAUP: Istanbul deprivation quartile rankings using the income and employment deprivation domain indices on neighbourhood and district boundaries

In Figure 5-5 while there are only four neighbourhoods that are highly deprived and several others which are moderately highly and moderately least deprived to the East, the corresponding areal units on the district scale becomes highly deprived. A similar observation can be seen to the West of Istanbul. Also the Eastern part of the European part of Istanbul shows a clear differentiation of deprivation on both scales with the district scale being unified to moderately highly deprived. It's worth noting that the demographic deprivation domain is not a measure of deprived individuals, but a measure of people who are more prone to suffer from deprivation (see section 4.5.1). From the above observations, it can be concluded that, the scale problem causes spatial patterns of multiple deprivations manifested at the district to over or under state those of the neighbourhood scale in Istanbul as demonstrated by IMD and the deprivation domain index maps. The district scale assigns a common score (e.g. highly deprived) to areal units which have varying deprivation scores on the neighbourhood scale. In most of the districts that are classified as highly

deprived, only few neighbourhoods have the same class. The map of the IMD of Istanbul best demonstrates this observation.

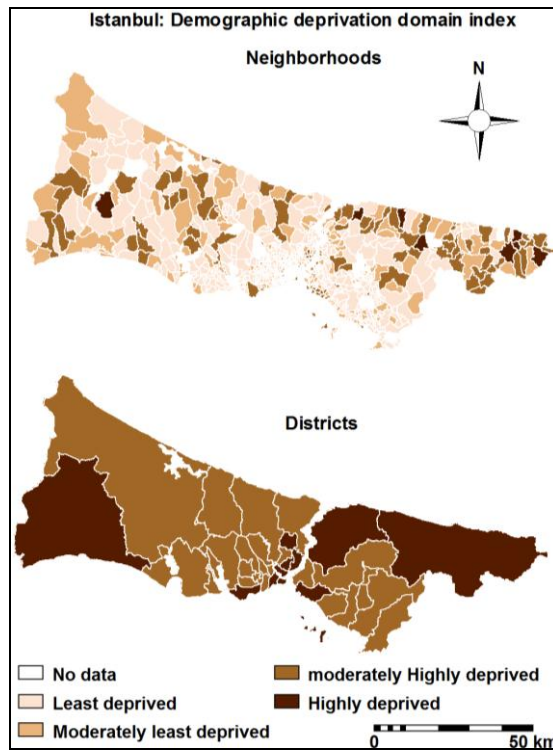


Figure 5-5: Scale effect of MAUP: Istanbul deprivation quartile rankings<sup>5</sup> using the demographic deprivation domain index on neighbourhood and district boundaries

### 5.2.3. The scale effect on descriptive statistics

Scale effect was evident from the statistical nature of multiple deprivations as differences in descriptive

Table 5-1: Descriptive Statistics by scale

Variables	Mean		Std. Deviation		N	
	Neighbourhood scale	District scale	Neighbourhood scale	District scale	Neighbourhood scale	District scale
LHINCOME	43.60	45.88	20.01	9.92	950	33
NOCAR	66.10	67.37	16.87	9.06	950	33
RENTER	30.40	33.33	18.03	9.70	950	33
MHINCOME	840.21	830.61	383.21	180.12	950	33
VERYOUNG	19.20	19.69	6.81	3.00	950	33
VERYOLD	8.02	6.739	7.76	4.32	950	33
YOUNGUNEMP	11.97	12.19	4.49	1.33	950	33
MALEUNEMP	14.49	13.65	6.33	2.61	950	33
FEMALEUNEMP	32.19	31.43	5.83	2.39	950	33
EDULOW**	46.27	44.63	13.18	6.92	950	33
ILLITERATE	13.38	13.72	6.46	3.25	950	33

<sup>5</sup> See Appendix 7 for the quartile ranking system used. This used a different ranking system from other maps. This is not a measure of deprived people, but a measure of people who are more prone to suffer from deprivation. There was need to show variation between the different areal unit definitions

statistics by scale were seen. For instance, in Table 5-1 the neighbourhood scale mean rate for LHINCOME was found to be 43.6 % while that of the district was 45.9%. Also on average, the percentage of NOCAR, LHINCOME, RENTER, VERYOUNG, YOUNGUNEMP and ILLITERATE was greater at the district than it was at the neighbourhood scale. For the mean percentage of MHINCOME, VERYOLD, MALEUNEMP, FEMALEUNEMP and EDULOW, it was observed that, the result was higher on the neighbourhood than was at the district scale. However, from the results of the independent samples t test on Appendix 10, these differences were statistically non significant at  $p > .05$  (see Appendix 8 for a complete reporting of the t test results). The value of the standard deviation for each form of deprivation was different depending on the scale of aggregation. It was seen to have higher values at the neighbourhood level than at the district. For example, the standard deviation for LHINCOME was 20.01 at the neighbourhood while on the district scale it was 9.92. A reflection that neighbourhood scale shows more heterogeneity.

Levene's test for equality of variances (Appendix 10) confirms the scale influence on the mean rates of multiple deprivations. Variances were significantly different on the district and neighbourhood scale, at  $p < .05$ . By comparing these statistical findings, with the variations in spatial patterns by scale, the potential problems of the scale effect emanating from data aggregation can be highlighted.

#### **5.2.4. Scale effect on regression and correlation analysis**

A correlation matrix was generated for all variables on the district and neighbourhood scales. This in itself was an indication as to whether the value of the correlation coefficient was subject to scale. The results of the analysis (in Table 5-2) indicate that scale effect had significant influence on the coefficient of correlation. For instance, one of the major effects was seen between ILLITERACY and NOCAR. The value changed from .363 on the neighbourhood scale to .633 on the district scale; and between EDULOW and MHINCOME where the value changed from -.541 on the neighbourhood scale to -.850 on the district scale; the correlation was significant at the 0.01 level. However, a slight influence was observed on the correlation between VERYOLD and RENTERS where the change on the value of the correlation coefficient was only by -.058. The sign of the correlation coefficient along with the statistical significance was seen to change in some cases as a result of the scale alteration e.g. between YOUNGUNEMP and NOCAR and also between VERYOLD and MHINCOME.

Table 5-2: Correlation matrix between deprivation variables on the neighbourhood and district scale

	LI	NC	RE	MI	VY	VO	YU	MU	FU	EL	ILL
LI	N 1										
	D 1										
NC	N -.353*	1									
	D -.527*	1									
RE	N .168*	.353*	1								
	D .151	.473*	1								
MI	N .750*	-.450*	.063**	1							
	D .931*	-.642*	.049	1							
VY	N -.045	.248*	.415*	-.090*	1						
	D -.089	.376**	.789*	-.116	1						
VO	N -.063**	-.216*	-.421*	-.008	-.435*	1					
	D -.002	-.256	-.479*	.126	-.723*	1					
YU	N -.037	.073**	.218*	-.048	.645*	-.294*	1				
	D .126	-.126	.469*	.209	.735*	-.585*	1				
MU	N -.129*	-.121*	-.240*	-.114*	-.165*	.626*	.093*	1			
	D -.029	-.380**	-.468*	.123	-.556*	.877*	-.345**	1			
FU	N -.181*	-.182*	-.392*	-.195*	-.244*	.495*	.073**	.350*	1		
	D -.173	-.319**	-.648*	-.058	-.767*	.868*	-.494*	.807*	1		
EL	N -.571*	.278*	-.321*	-.541*	-.024	.095*	-.071**	.166*	.195*	1	
	D -.804*	.502*	-.218	-.850*	.060	-.151	-.240	-.056	.064	1	
ILL	N -.363*	.363*	.157*	-.346*	.221*	-.256*	.027	-.269*	-.176*	.068**	1
	D -.577*	.633*	.333**	-.637*	.558*	-.669*	.210	-.688*	-.609*	.522*	1

N : Neighbourhood scale

D : District scale

LI=LHINCOME, NC=NOCAR, RE=RENTER, MI=MHINCOME, VY=VERYOUNG,  
 VO=VERYOLD, YU=YOUNGUNEMP, MU=MALEUNEMP, FU=FEMALEUNEMP,  
 EL=EDULOW, IL=ILLITERATE

\* Correlation is significant at 0.01 percent (1-tailed)

\*\* Correlation is significant at 0.05 percent (1-tailed)

The regression coefficient of correlation was significantly affected by the scale at which an aspect of deprivation was computed. The R, R square and adjusted R observed from the model summary (Table 5-3 and Table 5-4) highlight the differences in the strength of the correlation and variation explained by the value at each scale. The coefficient of correlation was observed to increase as the level of aggregation

increased. The value was smaller at the neighbourhood level than at the district. These deviations confirm the influence of the scale effect on statistical patterns of multiple deprivations.

Table 5-3: The coefficient of correlation R, R square and adjusted R square at the neighborhood scale

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.796 <sup>a</sup>	.634	.630	12.172

a. Predictors: (Constant), ILLITERATE, YOUNGUNEMP, EDULOW, FEMALEUNEMP, MALEUNEMP, NOCAR, RENTER, MHINCOME, VERYOUNG, VERYOLD

Table 5-4: The coefficient of correlation R, R square and adjusted R square at the district scale

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.977 <sup>a</sup>	.954	.933	2.573

a. Predictors: (Constant), ILLITERATE, YOUNGUNEMP, RENTER, EDULOW, MALEUNEMP, NOCAR, FEMALEUNEMP, MHINCOME, VERYOUNG, VERYOLD

**5.2.5. The zoning effect on the index of multiple deprivation**

Examination of the zoning problem was done by comparing the actual Istanbul old districts map to the newly designed districts. The new districts were designed using the Districting add-on extension in Arc GIS 10.

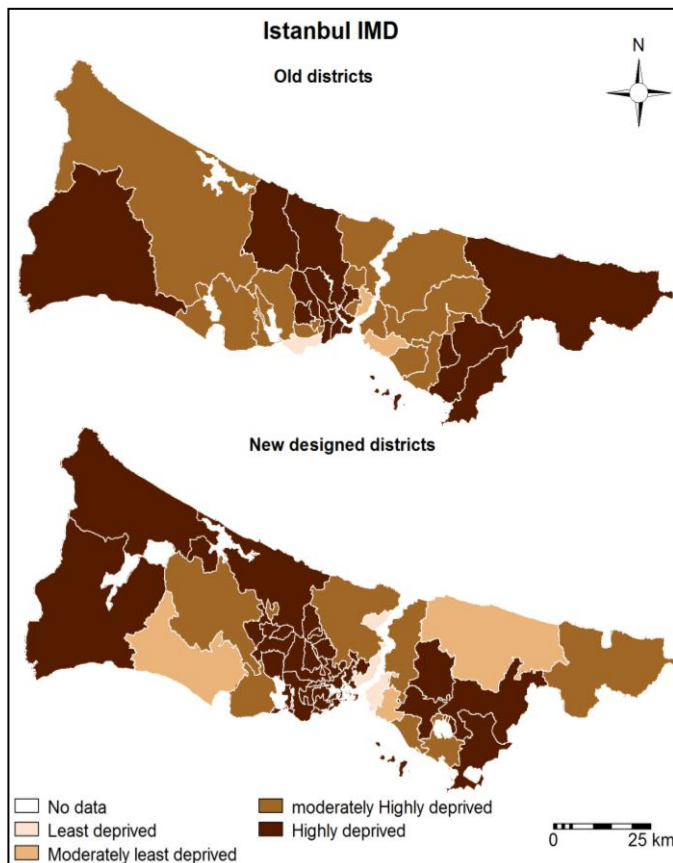




Figure 5-6: MAUP zoning effect: Istanbul deprivation quartile rankings using the Index of Multiple Deprivation (IMD) on the actual Istanbul old districts and the new designed district boundaries

The study utilized the same proportionate classification used in section 5.2.1 to test the influence of the zoning problem on the spatial patterns of multiple derivations in Istanbul. Based on quartile rankings, the scheme modelled the new district designs.

First, the IMD was constructed through multi-criteria analysis on both district designs, and then inferences from the zoning systems were made. While there were differences from the results between the two district designs, some of the geographical patterns of deprivation apparent in the new district designs mirrored those of the actual Istanbul districts. This was particularly true for the districts to the south west and south east of Istanbul on both designs which were found to be highly deprived. Furthermore, the areas along the Bosphorus strait and on the opposite sides of the Anatolian and European parts of Istanbul reflected the same deprivation patterns on both maps as shown in Figure 5-6. The areas within the south-eastern districts of the European side of Istanbul were highly deprived on both designs. However, differences can be seen for varying deprivation patterns between the two district designs. Parts of some districts that are highly and moderately highly deprived in the actual districts (Anatolian part) are moderately least deprived in the newly designed districts. It is clear that the largest of the actual old districts to the west of the European side which is moderately highly deprived reflects three dissimilar deprivation patterns (high, moderately high and moderately least) in the new designed districts.

**5.2.6. The zoning effect on material and social deprivation**

From the asset and education domain index maps in Figure 5-7, clear cut differences can be recognized from those of the old district maps. For example, in the asset domain, there are spatial units to the west and Eastern part of Istanbul which are moderately least and least deprived respectively in the actual districts. These districts are contiguous to areas which are moderately highly deprived. Meantime, these spatial units are moderately highly deprived in the new district designs; as such they no longer have the same deprivation rankings that were evident in the old districts.

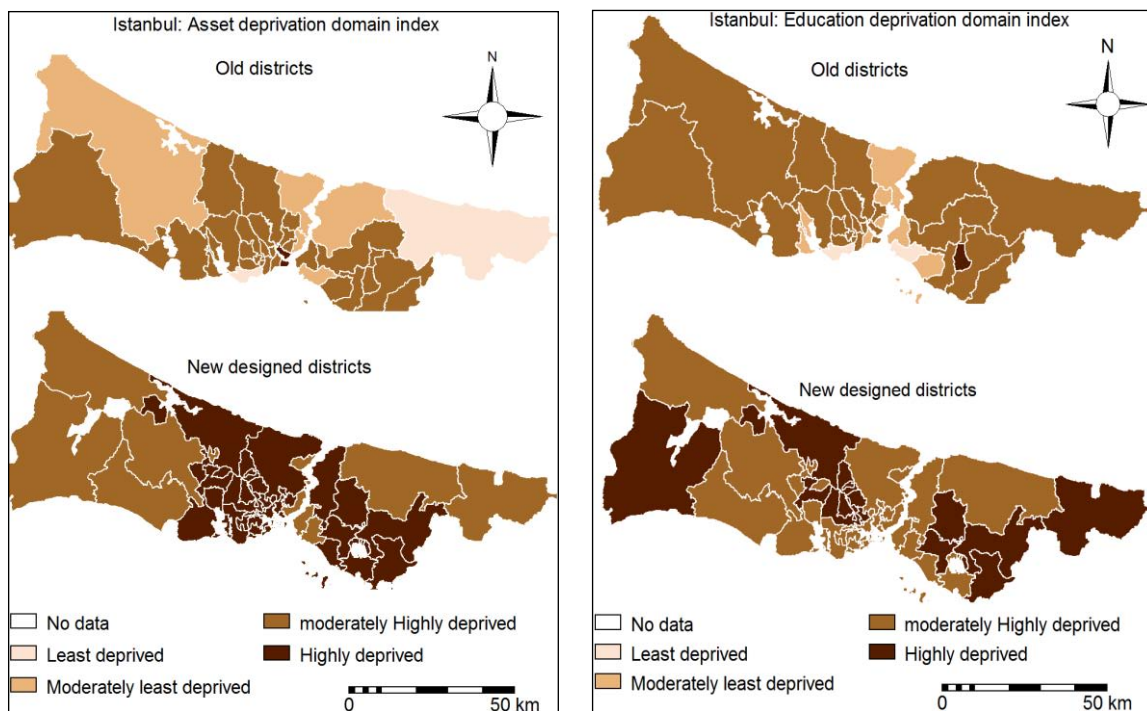


Figure 5-7: MAUP zoning effect: Istanbul deprivation quartile rankings using the asset and education deprivation domain indices on the actual Istanbul old districts and the new designed district boundaries

At the same time, the zoning problem is visible in the units around the central parts of Istanbul. While these units on the new designs are highly deprived, for the most part on the old districts, they are moderately highly deprived.

As much as the education domain (Figure 5-7) presents a more distinct view of the zoning effect, most of the patterns manifested in the old districts can also be seen in the new designs. However, some units that are moderately deprived become highly deprived in the new districts. Again, areas along the Bosphorus strait are moderately highly deprived, contrary to the old districts in which they are moderately least deprived. Similarly, there are differences between the East and West districts between the two designs.

The effect of the zoning problem is more extreme in the income deprivation domain index map (see Figure 5-8). Examining the new districts, nearly all areal units lying west of the Bosphorus becomes highly deprived. On the contrary, these areal units are moderately and highly deprived on the actual districts. Besides, the areal units on the eastern side of Istanbul have similar deprivation ranking (least deprived) on both district designs and so is the case for the employment domain (highly deprived) as seen in Figure 5-8 below. Furthermore, on the employment domain, the influence of the zoning effect is seen on the units to the north west of Istanbul.

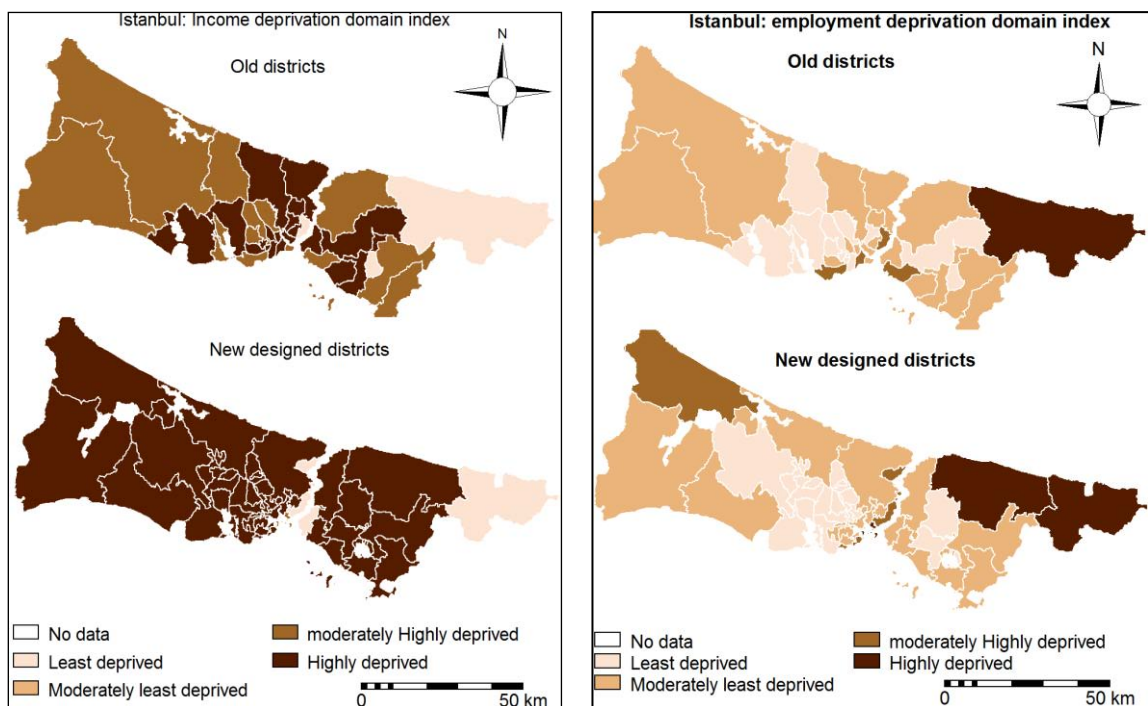


Figure 5-8: MAUP zoning effect: Istanbul deprivation quartile rankings using the income and employment deprivation domain indices on the original Istanbul old districts and the new designed district boundaries

Lastly, the zoning effect is also revealed by the demographic deprivation domain index map as seen in Figure 5-9. While there are areal units around the urban core of Istanbul that have the same deprivation ranking: moderately least deprived, there are units that reflect different deprivation rankings on both district designs. From the actual districts, all the units are identified as least deprived with an exception of seven districts. Conversely, the same areal units appear to have different levels of deprivation: moderately highly and least deprived at the new district designs. The differences seen between the actual old districts and the new designed districts highlight the influence of the zoning effect.



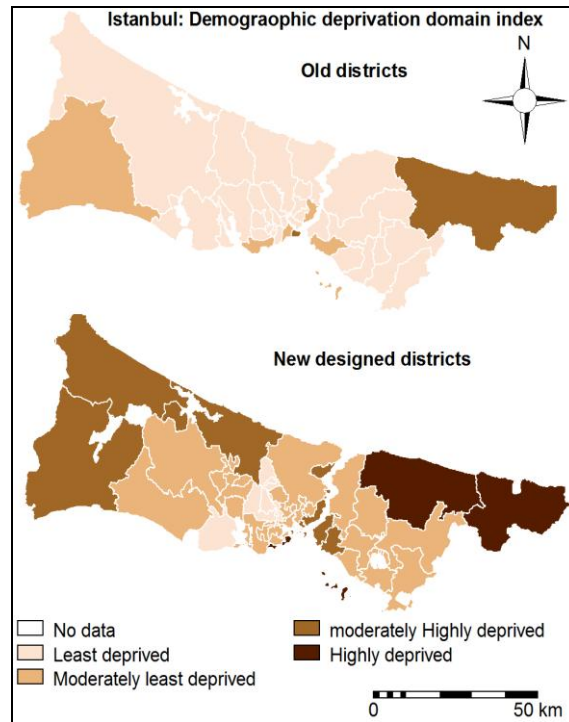


Figure 5-9: MAUP zoning effect: Istanbul deprivation quartile rankings using the demographic deprivation domain indices on the original Istanbul old districts and the new designed district boundaries

**5.2.7. The zoning effect on descriptive statistics**

Statistical differences by district design illustrate the influence of the zoning effect on the analysis of deprivation. From Table 5-5, the mean rate of most aspects on the actual districts is higher than on the new districts designs. The mean percentage of LHINCOME in the actual districts is 45.9 %, somewhat higher than the mean percentage in the new district designs at 43.9 %. Similarly, that of NOCAR, RENTER, MHINCOME, VERYOUNG, VERYOLD, YOUNGUNEMP, MALEUNEMP, FEMALEUNEMP and EDULOW is as well higher on the actual districts than is on the new district

Table 5-5: Descriptive Statistics by district design

Variables	Mean		Std. Deviation		N
	Old districts	New district designs	Old districts	New district designs	
LHINCOME	45.88	43.94	9.92	10.75	33
NOCAR	67.37	65.87	9.06	13.41	33
RENTER	33.33	31.46	9.70	8.45	33
MHINCOME	830.61	713.87	180.12	423.52	33
VERYOUNG	19.69	19.01	3.00	4.20	33
VERYOLD	6.739	6.30	4.31	4.26	33
YOUNGUNEMP	12.19	11.74	1.33	2.44	33
MALEUNEMP	13.61	12.86	2.61	3.28	33
FEMALEUNEMP	31.43	30.48	2.39	5.87	33
EDULOW	44.65	44.09	6.92	9.21	33
ILLITERATE	13.72	13.93	3.25	3.32	33

designs. The reverse was observed for the mean percentage of ILLITERATE which was slightly higher at 13.7% on the new designs than on the actual districts at 13.9 %. However, as confirmed by the independent samples t test in Appendix 11, these mean differences were statistically non significant at  $p > .05$ ; (for a complete reporting of all the t test results, see Appendix 9)

The differences in the standard deviation by district design in Table 5-5 , further sustains the inferences made in the case of mean rates. All aspects are seen to have larger standard deviation on the new district designs than on the actual districts except for VERYOLD which reflects the opposite. These findings demonstrate the influence of the zoning problem on the inferences based on statistical analysis of multiple deprivations in Istanbul.

The influence of the zoning effect on variance was also confirmed by the results of the Levene's test for equality of variances (see Appendix 11). The variances for the MHINCOME were significantly different for the two district designs at  $p < .01$ . However, for the other aspects (ILLITERATE, LHINCOME, VERYOLD, RENTER, YOUNGUNEMP, NOCAR, EDULOW, MALEUNEMP, FEMALEUNEMP and VERYOUNG) of multiple deprivation, the variances were statistically non significant at  $p > .05$ .

#### **5.2.8. The zoning influence on regression and correlation analysis**

Does the zoning system exert equal influence to the correlation coefficient as the scale effect? To answer this question, a correlation matrix was done between all the variables on the two district designs. From the results in Table 5-6, an observable feature was that the correlation coefficient was modifiable. The value was a function of the zoning design used. Great influence on was seen on the correlation between people renting houses (RENTER) and those with low income (LHINCOME). In fact the zoning system made the correlation to change from a non significant value on the actual districts to statistical significance on the new designs. In some instances despite the change in value, the sign of the correlation coefficient also changed between the two district designs; for example between NOCAR and LHINCOME and between MALEUNEMP and YOUNGUNEMP.

Table 5-6: Correlation matrix between deprivation variables on the actual district and new district designs

		LI	NC	RE	MI	VY	VO	YU	MU	FU	EL	ILL
LI	AD	1										
	ND		1									
NC	AD	-.527*	1									
	ND	.547*		1								
RE	AD	.151	.473*	1								
	ND	.783*	.688*		1							
MI	AD	.931*	-.642*	.049	1							
	ND	.540*	.120	.369**		1						
VY	AD	-.089	.376**	.789*	-.116	1						
	ND	.669*	.738*	.827*	.300**		1					
VO	AD	-.002	-.256	-.479*	.126	-.723*	1					
	ND	-.004	.221	-.346**	.021	-.315**		1				
YU	AD	.126	-.126	.469*	.209	.735*	-.585*	1				
	ND	.682*	.728*	.759*	.378**	.961*	-.149		1			
MU	AD	-.029	-.380**	-.468*	.123	-.556*	.877*	-.345**	1			
	ND	.361**	.551*	.080	.277	.241	.797*	.412*		1		
FU	AD	-.173	-.319**	-.648*	-.058	-.767*	.868*	-.494*	.807*	1		
	ND	.578*	.824*	.426*	.234	.581*	.571*	.690*	.882*		1	
EL	AD	-.804*	.502*	-.218	-.850*	.060	-.151	-.240	-.056	.064	1	
	ND	.335**	.828*	.396**	.068	.715*	.264	.741*	.676*	.844*		1
ILL	AD	-.577*	.633*	.333**	-.637*	.558*	-.669*	.210	-.688*	-.609*	.522*	1
	ND	.328**	.757*	.578*	-.027	.839*	-.171	.786*	.262	.588*	.841*	

AD : Actual District Designs

ND : New District designs

LI=LHINCOME, NC=NOCAR, RE=RENTER, MI=MHINCOME, VY=VERYOUNG,  
 VO=VERYOLD, YU=YOUNGUNEMP, MU=MALEUNEMP, FU=FEMALEUNEMP,  
 EL=EDULOW, IL=ILLITERATE

\* Correlation is significant at 0.01 percent (1-tailed)

\*\*Correlation is significant at 0.05 percent (1-tailed)

Regression analysis shows that, the value of the coefficient of correlation R between variables was influenced by the district design at which the variables were aggregated. The coefficient of correlation R, R square and adjusted R square is slightly higher on the actual districts than on the new district designs. In Table 5-7 and Table 5-8 it can be seen that the value of R is =.977, adjusted R =.933 which is bigger than the values on the new district designs. These results by district design highlight how the zoning effect influences the results of regression analysis on multiple deprivations in Istanbul.

Table 5-7: The coefficient of correlation R, R square and adjusted R square on the actual districts

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.977 <sup>a</sup>	.954	.933	2.573

a. Predictors: (Constant), ILLITERATE, YOUNGUNEMP, RENTER, EDULOW, MALEUNEMP, NOCAR, FEMALEUNEMP, MHINCOME, VERYOUNG, VERYOLD

Table 5-8: The coefficient of correlation R, R square and adjusted R square on the new district designs

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.957 <sup>a</sup>	.916	.877	3.766

a. Predictors: (Constant), ILLITERATE, MHINCOME, VERYOLD, RENTER, YOUNGUNEMP, NOCAR, EDULOW, ALEUNEMP, FEMALEUNEMP, VERYOUNG

### 5.3. Discussions

Different patterns of multiple deprivations were observed when the IMD and the general deprivation domain indices were subjected to a two scale analysis. The nature of the units of analysis in the visualization of a particular deprivation domain, whether material or social, determined the results of the analysis owing to the scale influence. The education domain exhibited less spatial variations at the district scale and so where the asset, income, employment and education domains. However, on the demographic domain there were areal units on both scales that reflected similar patterns. From the findings, it can be inferred that there was more heterogeneity between highly and least deprived areal units at the neighbourhood scale than was observed at the district scale; also this is shown by the higher standard deviation manifested at the neighbourhoods level.

The scale effect was also seen to affect the values of descriptive statistics. Levene's statistic confirmed that the differences in variance between the district and neighbourhood scales were significant at  $p < .05$ . This finding is comparable to Hayward & Parent, (2009) where Levene's test showed that the variances of the mean poverty rates by scale were unequal at  $p < 0.01$  level but is in contrast to Amrhein, (1995) who concluded that the variances were stable as areal units of analysis changed to a different scale. Meanwhile, as *t-test* indicated that the differences in mean percentages from aspects of multiple deprivations were non-significant, from observation the means values were different. This result mirrors the demonstrations by Oliver,(2001) even though he did not use a t-statistic to examine the statistical significance of the variations; however, it is in contrast to Amrhein, (1995) who reported that there was no prove of the scale influence in the mean values as size of the units of analysis changed.

The difference in values of the regression correlation coefficient R and Pearson's correlation coefficient, between district and neighbourhood scale also highlighted the influence of the scale effect. Typically, the value increased as data was aggregated into larger spatial units. This also reflected the findings by Amrhein, (1995), Openshaw, (1984) and somewhat by Fotheringham and Wong (1991) cited in Dumedah, et al., (2008) who found that the coefficients for linear regressions showing the relationship between socioeconomic variables were unpredictable for areal data. In some instances the sign of the Pearson's correlation coefficient amid two deprivation variables changed as units of analysis changed; a comparable outcome to what Openshaw and Taylor (1979) cited in Reynolds (1998) found.

The differences in geographical patterns of the IMD, asset, education, employment and demographic domains between the new district designs and the actual old districts in Istanbul signalled the zoning effect. More extreme differences in patterns were demonstrated in the income domain. Similar patterns to this were also reported by Schuurman et al. (2007) in Vancouver and Hayward & Parent,(2009) in Pennsylvania. However the comparisons here are constrained by the fact that these studies used different deprivation variables. Similarly, the results of descriptive statistics (mean and variance) confirmed these changing patterns of multiple deprivations between the two district configurations. Nonetheless, *t*-test and Levene's statistic results confirmed that most of the differences in the mean percentages and variance respectively were non-significant between the two designs. This is partly comparable to Hayward & Parent,(2009) who found a significant difference in mean poverty values while at the same time he reported a non significant difference in variances by district design. The value of the coefficient of correlation, R and Pearson's correlation coefficient was also influenced by the zoning effect. R on the actual district was .977 while at the new district design R was .957 indicating that the value of the coefficient of correlation is dependent to the zoning design used. Thus it is not reasonable to make comparisons with other correlation coefficients when using same variables but in different zoning systems; a result also observed by Yule and Kendall (1950)cited in Openshaw (1984).

Meanwhile, as mirrored patterns were observed in the descriptive statistics and spatial patterns for both the zoning and scale effects, there were different implications to policy emanating from both problems of MAUP (see section 6.4.1). Fundamentally, there is a significant loss of information which is associated with the smoothing effect that occurs upon aggregation (Dark & Bram, 2007; Jelinski & Wu, 1996; Openshaw, 1984). As observed (the fact that the differences in values were non-significant), this study agrees with Dark & Bram (2007) that the zoning effect has little uncertainty of results for the mean and variance.

As Baud et al.,(2009) observes, efficient policy targeting of deprivation in mega cities calls for cognizance of the sources and spatial patterns by urban planners and policymakers. This can be realised by mapping deprivation at an appropriate scale. Depending on the scale chosen, deprivation may be masked or unmasked. In Istanbul, and the fact that deprivation analysis was done at two different scales, it is worth noting that numerous highly deprived areal units could be singled out at the neighbourhood scale. Such inferences could also hold for quality of live studies. In Ülengin et al.(2001) there could have been significant differences in respondent's preferences for urban quality of life in Istanbul if the reporting was not based on city -wide aggregated results. Also, Ülengin et al. (2002) saw that city aggregated level analysis might have been inappropriate because of the variability in demographic and socioeconomic structure of the city of Istanbul. Arguably, larges scales with data ascribed to geographical units with fine resolution may assist in categorizing particular individuals that need services or more resource based allocations (Schuurman, et al., 2007) in Istanbul. This way, disaggregated analysis would potentially allow urban planners and politicians to implement targeting programs to specific locations, help them prioritize local needs while at the same time being efficient in the use of public funds (*ibid*). It should however be stressed that mapping multiple deprivation at the neighbourhood level does not necessarily mean that it is the most appropriate scale at which to try to intervene and tackle deprivation (Bailey, et al., 2003). Thus incorporating scale issues into spatial based decisions could improve the distribution of social services and resources be it public or private while at the same time guiding spatial analysts in the selection of areal unit size for analysis (Dumedah, et al., 2008).

Findings from this study echoes Dusek (2003) that, if the results of the different statistical analyses were independent of the zoning configuration used, the zoning problem would not exist. Furthermore, multivariate analysis based on correlations will seem to magnify differences in outcomes as a result of different zoning configurations (Openshaw, 1984). However, the zoning problem has less practical

concerns compared to the scale effect regarding the modifiable areal unit problem. At the same time, while acknowledging the fact that neighbourhood and district configurations in Istanbul were reviewed<sup>6</sup> recently, this rarely happens. However, data aggregation and more so the scale effect is almost inevitable in research especially where every researcher has to deal with it in one way or another.

In a nutshell, observations from these findings lead to the conclusion that the scale effect influences analysis of multiple deprivations such that spatial patterns manifested by the district scale overstress those of the neighbourhood scale in Istanbul; by assigning high deprivation/low deprivation to areal units of the neighbourhood scale which had several moderate deprivation classes. An observation comparable to that of Tesfazghi et al. (2010) on variability of quality of life in Addis Ababa where she reported that aggregation at large scale could average out the variability that was seen at small scales. As it was also observed in our correlation analysis, Openshaw, (1984) emphasized that for most studies founded on modifiable areal units, the size of the correlation will be a function of the units of analysis that are used. It was also found that the nature of the deprivation maps and mean rates of poverty are scale dependent. A critical finding that highlights the dangers of drawing individual inferences based on analysis from aggregated data.

#### **5.4. Mitigating the effects of MAUP**

In spite of the studies described in chapter two, and the fact that the modifiable areal unit problem has been observed for many years, researchers are not far away to dealing with the problem effectively (Fotheringham, et al., 2002). A few praxis oriented solutions exist and researchers have only started unpacking the effect of MAUP on analysis. This study has dealt with MAUP by unravelling its effects on the spatial patterns and statistical description of multiple deprivations.

The weighing of areal units by population as well as complex statistical procedures are currently being explored to address the MAUP (Yang, 2005). Interestingly, a more straight way to deal with this problem would be doing analysis at multiple scales or zones (ibid.). Another solution would be showing the results of the analysis at the most spatially disaggregated level available and then demonstrating visually the sensitivity of the results to both the scale and zoning effects (Fotheringham, et al., 2002). If the stability of results can be demonstrated over a wide variety of zoning systems, then the researcher could be confident that the results are meaningful and not mere artefacts of the way data is ascribed to space (P´aez & Scott, 2004, citing Fotheringham et al., 2000). Vividly, the only way results from urban analysis would be independent of MAUP is using individual level data which defers from areal data by the fact that their locations are latitude- longitude defined (P´aez & Scott, 2004); that is simply visualizing phenomena as points in space. However, almost all governments don't allow use of individual level data due to confidentiality issues. This explains why such data is hardly available at those levels. There is also, as explained reluctance in the use of individual level data due to extreme outliers that may render individual attribute analysis problematic or the enormity of computational complexity in handling vast data points. With this in mind, and researchers getting frustrated with the lack of solutions, being cognisant of the fact that the results of analysis may be influenced by the zones or scale used to aggregate data is an important step (Oliver, 2001).

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<sup>6</sup> New districts in Istanbul were created for political reasons. The process was not aided by any districting software. Districting software was used in this study to design new zoning systems for methodological purposes.



## 6. SPATIAL SCALE AND POLICY IMPLICATIONS

*The main aim of this research was to utilize GIS and statistical techniques to examine the effects of the modifiable areal unit problem on the analysis of multiple deprivations and its implications to policy and planning in Istanbul. The study also sought to explore the factors behind the selection of certain geographical units of analysis for analyzing multiple deprivations. In this chapter, geographical units of analysis in the analysis of deprivation, determinants in the choice of a spatial unit of analysis and the administrative unit for mapping deprivation in Istanbul are discussed. General planning scales in Istanbul, basic drawbacks about data and the implications of MAUP to policy and planning are described too. The results and information presented on this chapter are based on interviews and discussions with policymakers and experts in Istanbul.*

### 6.1. Geographical Units in the analysis of multiple deprivations

This section discusses the units of analysis used, determinants in the choice of those units and an administrative boundary for deprivation mapping, and the basic limitations about data and spatial scales in Istanbul.

#### 6.1.1. Geographical units of analysis

In spatial analysis of phenomena, it is important to understand the nature of the units of analysis that establish the level of aggregation of the data (Rengert & Lockwood, 2009). There were varying geographical units of analysis used by experts and policymakers when studying socio-economic phenomena in Istanbul. While data was found to be organized and reported at different spatial resolutions, the geographical units of analysis used in deprivation are arbitrarily selected. There are no predetermined units of analysis for particular cases. Spatially aggregated data are normally used for official statistics and by researchers (Stafford et al., 2008) investigating different phenomena. Reasons are that individual level data is not available to the public for privacy concerns. However, in Istanbul, outcomes of analysis vary according to the issue being investigated as well as the scale chosen for analysis. The choice of areal units for reporting is also researcher dependent. As such, the geographical units of analysis are fundamental in any study (Brantingham, et al., 2009). This is because the manner under which data is aggregated may partly determine the character of the spatial relationships of the results between the units.

Following is a description of the geographical units of analysis through which data is organized in Istanbul. This also includes a discussion on the units at which some forms of deprivations are analysed:

1. Provincial boundaries(*Il*)
2. District boundaries(*Ilce*)
3. Neighbourhood boundaries(*Mahalle*)

Provincial and district boundaries are mostly used for environmental quality or quality of the place studies. Most environmental quality issues are believed to cut across different provinces or districts. For comparison purposes between contiguous administrative areas in socio-economic factor measures such as income levels, the provincial or district boundaries are applied too. Other types of deprivation measures may require finer resolutions for analysis. For example, for studies dealing with average building heights<sup>7</sup>, average household income, population health e.t.c. the neighbourhood level data is used for analysis since it can show more inter-area variation. No electricity, overcrowding, durability of structures and physical

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<sup>7</sup> Average building height was cited by experts as a factor used in residential quality of the environment indicators.



deprivation indicators e.g. open space derived from remote sensing techniques utilize the neighbourhood as the focal unit of analysis. The neighbourhood is the lowest administrative boundary within which data is available to the public in Istanbul. However, as explained, for large scale studies focusing on several interrelated phenomena, all the three units may be used. An expert<sup>8</sup> explained that:

*“For digital divide issues, office land determination, environmental applications especially when studying how the quality of the urban environment changes at different scales and depending on the nature of the field you have to use either provincial, district (Ilce) or neighbourhood (Mahalle) or sometimes three of them. For instance, in my office land determination project, we had to use census data at provincial scale since we were working with limited factors like the general income levels, employment opportunities of both the European and Anatolian parts of Istanbul. But in terms of specific factors of office land determination such as ratio of the office functions to the housing or residential units we had to know specific numbers by district levels as well as in examining how rent changes according to transport accessibility levels. For the Mahalle (neighbourhoods), we wanted to understand the specific or more detailed indicators of the land determination process. For example, some of the high-rise buildings have different physical structures for office layouts and besides, they house people of different socio-economic status. As such we went for the neighbourhood scale”.*

### **6.1.2. Policy makers' preference**

As for policy makers, the choice of the unit of analysis depends on the research in question. For instance, when preparing development plans for the province of Istanbul, the district boundaries could be used. District units are used in this case for equity purposes since resources for targeting problematic areas are allocated at the provincial level. For this reason, policy makers may prefer the district unit. In other cases, when fine details are required especially for targeting intervention in a particular deprived historical area, neighbourhoods or parcels may also be used.

In the analysis of deprivation for area targeting, policymakers consider doing it at finer resolutions. They rely mostly on the advice from urban planners. They observed that planners suggest the use of fine resolutions since that way more populations in need can be identified. While neighbourhoods were seen as the more appropriate units of analysis than the district boundaries, there were concerns from policy makers that some of them were still too large and that smaller units like building parcels may be adopted in future analysis. As a policy maker observed, finer spatial resolutions than neighbourhood boundaries would be useful in showing characterization of an area more so, when severely deprived individuals needed to be identified for purposes of policy targeting.

### **6.1.3. Determinants in the choice of a geographical unit for analysis**

#### **a. Availability of data**

The nature of the research area and availability of data is a cardinal factor in the selection of a particular unit of analysis. The choice of an appropriate unit depends both on the research question to be addressed and the availability of data (Rengert & Lockwood, 2009). If data is sufficiently available, the study usually begins with the minimum level of aggregation possible. For example, if data is available at the neighbourhood level, then it becomes the basic unit of analysis. For cases where data cannot be collected at the neighbourhood level, the district is assumed as the unit for data aggregation and analysis.

The appropriateness of a geographical unit of analysis or its usefulness when analyzing a certain issue may not be a major factor of consideration before starting a research, but rather the level at which data is available for public use. Usually, researchers use data at the units that are available to them in situations where data is available at particular units. Nonetheless, if data is organized at different geographical units,

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<sup>8</sup> Key informant interview with an expert from an Istanbul University, Istanbul, October 2010

then researchers should deliberate on the appropriate unit to use. It was advocated by experts that the smallest unit of disaggregation should be used since inferences based on the analysis are more stable at smaller units.

#### **b. Reliability/ meaningfulness of data**

Some data provide reliable results when examined at a certain spatial scale. A discussion with experts revealed that for environmental deprivations and industrial pollution mapping, especially, where a comparative analysis of the intensity is done between districts, then more meaningful inferences could be arrived at if the district is used as the unit of analysis. Additionally, experts continued that measures based on access to schools tend to be done at the district level because there are no schools at each neighbourhood. However, when looking at such measures like ownership of household assets, results are more representative when data is analysed at the neighbourhood level. A discussion with an expert<sup>9</sup> reported below illustrates this:

*“Of course in an area problem analysis, when you employ a larger scale, you get more accurate or stable results while on the contrary, when you use smaller scales, you get averaged results of all the smaller units. Some data are more reliable at neighbourhood level while others are reliable at the district level. For example schools; when using small area statistics on educational issues, you may only use the district since there are no schools for every neighbourhood. Interestingly, when looking at ownership of household assets like cars, then neighbourhood level can give more reliable results”.*

#### **c. The detail of information required**

A more important factor is the detail of information required from the analysis. It is known that analysis of data at geographical units of high spatial resolutions results to finer details. Therefore, when more detailed results are required from the analysis, the neighbourhood becomes the unit of analysis. The nature of the research thus determines the unit to be used. Experts were of the views that, in some analyses like mapping environmental deprivations .e.g. the amount of green space in a city the main objective does not seek to identify exactly how many individuals are deprived. As such analysis may be done at the district scale although there was general consensus that researchers have the option to choose their preferred scale.

#### **d. Comparative analysis**

For comparative reasons with previous studies, particular geographical units of analysis may be used in subsequent studies. If the previous study was done at the neighbourhood level, then for subsequent studies commissioned for monitoring and assessment of progress, the same units of analysis are used. This ensures that comparison is done with ease while at the same time maintaining consistency.

### **6.1.4. Factors in the selection of an administrative boundary for deprivation mapping**

In many deprivation studies (Baud, et al., 2009; Baud, et al., 2008; Langlois & Kitchen, 2001; Schuurman, et al., 2007), certain census geographies are used when analyzing data. However, the map for final reporting of the results and the scope of the study are determined by the administrative boundary selected by the researcher. For instance, using census wards in one district or as in Baud, et al., (2008) using all electoral wards in the whole municipal corporation. This study attempted to unravel the triggers for selecting the main administrative boundary in which the results of analysis are based on and from which conclusions are drawn upon. Discussions with experts and policy makers revealed the following:

<sup>9</sup> Key informant interview with an expert from a University in Istanbul, Istanbul, October 2010.

**a. Coverage of phenomena**

The coverage of phenomena being researched on influences the administrative boundary selected for the final production and visualization of results. Also, it is an issue of consideration when selecting the extent of the case study area. Some socio-economic phenomena traverse different geographical regions. As such the administrative boundary should be selected in a way that it captures the extent of the issue being researched on. For, example, traffic management studies or studies on access to transport services may require a large boundary; a district or a municipal corporation. This is because transport networks connect different parts of a city.

**b. The aim of the study**

The goal of the research plays an important role in the selection of the administrative boundary. For studies commissioned at the metropolitan level, where the aim is to draw conclusions for the whole metropolitan area, using a district cannot suffice. City-wide study would be more appropriate.

**c. Data availability**

Some municipalities do not have proper data organization and documentation. And also, data that guides the research might be available at one boundary only .e.g. sometimes some data is available for a particular district or area (either the European or Anatolian part in Istanbul). Doing an independent household survey is considered a prudent activity where then selection of the case study area is not influenced by data availability. However, conducting a household survey for broad study areas is constrained by time and money limitations. Researchers delimit areas where they are certain of getting appropriate data for the intended study. As revealed below by an expert from Istanbul, the quality of data sourced plays an important role.

*“Some municipalities may have the data required while others do not have. By selecting a case study area, making sure that the study will source data of good quality and variables required is vital. For my case I ensure that I would be able to get adequate data for the study area that would meet my objectives”.*

**d. Time limitations**

Time is an important resource that requires careful planning in research. As much as it determines the scope of the research, time also determines the size of the administrative boundary to be used. Many studies in Istanbul end up using a few districts or either side of the Bosphorus straight instead of doing it at the provincial level due to limited time and resources.

**6.1.5. Basic Drawbacks about data and geographical units of analysis in Istanbul<sup>10</sup>**

In Istanbul, there are several types of administrative boundaries and relevant statistical data. This is data which is utilised by researchers focussing on deprivation or quality of life studies. However there are basic problems about the nature of statistical data and the units of aggregation.

**Data acquisition**

It is almost impossible to reach comprehensive data from one source like Turkish National Statistics Bureau (TUIK) or Ministry of Environment and Forestry. Researchers have to contact several administrative bodies in order to collect a complete set of data. However, consistency of the data is not guaranteed since different bodies collect data at different levels of aggregation for diverse purposes.

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<sup>10</sup> Based on interviews with experts from a university in Istanbul and policymakers from IMM, Istanbul, October, 2010

### **Contradictions**

Most of the data, for example, environmental data contradict each other even for the same year. The amount of forests and green space for each province for instance is an important parameter of environmental quality. Nonetheless, it discerns contradictions when comparing the figures reported by several sources all of which are regarded official numbers.

### **Unstable boundaries (territorial) relevance**

Amongst several reasons, the basic one is frequently changing boundaries and laws (by-laws). Istanbul has a province, districts and neighbourhoods as official administrative units. The boundaries of these geographical units frequently change. For example, four years ago, the district and neighbourhood boundaries were rezoned into completely new areal units of distinct configurations. As a result of the boundary changes, data previously collected at those units cannot be ascribed to the new ones. Hence, a mismatch in data results between the old and new boundaries.

### **Non-Periodical dissemination of data**

Data is not published periodically; as such it is not easy for instance, to follow the changing pattern of any data in the units of analysis for every five or ten years. A well-known example of this problem is the population censuses. A detailed, including most of the social variables like education profiles, age groups, economic activities, and detailed sectoral breakdown of the inhabitants of all neighbourhoods were clearly disseminated in the population census of the year 2000. Conversely, in the subsequent population censuses of 2008 and 2009, the same data was hardly available with the same details as the former.

These drawbacks have been seen to be a limiting front in planning. The following section outlines the implications to planning.

### **Implications to planning**

- 1) Inconvenience and inconsistency; Many studies analyse data at different spatial and temporal resolution either in the preparation of plans, mapping deprivation or in quality of life studies. Due to lack of consistency in the way old data differs from the new one (non-periodical dissemination), monitoring the impact of policy targeting to deprived areas becomes problematic.
- 2) It becomes a thorny issue to make meaningful comparisons especially when using data of different temporal and spatial resolution. Against this backdrop, it is practically hard to make analysis and highlight the nature of deprivation when making comparisons with previous studies for purposes of monitoring be it at city or district level.
- 3) The basic effort becomes data collection and organization more than developing the research itself. More resources and time is spent on data collection rather than developing plan proposals, assessing deprivation or quality of life. The repercussions are slow policy response to problematic areas since experts cannot deliver project results on time. As a researcher echoed, much of the time and money is directed towards collection and organization of data.

*“I spend much time in looking for research funding to support field work and data collection. I conduct my own field survey in order to fill in gaps in existing data. If I had adequate secondary data of good quality, then I would spend more time on doing research than on data collection. Sometimes we cannot meet our research targets set by policymakers on time due to these constraints”.*

## 6.2. Planning and scales in Istanbul

In this section, scale refers to the level of spatial representation, as commonly used in cartography, and defines the relationship between distance on a map image and the corresponding difference in reality. For disambiguation, with the other sections of this study, spatial scale is discerned as methodological scale referring to the units selected by the researcher in order to aggregate data necessary to pursue the research problem as discussed in Harris, (2006) or the level of spatial detail (Goodchild, 2001).

According to IMP, planning in Istanbul is undertaken using different scales i.e. 1:1000, 1:5000, 1:25000, 1:50000, 1:100000. The choice of a planning scale largely depends on the phenomena being mapped and the detail of information required. For example, for plans of environmental, water catchments, forests and land use nature a scale of 1:100000 may be used.

Table 6-1 shows a breakdown of how a scale may be chosen depending on the issue at hand.

Table 6-1: Type of plans and scales in Istanbul

Scale	Type of plan
1:1000	Neighbourhood level development plans (showing parcel details, roads and pedestrian pathways)
1:5000	Settlement plans which can either be at district (Ilce) or neighbourhood (Mahalle) level
1:25000	Master plans, land use plans
1:50000	Master plans, land use plans
1:100000	Environmental, forest, water catchments, land use or master plans.

An example of a recent planning exercise using one of the above scales was the Istanbul Provincial Environmental Master Plan prepared in 2006 with revisions in 2009. It was prepared at the 1:100,000 scale with the objectives of improving the quality of live, ensure sustainability of natural assets and improve the standards of living (Gachanje, 2010).

## 6.3. What are the appropriate units of analysis?

After examining the extent at which MAUP affects the IMD or indices in quantifying deprived areas in need of targeting, the next foremost concern was to review the research question of what would be the most appropriate unit of analysis for reporting the outcome.

For experts, identification of an appropriate scale for data analysis and inevitably dealing with the compromise between resources at hand and data collection was a major issue. Harris (2006) added that as much as the detail of any spatial representation depended on the scale used, discussions on how well that scale represents phenomena in analysis were missing having in mind that there were no prescribed measures of uncertainty for a certain level of analysis. From literature as well as discussions with experts and policymakers, this section looks at the question of what would be the appropriate unit(s) of analysis for a particular dimension of deprivation.

Experts<sup>11</sup> held a consensus that in research the appropriateness of the unit of analysis is guided both by the research questions to be answered and more importantly the availability of data especially when the main source is secondary data. When data is available at multiple scales, analysis would typically start with the smallest units of aggregation (Rengert & Lockwood, 2009) since data is collected and aggregated to units which are modifiable in nature (Openshaw, 1984) such as post codes, neighbourhoods and districts. It is the scale of the study that determines the range of spatial patterns, processes and amount of detail that can be detected (Dark & Bram, 2007). Research has also shown that moving from micro to macro

<sup>11</sup> Discussions with Experts from universities in Istanbul, October 2010.

scale in any analysis could lead to serious worries due to ecological fallacy (Harris, 2006), since generalizations of spatial patterns made for a particular scale may not be observable at a different scale of aggregation (Gregory 1994 cited in Harris, 2006). The choice between the units of aggregation should depend upon the intended use and the constraints brought forth by the data. For geographically aggregated data, it is imperative to categorize appropriate areal units of analysis and to acknowledge too the errors that may occur when relationships change for diverse spatial units (Dumedah, et al., 2008; Oliver, 2001). It is the areal unit definition that determines the stability of the results. The choice of appropriate unit for analysis should be guided by theoretical arguments or empirical support (Tita & Greenbaum, 2009). It should be a compromise since no ideal single unit can capture all spatial processes for all dimensions of deprivation (Manley, et al., 2006). As seen in section 5.2.1 depending on the scale chosen, areal units could mask or unmask deprived areas. More detail could be detected through analysis at the neighbourhood scale in Istanbul. This observation was confirmed by high standard deviation at the same scale. The coefficient of correlation was seen to increase with scale aggregation.

Experts and policymakers' recommended neighbourhoods as the most appropriate units of analysis. They indicated that neighbourhood scale would give a more robust way of prioritizing places for policy targeting. Based on the results observed in section 5.2 and discussions on section 5.3, this study agrees with experts recommendation on neighbourhoods scale aggregating them only if need be. However, the factors highlighted in Section 6.1.3 should also be considered.

#### **6.4. Discussions**

This section presents a discussion on how MAUP influences deprivation mapping. Through review of literature and discussions with experts and policymakers, we link the effects to urban policy and planning

##### **6.4.1. Influence of MAUP on deprivation mapping: linking its effects to urban policy and planning**

Over the years, poverty and deprivation has occurred in urban areas as well as in rural villages all over the globe. Multiple deprivations have been more ubiquitous in cities of most developing countries as well as developed ones. In these areas, problems concentrate in particular places, affecting the quality-of-life of those inhabiting the area (Martínez, 2009). However, lack of functional scales of analysis coupled with poor policy has done less than increasing the gap between the affluent and those living in abject poverty. At the same time, while a practical use of the general deprivation domains and the IMD can help policy makers identify both problematic areas and the predominant aspects of multiple deprivations, research has shown that the MAUP and particularly the scale effect has a limiting influence on deprivation mapping. Openshaw (1984) warned that the outcome of any study based on spatial data will always be a function of the areal units under study. The scale effect demonstrated in section 5.2, contributed to loss of information details as analysis was done at high levels of aggregation. Policymakers in Istanbul acknowledged that, deprivation analysis done at the district level would be misleading in prioritizing areas for policy targeting; which could be seen as the possible effects of ecological fallacy (see section 2.3). For experts ecological fallacy may have far reaching implications as resources may be directed to the wrong areas. This view resonates with Pacione (2009) that due to ecological fallacy, policy makers could channel resources to areas in which a significant number of the residents do not need public assistance.

Meanwhile, Moor, 2000, cited in Martínez, (2009) admits that, many cities suffer from an information crisis which undermines their power to develop effective urban policy. In fact policy makers were of the view that policy implementation can only be better achieved if analysis and monitoring of projects was done using highly disaggregated data. In addition, assessing and targeting deprived areas pragmatically call for quality spatial data. They indicated that, neighbourhood scale would show exact areas that would require more attention for targeting. Furthermore, neighbourhoods are understood as relatively small and relatively homogeneous areal units (Ghose & Huxhold, 2002) and thus they could be used when a more

detailed analysis of inhabitants with regards to their socio-economic and demographic characteristics were needed in Istanbul (Dokmeci, et al., 1996).

Experts were concerned that, despite the well recognized use of indicators in monitoring the success of policy targets or project implementation, relatively little attention had been directed towards their spatial sensitivity to scale and realistic concerns regarding the MAUP. It was observed that more efforts were geared towards the individual variable attributes that constitute the indices rather than the effects the use of a certain scale may have on the results. Scale effect was recognized<sup>12</sup> as a central factor when making inferences from mapped results. This was seen to be verified by Reynolds (1998) citing Openshaw and Taylor (1979) in the indication that the sign of the correlation amid two variables may change, based on the level of aggregation of the data in analysis. His concerns were that in cases where the results of analysis from the data were to be used in persuading a decision in public policy, severe errors could surface.

As Martínez (2009) clearly explains, targeting deprived areas, monitoring spatial inequalities and prioritizing resources can be aided by the use of GIS and indicators where as urban planning measures and policies for mitigation would enhance spatial equity thus making urban environments more sustainable. However, he adds that the influence of the areal unit definition in the explanation of inequalities is very relevant due to the scale issue. In Istanbul spatial differences were clear in smaller units of analysis. A common trend observed in Ecuador (Henninger & Snel, 2002) and Rosario (Martínez, 2009). This study also found that, zoning effect of MAUP greatly influenced the way deprivation was mapped in Istanbul. Depending on the nature of the district configuration, different spatial patterns of deprivation emerged. Generally, policymakers shared a common vision to that held by Kingsley (1999) that lack of data at a disaggregated level may lead to aggregation of indicators at the district level and for Istanbul, this would lead to wide mistakes in the allocation of resources. Constructing indices at a highly aggregated level can deceive policymakers if MAUP is not shown and emphasis about its effects made in the research world. This follows that spatial distribution of deprivation in an area depends on the scale at which it is analysed. It may be spread equally across a municipality or concentrated in small pockets (Smith, 1999).

As shown above, indicators are imperative in monitoring the coverage of socio-economic problems in an area. In Istanbul, indicators could be developed at provincial, district or neighbourhood level. At the district or provincial level, they may not clearly depict the intensity of multiple deprivations as can be expected. Therefore, making inferences about individuals based on results from aggregated data may very well be deceptive. But as Henninger & Snel (2002) agrees, otherwise indiscernible poor areas may be exposed if deprivation is mapped using high resolution data. High resolution data of numerous small units could limit ecological fallacy particularly in areas classified as least deprived. This is because not all individuals inhabiting a well off area are necessarily affluent (Martínez, 2009). Thus highly disaggregated spatial information could improve urban governance if decision makers choose to intervene at such scales (Henninger & Snel, 2002).

Even cities that have adopted sustained methods for assessing and monitoring urban deprivation have not done so effectively. A standing reason is that, they use urban indicators ascribed to particular units of analysis. Despite their well-known use, indicators have geographical variability depending on the scale used and have major concerns regarding the Modifiable Area Unit Problem. A complete understanding of the zoning problem makes us conclude that for any study dealing with deprivation and spatial scales, the outcome will be subject to the zoning system used but as indicated in this study the scale issue is the more problematic element of MAUP (Schuurman, et al., 2007) when working with multiple deprivation indicators. Thus, how serious are MAUP effects? Would this limit approximating the actual number of multiply deprived individuals in an area for purposes of planning and policy intervention? How can we

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<sup>12</sup> Based on discussions with policymakers and experts in Istanbul, October 2010

make sure that there is little or no misallocation of resources as a result of MAUP? These important questions raises the concern that MAUP is a major problem in planning and has far reaching implications to policy in regards to targeting deprived areas. The challenge for decision makers therefore, faced with this advancing evidence of MAUP on representation of multiple deprivation is how to tackle inequalities; while in the meantime appreciating that the results are highly affected by scale. And as Hayward & Parent (2009) observes, policy programmes must establish whether the modifiable areal unit problem is a worrisome issue that should be considered right before embarking on mapping deprivation; a prudent reflection for Istanbul city.



## 7. CONCLUSIONS AND RECOMMENDATIONS

*The commencement of any research in multiple deprivation analysis should not ignore the scale sensitivity of the results subject to the areal unit definition adopted in the analysis. Although as foreseen in the analysis, the spatial patterns of deprivation were scale dependent, this study went a step further to seek knowledge on the geographical units of analysis, the determinants in the choice of those units, their basic drawbacks and the implications of the MAUP to urban policy and planning in Istanbul. In this chapter, the main conclusions of the research are presented based on the specific objectives set out on the beginning of the research. The aim is to reflect from the foregoing the prominent aspects from the findings of this study. Recommendations are also outlined against the limitations of the current research.*

### 7.1. Objectives and summary of findings

The main task of this research was to examine the spatial scale of multiple deprivation and the effects emanating from the modifiable areal unit problem on the interpretation of multiple deprivation in Istanbul, Turkey. The idea was to examine the effects of MAUP on deprivation mapping with a goal of searching for the leading features that might be limiting urban planning and policy targeting to deprivation. The sections below present a summary under each specific objectives set out earlier in the beginning.

#### **Objective one: To review the geographical units of analysis applied when mapping deprivation in Istanbul.**

Analyses from experts and policy maker's interviews sought to answer the research questions under this objective. The outcome revealed that a collection of spatial scales was at the disposal of researchers in Istanbul. Depending on the socioeconomic or environmental issue under investigation, the province, district or neighbourhood units may be adopted as the functional scale of analysis. However, the choice of unit of analysis is researcher dependent. But by being the finest spatial scale at which data is available, the neighbourhoods were by and large the units of analysis used in many studies. Interestingly, policy makers desire targeting deprivation at two major scales: the district (Ilce) or the neighbourhood (Mahalle). When the guiding principle is equity, they prefer using the district to fairly allocate resources; nonetheless they consider the neighbourhoods as a finer resolution that can be used to target specific areas that are highly deprived.

The choice of scale for a particular deprivation is constrained by a number of factors. Availability of data, envisaged reliability or meaningfulness of results at a certain spatial scale were the core factors. The amount of detail required in the results and comparability with previous studies (to maintain consistency in monitoring and assessment of progress for projects based on previous studies) were also the major pre-defined factors that guide the choice of scale for analysis.

#### **Objective two: To examine the effects of the modifiable area unit problem (MAUP) on different forms of deprivation at different scales.**

The scale and zoning effects were analysed by producing choropleth maps of the General Deprivation Domain indices and Index of Multiple Deprivation at two scales and two zoning systems respectively. They were based on quartile proportionate classification schemes. The new zoning systems were designed based on random aggregation of neighbourhoods on Districting add-on extension in ArcGIS. Levene's test and  $t$  statistic were computed to test the influence of the zoning and scale effect on variance and the mean percentage of the variables. MAUP effects on regression and correlation analysis were also analysed. The scale effect had a pronounced influence on the spatial relationships of deprivation when variable data was

analysed at changing spatial resolutions. The influence of the level of aggregation and zoning system on multiple deprivations indicators in Istanbul was a pertinent issue. Scale effect showed a homogenizing effect to deprivation with increasing aggregation. The statistical tests highlighted the presence of the scale effect as significant differences in variance and mean rates were found between the scales. The value of the correlation and regression coefficient increased with data aggregation; the sign and the statistical significance of the correlation coefficient also changed in some cases. For the zoning effect, equally, spatial patterns of multiple deprivations were dependent of the zoning system; changes in spatial patterns were seen as deprivation indices were visualised using the new designed districts against the old ones. However, as indicated by the statistical tests, these differences were non significant. The value and sign of the correlation coefficient were also modifiable owing to the zoning system. This showed that, for a certain level of spatial resolution a wide variety of possible results would emerge from the same analytical methods owing to the changes in the zoning system.

However, this MAUP study agrees with Manley, et al. (2006) in that it did not aim at searching for overall solutions to its problem but rather that results from its analysis gave a better understanding of the effects behind it, how they can be isolated and their influence and/or relevance to policy and planning. One such policy relevance of MAUP is that small places that are highly deprived may go undetected if inequalities are mapped using the wrong scales or at coarser resolutions. Secondly, constructing indicators at the district scale (high aggregation) may deceive decision makers; and may cause serious errors in the allocation of resources. Finally, due to aggregation of deprivation indicators e.g. at the district scale, not all individuals living in one place classified as highly deprived could actually be poor; a major cause for the all important problem of ecological fallacy in urban geography. However, despite having gotten much attention in recent discussions, MAUP is yet to be fully assimilated in the research world. This study therefore follows the line of argument that the modifiable areal unit problem is an imperative element of research and should be accorded equal consideration as deprivation in any analysis as such.

**Objective three: To find out the scale of analysis that is more appropriate for a particular aspect of deprivation.**

By integrating results from objective one and two with literature review and discussions with experts, a broad overview on selecting a suitable spatial scale for analysing a particular deprivation was provided. The suitability of a particular scale of analysis was seen to be determined by the research questions to be answered by the study as well as the level at which data is available. If data is obtainable at multiple scales, then analysis would necessarily start at the smallest unit of disaggregation. Besides, the choice of scale should be steered by theoretical arguments and if need be empirical support. The neighborhood scale through local preferences, stability and heterogeneity of results was suggested as would be an appropriate scale of analysis in Istanbul.

In an increasing order of aggregation, data was available at neighborhood, district and provincial level. Lack of data at a lower level than the neighborhood scale was due to reluctance of public agencies to release data at highly disaggregated levels. Because of the very legitimate concerns of confidentiality at the individual level. A universal concern guarded by law in many governments. Another reason was the problems of having extreme outliers in individual level data.

Additionally, selecting an administrative boundary for final reporting is determined by the coverage of phenomena, aim of the study, data availability and time limitations.

## **7.2. Limitations**

- Availability of data proved to be a major limitation. Most of the indicators set out to be constructed on the onset could not be developed. This was obvious where only limited variables could be used for constructing the indices (IMD and GDD) of deprivation. It has been shown that

apart from being influenced by the unit of analysis, variable grouping is a major factor in amplifying, depicting or weakening the severity of deprivation. Therefore more robust indices could be realised if a wide socioeconomic dataset was available.

- Based on the changes from the old to new administrative boundaries in Istanbul, many datasets are still ascribed and aggregated to the old boundaries as transition is being made to the new ones. Owing to this limitation, socioeconomic data used in this study could only be analysed on the old district and neighbourhood boundaries. This therefore might front a mismatch in boundaries with other socio-economic studies.

### **7.3. Recommendations**

- Deprivation indices should be constructed at the neighbourhood or at a lower level of disaggregation if small pockets of deprived areas are to be detected by policy initiatives in Istanbul. Very high resolution multiple deprivation mapping would put a strong contribution to municipality as well as metropolitan level decision making.
- There is a frequent review of administrative boundaries in Istanbul. Also recently, there has been a reorganisation of statistical data into what is known as Nomenclature of Territorial units for Statistics (NUTS) regions in Istanbul and Turkey at large; which is set as a requirement within the European Union). Therefore, the zoning and scale effects are pertinent issues that researchers should be aware of. Future studies in Istanbul are warned to be keen in their selection of the zoning system or scale for data analysis. Data collection and analysis should be based on the new boundaries in order to attenuate the zoning effect and perpetuate consistency with policy issues.
- Programs and policy initiatives should recognize the universal influence of scale and MAUP on mapping poverty and deprivation and incorporate scale sensitivity in their analysis. Especially when working with composite indices of multiple deprivation or the raw indicators per se. Incorporating scale sensitivity assessments into spatial based analysis of inequalities may assist urban planners in their advice to decision makers. This could enhance spatial decisions with regard to allocation of public services and resources in Istanbul.
- It has been reported that there are three boundaries through which analysis for reporting public issues whether on inequality or human well being can be done in Istanbul. Addressing such issues requires reporting that is reliable for decision making. This study dealt with a model that could be used for such stability tests. Researchers in other cities may use the model described here to examine the sensitivity and reliability of their results depending on the scale of analysis.
- In this study, the research question of ‘what are the appropriate units of analysis?’ was only met based on discussions with experts and extensive literature review. Indeed there were no methods or models to validate with certainty what would be an appropriate spatial scale for a particular socio-economic aspect. Thus, it is important in future studies to explore methods and models for testing such. This would aid urban planners and experts in choosing an appropriate unit for urban socio-economic analysis in Istanbul.

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## APPENDICES

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Appendix 1: Research matrix

Main Objective	To examine the spatial scale of multiple deprivation and the effects of MAUP on the analysis of multiple deprivation at different geographical units of analysis using GIS and indicators in Istanbul, Turkey.		
Research questions	Data required	Source	Method
Specific objective1: To review the geographical units of analysis applied when mapping deprivation in Istanbul.			
What are the geographical units of analysis commonly used when mapping multiple deprivations?	Relevant literature/ interview data	Primary/ Secondary	Key informant interviews literature review
What are the constraints that affect the choice of scale for a particular deprivation?	Relevant literature/ interview data	Primary/ Secondary	Key informant interviews literature review
At what scale do policy makers look at different deprivations?	interview data	Primary	Key informant interviews
Specific objective 2: To examine the effects of the modifiable area unit problem (MAUP) on different forms of deprivation at different scales.			
What are the effects of MAUP on deprivation indicators?	Socio-economic data	Secondary	Multi-criteria analysis /GIS analysis, descriptive statistics, regression analysis
How do inferences based on spatial analysis of multiple deprivation change when the same data are analysed using different scales?	Socio-economic data	Secondary	Multi-criteria analysis /GIS analysis, descriptive statistics, regression analysis
What are the possible implications to policy intervention with regard to the effects of the MAUP?	Relevant literature interview data	Primary/ Secondary	Key informant interviews Literature review
Specific objective 3: To find out the scale of analysis that is more appropriate for a particular aspect of deprivation.			
What spatial scale is more suitable for what deprivation during analysis?	Socio-economic data Literature review	Secondary	Key informant interviews Literature review
What influences the choice of a certain administrative boundary when mapping multiple deprivations?	Relevant literature/ interview data	Primary/ Secondary	Key informant interviews Literature review

Appendix 2: Key informant questionnaire - Experts

**KEY INFORMANT QUESTIONNAIRE**

<b>Interviewer:</b>	<b>Alex Nthiwa</b>
<b>Date of interview:</b>	
<b>Designation of key informant:</b>	
<b>Research areas/Profession:</b>	

**Declaration:** “I am an Msc student from the Faculty ITC of the University of Twente, the Netherlands. Information that would be made available will be only utilized for the research objectives and not for any other purpose(s).”

**Introduction**

*Information for this research centres on multiple deprivation or disadvantage faced by people in Istanbul and the problems that arises when data is analysed using different units e.g. at district or neighbourhood level. Please indicate from the following list which domains of deprivation you usually work with or research on.*

<p><b>C. Material deprivation</b></p> <p><b>9. Housing deprivation</b></p> <ul style="list-style-type: none"> <li>+ External structural defects</li> <li>+ No electricity</li> <li>+ Overcrowded</li> <li>+ Internal structure defects</li> </ul> <p><b>10. Deprivation of home facilities</b></p> <ul style="list-style-type: none"> <li>+ No car</li> <li>+ No refrigerator</li> <li>+ No telephone</li> <li>+ No washing machine</li> <li>+ No central heating</li> <li>+ No television</li> </ul> <p><b>11. Deprivation of environment</b></p> <ul style="list-style-type: none"> <li>+ No garden</li> <li>+ Industrial air pollution</li> <li>+ Other forms of pollution</li> <li>+ No safe playground for under 5 children</li> <li>+ Risk of road accidents around home</li> </ul> <p><b>12. Deprivation of location</b></p> <ul style="list-style-type: none"> <li>+ No recreational facilities nearby</li> <li>+ Hospital department not within 10 minutes journey</li> </ul>	<p><b>B. Social deprivation</b></p> <p><b>7. Lack of rights in employment</b></p> <ul style="list-style-type: none"> <li>+ Unemployed</li> <li>+ No social security</li> </ul> <p><b>8. Lack of integration into community</b></p> <ul style="list-style-type: none"> <li>+ Did not vote in last election</li> <li>+ Racial harassment</li> </ul> <p><b>9. Educational deprivation</b></p> <ul style="list-style-type: none"> <li>+ Illiterate</li> <li>+ Fewer than 10 years of formal education</li> </ul>
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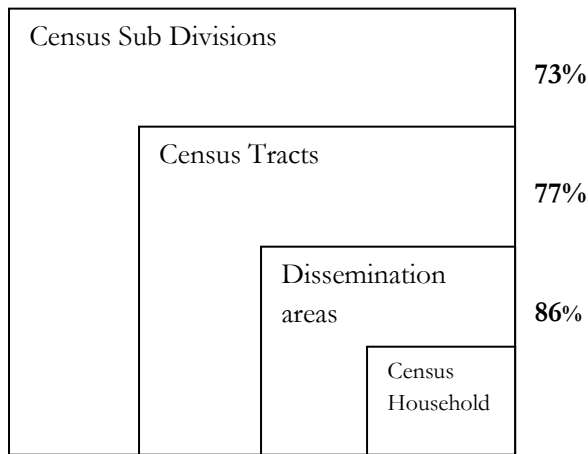
*Table 1: Dimensions of multiple deprivation*

*Adapted from Townsend, P. (1987). Deprivation. Journal of Social Policy(16), 125-146.*

**The modifiable areal unit problem (MAUP)**

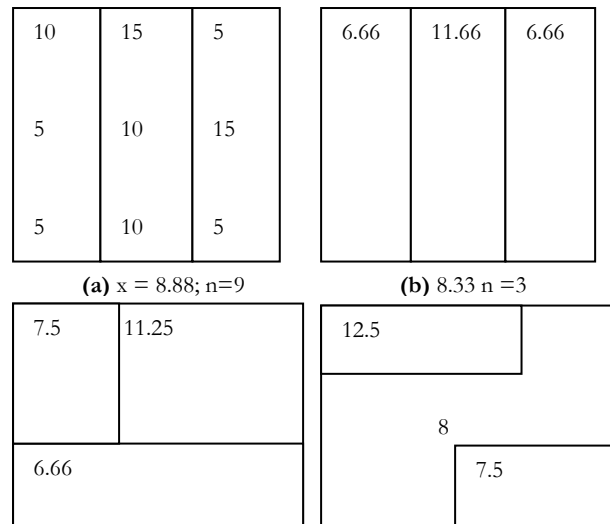
The MAUP is the problem that arises when inferences based on spatial analysis change when the same data is analysed through different zoning systems or through variations in scales. It has two components: the scale and zoning effect (Schuurman et al., 2007). The **scale effect**, is the trend of arriving at different results from analysis of the same dataset after doing several scale alterations e.g., neighbourhoods, districts and regions. The **Zoning effect** results from the variations in the number of zoning configurations that can be used in analysis at a given scale thus getting varying results by merely changing the boundaries of the zoning systems at a specified scale.

*Source: P'aez, A., & Scott, D. (2004).*



Scale sensitivity measure for Deprivation Index across three census configurations (units of analysis).

*Source: Dumedab, G., Schuurman, N., & Yang, W.*



(a)  $x = 8.88; n=9$

(b)  $8.33 n = 3$

(c)  $x = 8.47; n=3$

*Source: Oliver, L. (2001).*

Modifiable area unit problem: scale effects (a, b) and zoning effects(c, d)

**Box 1; Modifiable areal unit problem**

**Geographical units of analysis (provincial, district or neighbourhood)**

1. In Istanbul, census data is reported at different geographical units, i.e. provincial, district (Ilce), neighbourhood (Mahalle), what are the unit(s) of analysis through which data is organized in your field of research.
2. With regard to question one, what are the geographical units of analysis commonly used when mapping any of the above dimensions of multiple deprivations that you work with (*see table 1*), in Istanbul/Turkey?
3. What are the factors considered when selecting a geographical unit to analyze data? Why do you choose a certain unit of analysis for a particular deprivation?
4. Cities like Istanbul have different administrative boundaries e.g. municipalities, districts, metropolis, what are the reasons for selecting a certain administrative boundary when mapping multiple deprivations for the purposes of final production of the maps?
5. What are the constraints in your case that affect the choice of your preferred unit of analysis for a particular deprivation?
6. Since data is organized at different geographical units, in your opinion do you think researchers should deliberate on the unit to use before analyzing data?

- 
- a. If yes, please explain...
  - b. If no, please explain...

**Modifiable Area Unit Problem (MAUP)**

- 7. Have you ever encountered one of the effects/problems (*see box 1 above*) in any of your studies or data analysis?
- 8. If yes, how have you attempted/ dealt with it or planned to mitigate the effects in your results? What in your opinion could be the possible ways to mitigate the effects/problems when analyzing any of the dimensions of multiple deprivations? (*See table 1*).
- 9. What are the possible implications to policy targeting of deprivation issues with regard to the effects/problems stated above?

<<<<Thank you very much for dedicating your time and for your cooperation>>>

A.N. Nthiwa

Appendix 3: Key informant questionnaire - Policy makers

**KEY INFORMANT QUESTIONNAIRE**

<b>Interviewer:</b>	Alex Nthiwa
<b>Date of interview:</b>	
<b>Designation of key informant:</b>	
<b>Research areas/Profession:</b>	

**Declaration:** “I am an Msc student from the Faculty ITC of the University of Twente, the Netherlands. Information that would be made available will be only utilized for the research objectives and not for any other purpose(s).”

**Introduction**

*Information for this research centres on multiple deprivation or disadvantage faced by people in Istanbul and the problems that arises when data is analysed using different units e.g. at district or neighbourhood level. Please indicate from the following list which domains of deprivation you usually work with or research on.*

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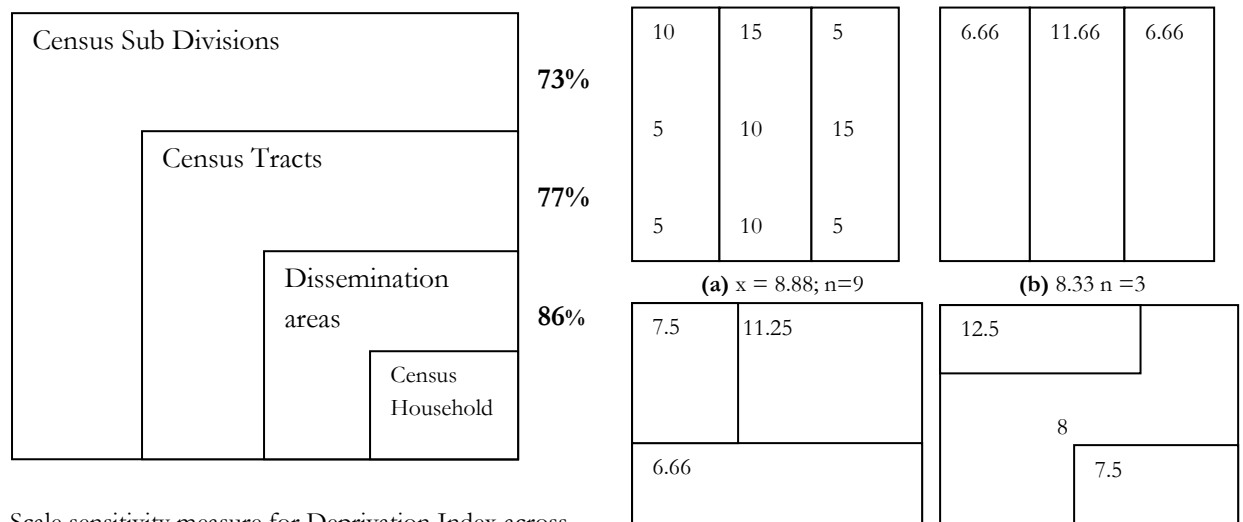
*Table 1: Dimensions of multiple deprivation*

*Adapted from Townsend, P. (1987). Deprivation. Journal of Social Policy(16), 125-146.*

## The modifiable areal unit problem

The MAUP is the problem that arises when inferences based on spatial analysis change when the same data is analysed through different zoning systems or through variations in scales. It has two components: the scale and zoning effect (Schuurman, et al., 2007). The **scale effect**, is the trend of arriving at different results from analysis of the same dataset after doing several scale alterations e.g., neighbourhoods, districts and regions. The **Zoning effect** results from the variations in the number of zoning configurations that can be used in analysis at a given scale thus getting varying results by merely changing the boundaries of the zoning systems at a specified scale.

**Source:** Paez, A., & Scott, D. (2004).



Scale sensitivity measure for Deprivation Index across three census configurations (units of analysis).

**Source:** Dumedab, G., Schuurman, N., & Yang, W.

(a)  $x = 8.88$ ;  $n=9$

(b)  $8.33$   $n=3$

(c)  $x = 8.47$ ;  $n=3$

(d)  $9.33$ ;  $n=3$

**Source:** Oliver, L. (2001).

Modifiable area unit problem: scale effects (a, b) and zoning effects(c, d)

### Box 1: Modifiable areal unit problem

#### Geographical units of analysis (provincial, district or neighbourhood)

1. In Istanbul, census data is reported at different geographical units, i.e. provincial, district (Ilce), neighbourhood (Mahalle), what are the unit(s) of analysis through which data is organized in your field of research?
2. With regard to question one, what are the geographical units of analysis commonly used when mapping any of the above dimensions of multiple deprivations that you work with (**see table 1**), in Istanbul/Turkey?
3. What are the factors considered when selecting a geographical unit to analyse data? Why do you choose a certain unit of analysis for a particular deprivation?
4. Cities like Istanbul have different administrative boundaries e.g. municipalities, districts, metropolis, what are the reasons for selecting a certain administrative boundary when mapping multiple deprivations for the purposes of final production of the maps?
5. What are the constraints in your case that affect the choice of your preferred unit of analysis for a particular deprivation?

6. Since data is organized at different geographical units, in your opinion do you think researchers should deliberate on the unit to use before analyzing data?
  - a. If yes, please explain...
  - b. If no, please explain...

**Modifiable Area Unit Problem (MAUP)**

7. Have you ever encountered one of the effects/problems (*see box 1 above*) in any of your studies or data analysis?
8. If yes, how have you attempted/ dealt with it or planned to mitigate the effects in your results? What in your opinion could be the possible ways to mitigate the effects/problems when analyzing any of the dimensions of multiple deprivations? (*See table 1*).

**For policy makers**

9. When delegating planning activities to consultants or other authorities, what is your preferred geographical unit(s) for analysing different deprivations? (*See table 1*).
10. What are the possible implications to policy intervention with regard to the effects or problems that occurs when interpretations based on spatial analysis change when the same data is analysed using different geographical units? (*See box 1 above*).

<<<<Thank you very much for dedicating your time and for your cooperation>>>

A.N. Nthiwa

**KEY INFORMANT QUESTIONNAIRE**

<b>Interviewer:</b>	Alex Nthiwa
<b>Date of interview:</b>	
<b>Designation of key informant:</b>	
<b>Research areas/Profession:</b>	

**Declaration:** “I am an Msc student from the Faculty ITC of the University of Twente, the Netherlands. Information that would be made available will be only utilized for the research objectives and not for any other purpose(s).”

**Introduction**

*Information for this research centres on multiple deprivation or disadvantage faced by people in Istanbul and the problems that arises when data is analysed using different units e.g. at district or neighbourhood level. Please indicate from the following list which domains of deprivation you usually work with or research on.*

<p><b>A. Material deprivation</b></p> <p><b>1. Housing deprivation</b></p> <ul style="list-style-type: none"> <li>+ External structural defects</li> <li>+ No electricity</li> <li>+ Overcrowded</li> <li>+ Internal structure defects</li> </ul> <p><b>2. Deprivation of home facilities</b></p> <ul style="list-style-type: none"> <li>+ No car</li> <li>+ No refrigerator</li> <li>+ No telephone</li> <li>+ No washing machine</li> <li>+ No central heating</li> <li>+ No television</li> </ul> <p><b>3. Deprivation of environment</b></p> <ul style="list-style-type: none"> <li>+ No garden</li> <li>+ Industrial air pollution</li> <li>+ Other forms of pollution</li> <li>+ No safe playground for under 5 children</li> <li>+ Risk of road accidents around home</li> </ul> <p><b>4. Deprivation of location</b></p> <ul style="list-style-type: none"> <li>+ No recreational facilities nearby</li> <li>+ Hospital department not within 10 minutes journey</li> </ul>	<p><b>B. Social deprivation</b></p> <p><b>1. Lack of rights in employment</b></p> <ul style="list-style-type: none"> <li>+ Unemployed</li> <li>+ No social security</li> </ul> <p><b>2. Lack of integration into community</b></p> <ul style="list-style-type: none"> <li>+ Did not vote in last election</li> <li>+ Racial harassment</li> </ul> <p><b>3. Educational deprivation</b></p> <ul style="list-style-type: none"> <li>+ Illiterate</li> <li>+ Fewer than 10 years of formal education</li> </ul>
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*Table 1: Dimensions of multiple deprivation*

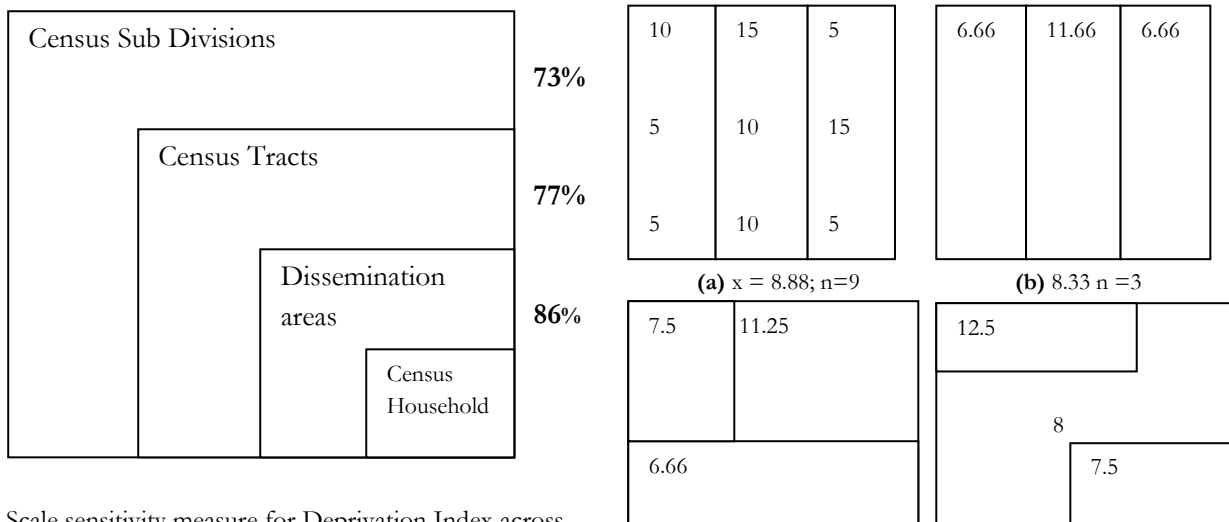
*Adapted from Townsend, P. (1987). Deprivation. Journal of Social Policy(16), 125-146.*



**The modifiable areal unit problem**

The MAUP is the problem that arises when inferences based on spatial analysis change when the same data is analysed through different zoning systems or through variations in scales. It has two components: the scale and zoning effect (Schuurman, et al., 2007). The **scale effect**, is the trend of arriving at different results from analysis of the same dataset after doing several scale alterations e.g., neighbourhoods, districts and regions. The **Zoning effect** results from the variations in the number of zoning configurations that can be used in analysis at a given scale thus getting varying results by merely changing the boundaries of the zoning systems at a specified scale.

**Source:** Paez, A., & Scott, D. (2004).



Scale sensitivity measure for Deprivation Index across three census configurations (units of analysis).

**Source:** Dumedab, G., Schuurman, N., & Yang, W.

(c)  $x = 8.47; n=3$

**Source:** Oliver, L. (2001).

Modifiable area unit problem: scale effects (a, b) and zoning effects(c, d)

**Box 1; Modifiable areal unit problem**

**Geographical units of analysis (provincial, district or neighbourhood)**

1. In Istanbul, census data is reported at different geographical units, i.e. provincial, district (Ilce), neighbourhood (Mahalle), what are the unit(s) of analysis through which data is organized in your field of research.
2. With regard to question one, what are the geographical units of analysis commonly used when mapping any of the above dimensions of multiple deprivations that you work with (*see table 1*), in Istanbul/Turkey?
3. What are the factors considered when selecting a geographical unit to analyse data? Why do you choose a certain unit of analysis for a particular deprivation?
4. Cities like Istanbul have different administrative boundaries e.g. municipalities, districts, metropolis, what are the reasons for selecting a certain administrative boundary when mapping multiple deprivations for the purposes of final production of the maps?
5. What are the constraints in your case that affect the choice of your preferred unit of analysis for a particular deprivation?

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6. Since data is organized at different geographical units, in your opinion do you think researchers should deliberate on the unit to use before analyzing data?
    - a. If yes, please explain...
    - b. If no, please explain...

**Modifiable Area Unit Problem (MAUP)**

7. Have you ever encountered one of the effects/problems (*see box 1 above*) in any of your studies or data analysis?
8. If yes, how have you attempted/ dealt with it or planned to mitigate the effects in your results? What in your opinion could be the possible ways to mitigate the effects/problems when analyzing any of the dimensions of multiple deprivations? (*See table 1*).
9. What are the possible implications to policy intervention with regard to the effects/problems stated above?

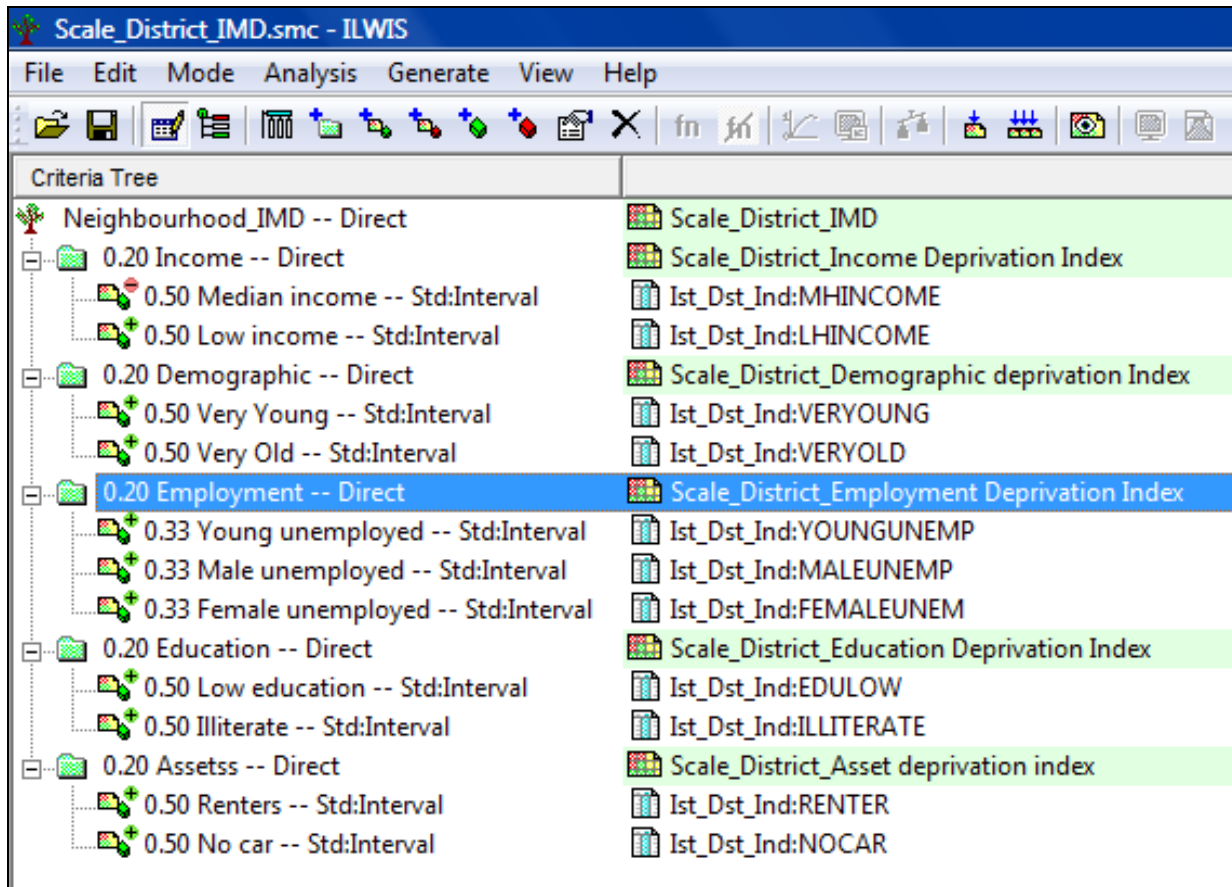
**For IMP**

10. Being a planning authority, what are the geographical units of analysis you employ when analyzing data for different planning activities?
11. What is the general structure of the planning system in Istanbul?
12. Is it centralized (done at metropolitan level) or done at the district or neighbourhood level?

<<<<Thank you very much for dedicating your time and for your cooperation>>>

A.N. Nthiwa

Appendix 5: An example of the criteria model processed in a multi-criteria evaluation- ILWIS



Appendix 6: Quartile ranking classification system used for the MAUP

Upper Bound	Class Name	Code	Description
0	No data	ND	
0.44	Least deprived	LS	
0.54	Moderately least deprived	MD	
0.64	moderately Highly deprived	MHD	
1	Highly deprived	HD	

Appendix 7: Quartile ranking classification system used for the scale effect demographic domain

Upper Bound	Class Name	Code	Description
0	No data	ND	
0.25	Least deprived	LS	
0.35	Moderately least deprived	MD	
0.45	moderately Highly deprived	MHD	
1	Highly deprived	HD	

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Appendix 8: a) Reporting and interpretation of t-test statistic results for equality of means between the neighbourhood and district scales

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1. On average the percentage of LHINCOME was greater at the district scale ( $M = 45.88$ ), than at the neighbourhood scale ( $M = 43.60$ ). This difference was not significant at  $t(981) = -.651, p > .05$ .
  2. The average percentage of NOCAR was greater at the district ( $M = 67.36$ ), than at the neighbourhood scale ( $M = 66.03$ ). The difference was not significant at  $t(981) = -.453, p > .05$ .
  3. The average percentage of RENTER was greater at the district ( $M = 33.33$ ), than at the neighbourhood scale ( $M = 30.40$ ). The difference was not significant at  $t(981) = -.929, p > .05$ .
  4. While on average MHINCOME was greater at the neighbourhood scale ( $M = 840.21$ ), than at the district scale ( $M = 830.60$ ). The difference was still not significant at  $t(981) = .143, p > .05$ .
  5. Also, on average, the percentage of VERYOLD was greater at the neighbourhood scale ( $M = 8.03$ ), than at the district scale ( $M = 6.74$ ). This difference was not significant at  $t(981) = .947, p > .05$ .
  6. The mean percentage of MALEUNEMP was greater at the neighbourhood scale ( $M = 14.49$ ), than at the district scale ( $M = 13.66$ ). The difference was non-significant at  $t(981) = .758, p > .05$ .
  7. By average the percentage of FEMALEUNEMP was greater at the neighbourhood scale ( $M = 32.19$ ), than at the district scale ( $M = 31.43$ ). The difference was not significant at  $t(981) = .740, p > .05$ .
  8. On average the percentage of EDULOW was greater at the neighbourhood scale ( $M = 46.27$ ), than at the district scale ( $M = 44.65$ ). The difference was not significant at  $t(981) = .705, p > .05$ .
  9. Average percentage of VERYOUNG was greater at the district ( $M = 19.69$ ), than at the neighbourhood scale ( $M = 19.19$ ). The difference was not significant at  $t(981) = -.414, p > .05$ .
  10. Average percentage of YOUNGUNEMP was greater at the district ( $M = 12.19$ ), than at the neighbourhood scale ( $M = 11.97$ ). The difference was not significant at  $t(981) = -.280, p > .05$ .
  11. Average percentage of ILLITERATE was greater at the district ( $M = 13.72$ ), than at the neighbourhood scale ( $M = 13.38$ ). The difference was not significant at  $t(981) = -.305, p > .05$ .
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**b) Reporting and interpretation of results on Levene's test for equality of variances by scale**

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For the mean percentage on NOCAR, the variances were significantly different for the district and neighbourhood scale,  $F(981) = 11.40, p < .01$ . Similarly, the variances for the other variables were significantly different on the two scales: RENTER,  $F(981) = 11.02, p < .01$ , MHINCOME,  $F(981) = 4.31, p < .05$ , LHINCOME,  $F(981) = 14.38, p < .01$ , VERYOUNG,  $F(981) = 9.28, p < .01$ , VERYOLD,  $F(981) = 5.70, p < .05$ , YOUNGUNEMP,  $F(981) = 15.78, p < .01$ , MALEUNEMP,  $F(981) = 9.91, p < .01$ , FEMALEUNEMP,  $F(981) = 9.09, p < .01$ , EDULOW,  $F(981) = 7.93, p < .01$ , ILLITERATE,  $F(981) = 13.23, p < .01$ .

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## Appendix 9: a) Reporting and interpretation of t-test statistic results for equality of means by district design

1. By average the percentage of LHINCOME was higher at the old district designs ( $M = 45.88$ ), than at the new district designs ( $M = 43.93$ ). This difference was not significant at  $t(64) = .764, p > .05$ .
2. The mean percentage of NOCAR was bigger at the old district designs ( $M = 67.37$ ), than at the new district designs ( $M = 65.87$ ). The difference was not significant at  $t(64) = -.532, p > .05$ .
3. The average percentage of RENTER was greater at the old district designs ( $M = 33.33$ ), than at the new district designs ( $M = 31.46$ ). The difference was not significant at  $t(64) = .835, p > .05$ .
4. While on average MHINCOME was greater at the old district designs ( $M = 830.61$ ), than at the new district designs ( $M = 713.89$ ). The difference was still not significant at  $t(64) = 1.457, p > .05$ .
5. Also, on average, the percentage of VERYOLD was greater at the old district designs ( $M = 6.74$ ), than at the new district designs ( $M = 6.30$ ). This difference was not significant at  $t(64) = .416, p > .05$ .
6. The mean percentage of MALEUNEMP was greater at the old district designs ( $M = 13.66$ ), than at the new district designs ( $M = 12.86$ ). The difference was non-significant at  $t(64) = 1.095, p > .05$ .
7. By average the percentage of FEMALEUNEMP was greater at the old district designs ( $M = 31.43$ ), than at the new district designs ( $M = 30.48$ ). The difference was not significant at  $t(64) = .860, p > .05$ .
8. On average the percentage of EDULOW was greater at the old district designs ( $M = 44.65$ ), than at the new district designs ( $M = 44.09$ ). The difference was not significant at  $t(64) = .279, p > .05$ .
9. Average percentage of VERYOUNG was greater at the old district designs ( $M = 19.69$ ), than at the new district designs ( $M = 19.00$ ). The difference was not significant at  $t(64) = .762, p > .05$ .
10. Average percentage of YOUNGUNEMP was greater at the old district designs ( $M = 12.19$ ), than at the new district designs ( $M = 11.75$ ). The difference was not significant at  $t(64) = .918, p > .05$ .
11. However, the mean percentage of ILLITERATE was greater at the new district designs ( $M = 13.93$ ), than at the old district designs ( $M = 13.72$ ). The difference was not significant at  $t(64) = -.248, p > .05$ .

**b) Reporting and interpretation of results on Levene's test for equality of variances by district designs**

For the mean percentage of MHINCOME, Levene's statistic shows that the variances were significantly different between the old and new district designs,  $F(64) = 9.80, p < .01$ . Conversely, the variances for the other variables on the two district designs were non significantly different at,  $p > .05$ : RENTER,  $F(64) = 4.24$ , LHINCOME,  $F(64) = .217$ , VERYOUNG,  $F(64) = .559$ , VERYOLD,  $F(64) = .193$ , YOUNGUNEMP,  $F(64) = .969$ , MALEUNEMP,  $F(64) = .001$ , FEMALEUNEMP,  $F(64) = .421$ , EDULOW,  $F(64) = .000$ , ILLITERATE,  $F(64) = .029$ . NOCAR,  $F(64) = .095$

Appendix 10: Independent samples t test and Levene's statistic by scale

Neighborhoods and old districts Independent Samples Test												
	Levene's Test for Equality of Variances			t-test for Equality of Means								
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference				
								Lower	Upper			
NOCAR	11.401	.001	-.453	981	.651	-1.33800	2.95304	-7.13301	4.45701			
RENTER	11.023	.001	-.929	981	.353	-2.93125	3.15610	-9.12473	3.26223			
MHINCOME	4.311	.038	.143	981	.886	9.60604	66.99071	-121.85553	141.06762			
LHINCOME	14.138	.000	-.651	981	.515	-2.27882	3.49914	-9.14547	4.58784			
VERYOUNG	9.280	.002	-.414	981	.679	-.49310	1.19103	-2.83036	1.84415			
VERYOLD	5.703	.017	.947	981	.344	1.28807	1.35995	-1.38067	3.95681			
YOUNGUNEMP	15.781	.000	-.280	981	.779	-.21946	.78338	-1.75675	1.31784			
MALEUNEMP	9.906	.002	.758	981	.449	.83790	1.10545	-1.33142	3.00723			
FEMALEUNEMP	9.093	.003	.740	981	.459	.75395	1.01854	-1.24482	2.75273			
EDULOW	7.930	.005	.705	981	.481	1.62498	2.30566	-2.89960	6.14957			
ILLITERATE	13.231	.000	-.305	981	.760	-.34503	1.13043	-2.56337	1.87331			
			-.572	41.370	.571	-.34503	.60335	-1.56320	.87313			

Appendix 11: Independent samples t test and Levene's statistic by district design

		Old districts and new district Independent Samples Test									
		Levene's Test for Equality of Variances					t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
									Lower	Upper	
NOCAR	Equal variances assumed	.095	.759	.532	64	.596	1.49987	2.81681	-4.12736	7.12709	
	Equal variances not assumed			.532	56.191	.596	1.49987	2.81681	-4.14246	7.14219	
RENTER	Equal variances assumed	.424	.517	.835	64	.407	1.87010	2.24023	-2.60528	6.34548	
	Equal variances not assumed			.835	62.807	.407	1.87010	2.24023	-2.60692	6.34711	
MHINCOME	Equal variances assumed	9.809	.003	1.457	64	.150	116.72039	80.11598	-43.32968	276.77045	
	Equal variances not assumed			1.457	43.209	.152	116.72039	80.11598	-44.82626	278.26703	
LHINCOME	Equal variances assumed	.217	.643	.764	64	.448	1.94470	2.54707	-3.14366	7.03305	
	Equal variances not assumed			.764	63.589	.448	1.94470	2.54707	-3.14429	7.03369	
VERYOUNG	Equal variances assumed	.559	.457	.762	64	.449	.68545	.89908	-1.11068	2.48157	
	Equal variances not assumed			.762	57.953	.449	.68545	.89908	-1.11430	2.48519	
VERYOLD	Equal variances assumed	.193	.662	.416	64	.679	.43944	1.05644	-1.67104	2.54991	
	Equal variances not assumed			.416	63.990	.679	.43944	1.05644	-1.67104	2.54992	
YOUNGUNEMP	Equal variances assumed	.969	.329	.918	64	.362	.44464	.48437	-.52300	1.41228	
	Equal variances not assumed			.918	49.518	.363	.44464	.48437	-.52848	1.41776	
MALEUNEMP	Equal variances assumed	.001	.971	1.095	64	.278	.79783	.72887	-.65825	2.25392	
	Equal variances not assumed			1.095	60.920	.278	.79783	.72887	-.65967	2.25534	
FEMALEUNEMP	Equal variances assumed	.421	.519	.860	64	.393	.94842	1.10321	-1.25550	3.15235	
	Equal variances not assumed			.860	42.326	.395	.94842	1.10321	-1.27745	3.17429	
EDULOW	Equal variances assumed	.000	.995	.279	64	.781	.55916	2.00581	-3.44790	4.56622	
	Equal variances not assumed			.279	59.381	.781	.55916	2.00581	-3.45391	4.57223	
ILLITERATE	Equal variances assumed	.029	.866	-.248	64	.805	-.20028	.80836	-1.81517	1.41461	
	Equal variances not assumed			-.248	63.973	.805	-.20028	.80836	-1.81518	1.41463	