ASSESSMENT OF SOCIAL VULNERABILITY USING GEOGRAPHIC INFORMATION SYSTEMS: PENDIK, ISTANBUL CASE STUDY

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Approval of the Graduate School of Natural And Applied Sciences

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ABSTRACT

ASSESSMENT OF SOCIAL VULNERABILITY USING GEOGRAPHIC INFORMATION SYSTEMS: PENDIK, ISTANBUL CASE STUDY

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Natural hazards are the reality of today's world, which considerably affect people's living conditions. As they cannot be prevented, the basic precautions should be taken before the occurrence to protect people. At this point, the preparedness for any threat is really important, which does decrease destructive effects of the hazard for communities and shorten recovery interventions. In terms of preparedness, identification of vulnerable people in the community gives an important contribution for better planning in disaster management.

In this respect, this thesis aims to develop a methodology in order to define vulnerable groups in terms of their social conditions for any possible hazard, with Geographic Information Systems (GIS) technology. Moreover, the thesis aims to find out an interrelation between hazards and vulnerability, to build awareness about identification of socially vulnerable groups in the pre- and post-disaster planning.

A case study area is selected in earthquake-prone Pendik, Istanbul, in order to find the contribution of the assessment. A study is carried out to describe social vulnerability levels in the study area using GIS. Criterion standardization, weighting and combining are accomplished by multi criteria evaluation methods. These calculations are supported with five explorative spatial data analyses to understand global trends and spatial interactions of the study data. The objectivity of the assessment and the complicated structure of the study data are also discussed. The main outcomes of the methodology and its applications in the case study area show that, the southeast part of Pendik is socially vulnerable to any possible hazard.

KEYWORDS: Social Vulnerability Assessment, GIS, Spatial Data Analysis, Pre- and Post-Disaster Planning, Disaster Management, Pendik-Istanbul

ÖZ

COGRAFI BILGI SISTEMLERI KULLANILARAK, SOSYAL HASSASIYET DEGERLENDIRME ÇALISMASI: ISTANBUL, PENDIK ÖRNEGI

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Jeodezi ve Cografi Bilgi Teknolojileri Yüksek Lisans Bölümü

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Insanlarin yasam kosullarini önemli biçimde etkileyen dogal afetler, günümüz dünyasinin bir gerçegidir. Engellenmeleri mümkün olmadigi için, insanlari korumak amaciyla olay öncesi temel önlemler alinmalidir. Bu noktada tehlikelere karsi hazirlikli olmak çok önemlidir. Böylece afetlerin toplumlar üzerindeki yikici etkileri gerçekten azalmakta, ve yeniden yapilanma müdahale süreleri kisalmaktadir. Hazirlikli olma adina, toplum içerisindeki afetlerden kolay etkilenebilen hassas gruplarin tanimlanmasi, afet yönetiminin planlama asamasinda önemli bir katki saglamaktadir.

Bu açidan, bu tez muhtemel bir afet durumunda sosyal durumlari bakimindan hassas olan gruplarin belirlenmesi için, Cografi Bilgi Sistemleri (CBS) teknolojisi yardimiyla bir metodolojinin gelistirilmesini amaçlamaktadir. Bunun yanisira bu tez, felaket öncesi ve sonrasi planlamada sosyal bakimdan hassas gruplarin belirlenmesi konusunda bilinç olusturmak için, hassasiyet ve afet kavramlari arasindaki baglantiyi bulmayi da amaçlamaktadir.

Degerlendirme çalismasinin katkisini göstermek amaciyla, örnek alan olarak birinci derece deprem bölgesinde yeralan Istanbul Pendik ilçesi seçilmistir. Bu çalisma, örnek alanin sosyal hassasiyet derecelerini CBS kullanilarak tanimlamaktadir. Kriter standardizasyonu, agirliklandirma ve birlestirme islemleri, çoklu kriter degerlendirme metodlari ile gerçeklestirilmektedir. Bu hesaplamalar, çalisma alanindaki global egilimleri ve mekansal etkilesimleri anlamak için, bes arastirici mekansal veri analizleri ile desteklenmektedir. Degerlendirmenin tarafsizligi ve örnek alan verisinin karisikligi da tartisilmaktadir. Metodoloji ve örnek alan uygulamasinin temel çiktilari göstermisdir ki, muhtemel bir afet durumunda Pendik ilçesinin güney dogu kismi sosyal bakimdan oldukça hassasdir.

Anahtar Kelimeler: Sosyal Hassasiyet Analizi, CBS, Mekansal Veri Analizi, Felaket Öncesi ve Sonrasi Planlama, Afet Yönetimi, Pendik-Istanbul

To Görkem

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CHAPTER 1

INTRODUCTION

Natural hazards are the reality of today's world, which considerably affect people's living conditions. As they cannot be prevented, the basic precautions should be taken before the occurrence to protect people. At this point, the preparedness for any threat is really important, which does decrease the destructive effects of the hazard for the communities and shorten recovery interventions.

In terms of preparedness, identification of the community's vulnerability gives a clear picture of risky and susceptible groups, which can also be called vulnerable groups. By identifying these vulnerable groups, better disaster preparedness plans can be undertaken and better public awareness studies can be developed in the pre-disaster phase. Besides, for during- and post-disaster interventions, the resource allocations can be organized fairly considering these vulnerable groups.

In this respect, this thesis aims to establish a methodology for identifying the vulnerable groups for any hazard, before it becomes a reality. The main reason for focusing on the determination of vulnerability in the hazard approach is because of the hazards' unexpected occurrences, since they can happen at any moment, it can result in high destruction in communities.

Although the concept of vulnerability is mentioned in different fields, generally it has been used and described in the natural hazard research fields. The concept entered officially in this area in 1979 with a report of UNDRO (Office of the United Nations Disaster Relief). It has been stated by UNDRO (1991) that there is a combined relation among Risk, Hazard, and Vulnerability. This relationship suggests that vulnerability cannot be described without reference to a specific hazard or a shock. So, the question that must always be asked is, "Vulnerability to what?".

However, the definition of vulnerability is interpreted by UNDRO (1991) as 'a measure of the susceptibility of structures to potentially damaging natural phenomena', and this approach is differentiated in the recent years. In fact, by defining the vulnerability just with the structures, the effect on the individuals and communities cannot be assessed properly. For example, although the building is seen in unsafe condition in any earthquake, it is the inhabitants of that building who are vulnerable.

In this respect, vulnerability is generally defined as; "… the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impacts of natural or man-made hazards" (International Federation of Red Cross and Red Crescent Societies, 2000).

As it is also understood from the above definition, it has been agreed in the literature that vulnerability has two sides. First side is the external side of risk, shock or stress to which an individual or household is subject to; and the other side is the internal side which is defencelessness, means lack of coping without damaging loss. Having these sides, the concept of vulnerability is described within five categories, which are economical, social, environmental, political, and cultural.

Besides, in the literature the concept is confused with concepts of risk, hazard, poverty, and inequality. Although, there are some similarities among these concepts, there is a delicate distinction of vulnerability from the others. For example, communities who are most vulnerable will also probably be the ones who are most at risk; however, communities that may face the same risk will not be equally vulnerable. This confusion is also detected in the concept of its assessment. However, the assessment of vulnerability involves consideration of all significant elements in the society, including physical, social, and economic considerations, and local coping mechanism.

The main challenge in the assessment of vulnerability, which is determined in the literature, is to find out the ways of analyzing people's vulnerability implicit in daily life. In other words, people's actual living conditions must be investigated in these assessments, to understand their potentials and weaknesses, which can make them vulnerable for any possible hazard.

At this point, the need of social vulnerability assessment becomes important; because, without any knowledge about the community's social conditions (such as, income levels, educational status, age or sex differentiations, kinship levels, or social support networks), it is impossible to describe their vulnerability and to develop appropriate strategies.

Besides that there are few researches on this topic, there is an absence of the assessment of physical factors in such studies. In fact, having spatially referenced data of the considered area, the projects on social sciences could get different perspectives, rather than just analyzing regular statistical data. This kind of data also helps to understand the causing factors of social vulnerabilities. In the analysis of physical factors, Geographic Information Systems (GIS) is a very powerful tool, with its visualization and spatial data analysis capabilities.

In these respects, this thesis aims to develop a methodology to identify vulnerable groups in terms of their social conditions for any possible hazard, before it becomes real. In order to reach this aim, Geographic Information Systems (GIS) technology constitutes the basis. In addition to that, MCE methods, the theoretical background being based on the multi-attribute utility theory (MAUT), are utilized to obtain social vulnerability levels from census data. It is also intended to use some explorative spatial data analyses in order to analyze the global trends and spatial interactions of the study data. A case study area is selected to find out the contribution of the use of this GIS-based Social Vulnerability Assessment methodology in the determination of inhabitants' social vulnerability, in earthquake-prone district of Pendik, Istanbul.

The thesis starts with the definitions of social vulnerability assessment and its components. In the second chapter, the examples of vulnerability assessments are also presented for better understanding and taking good results from the best practices. Since the aim of this thesis is to build a methodology for identifying socially vulnerable groups, these international attempts help to constitute a strong basis for it. In fact, the following positive sides of these studies have contributed to the thesis: (a) usability of census data and official statistics, (b) necessity of data on socio-economic profile, (c) importance of household interviews, study visits, meetings and dialogues with local inhabitants and authorities, neighborhood surveys, building use surveys, (d) spatial data analysis, and (e) Geographic Information Systems.

In the third chapter, the case study area is described. Pendik is an administrative district of Istanbul, which is also one of the 19 districts of the city in the first-degree earthquake risk zone. Location, population trends, economical and cultural features, and transportation possibilities are mentioned in this chapter. Besides, main corner stones of the GIS-based Social Vulnerability Assessment methodology are presented. In fact, in the calculation of social vulnerability, the needed variables and their sub categories are determined, which is constituted from State Institute of Statistics' "Public Use Samples from the 1990 Census". In addition to that, to avoid the subjective decision on the variables' weights determination, 10 more different evaluations are utilized in the case study application.

Moreover, in the third chapter, five explorative spatial data analyses are presented and applied in the case study. Namely, Spatial Moving Averages Method, Median Polish Method, Kernel Estimation Method, and Spatial Correlations are integrated into the methodology because of their characteristics of seeking good description of data, emphasizing graphical views of data, and involving a significant degree of 'value-added' data manipulations.

The fourth chapter covers the supplementary GIS Analyses, namely population, building usage, and transportation analyses, which are applied to determine the physical effects of basic service locations and transportation opportunities in the case study area. Besides, in the fourth chapter, a different approach to define the reliability of the study data's income level-based variables is examined for Pendik. The results of this approach constituted the strong basis for the variables' categorization, and resulted in more realistic social vulnerability levels for Pendik neighborhoods.

Finally, in the last chapter, the aim of the study and the developed methodology to reach this goal, are summarized. Main findings of the study are evaluated. The outcomes of the overall study and recommendations are also mentioned to guide further studies.

CHAPTER 2

DESCRIPTION OF SOCIAL VULNERABILITY ASSESSMENT

In this chapter, the main concepts of social vulnerability assessment and spatial data analyses are described, and related examples of these concepts are presented. Having these determinations and examples, this chapter has constituted a strong basis for developing a methodology in this thesis.

2.1 Social Vulnerability Assessment

2.1.1 Description of Vulnerability

The word vulnerability derives from the Latin “vulnus”, which means hurt, injury and it is used in medicine to refer to those individual characteristics which make some patients particularly prone to given illnesses. It indicates specific weaknesses which make prone a single person or a group to get ill with respect to another – who- exposed to the same agent – keeps his well being. What is exposed to a given hazard or dangerous agent, and how many people live in a dangerous area does not explain per se the amount and the severity of losses, while the term vulnerability does, by explaining in which way a society, a part of it, a given system, a person, is more likely to be damaged than another and why (Menoni, 2001).

In this respect, the concept of vulnerability has been used as a part of different research fields. However, the most use is observed in natural hazards research fields. The term vulnerability entered officially in the natural hazards research field in 1979 with a report issued by the UNDRO (Menoni, 2001). According to UNDRO (Office of the United Nations Disaster Relief), there is a combined relation among “Risk, Hazard, and Vulnerability” (UNDRO, 1991). This relation is formulized as:

Risk = (Hazard * Vulnerability) (Harding, 2001) 2.1

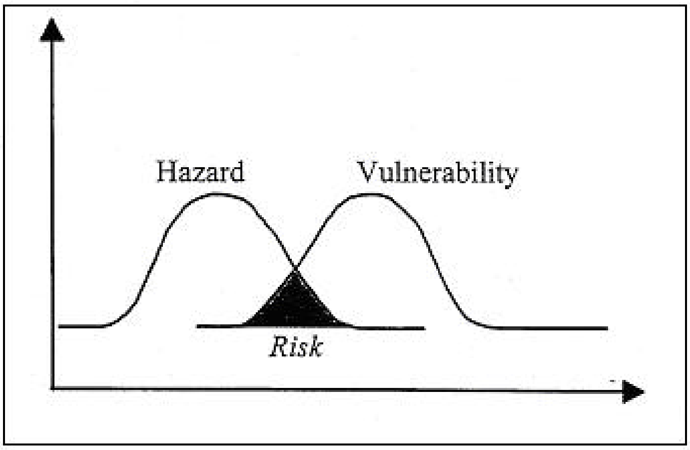

Figure 2.1 The Definition of Risk, According to UNDRO (Source: Menoni, 2001)

The above relation is very important for the concept of vulnerability. Because, it shows; “The definition of vulnerability suggests that it cannot be described without reference to a specific hazard or shock. So, the question that must always be asked is, ‘Vulnerability to what?’” (International Federation of Red Cross and Red Crescent Societies, 2000). People in coastal areas may be vulnerable to flooding, while people in the first-degree earthquake risk zone may be vulnerable to earthquake.

However this definition of vulnerability is interpreted by UNDRO as “… a measure of the intrinsic susceptibility of structures to potentially damaging natural phenomena” (Dibben and Chester, 1999). However, by defining vulnerability just with structures, the effect on the individuals and communities cannot be assessed properly. For example, although, the building is seen in unsafe condition in any earthquake, it is the inhabitants of that building who is vulnerable.

From this respect, this approach has changed in recent years. Although, there are still different approaches in the literature for the definition of vulnerability, generally the following two descriptions have been accepted. Which of the first one explains vulnerability as:

"… the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impacts of natural or man-made hazards (International Federation of Red Cross and Red Crescent Societies, 2000)".

and the other one describes as:

"…any condition of susceptibility to external shocks that could threaten people's lives and livelihoods, natural resources, properties and infrastructure, economic productivity, and a region's prosperity. (Uribe et al., 1999)

From the above descriptions, there is one common point especially emphasized in the literature, which are the main sides of vulnerability. In fact, Chambers (1983) explains these sides as; the first one is "an external side of risk, shocks and stress to which an individual or household is subject", and the other side is "an internal side which is defencelessness, meaning a lack of means to cope without damaging loss". These sides are also mentioned by Delor and Hubert (2000) in three categories; "namely, the risk of being exposed to crisis situations (exposure), the risk of not having the necessary resources to cope with these situations (capacity), and the risk of being subjected to serious consequences as a result of the crises (potentiality)".

However, Varley (1991) just mentions the internal side of vulnerability. In fact, he states that vulnerability is a "… function of the degree of social and self-protection available to potential victims". It is clearly related to the ability of households or communities to cope with and recover from outside events and particularly to shocks and sudden changes. It also concerns the predisposition of a society to experience substantial damage as a result of natural hazards (Alcantara-Ayala, 2002). However, it is the definition of Cannon (1993), which considers different factors affecting or producing the vulnerability of individuals or groups, which is most germane. According to Cannon (1993), vulnerability is "a characteristic of individuals and groups of people who inhabit a given natural, social and economic space, within which they are differentiated according to their varying position in society into more or less vulnerable individuals and groups. It is a complex characteristics produced by a combination of factors derived especially (but not entirely) from class, gender, or ethnicity.'' Cannon divided vulnerability into three parts: (1) Livelihood resilience: the degree of resilience of the particular livelihood system of an individual or group, and their capacity for resisting the impact of hazard. (2) Health: including both the robustness of individuals, and the operation of various social measures. (3) Preparedness: determined by the protection available for a given hazard, something that depends on people acting on their own behalf, and social factors (Alcantara-Ayala, 2002).

The above-mentioned aspects cover general types of vulnerability. Nevertheless, each aspect has different components and the combinations of them can be so numerous that it is necessary to specify the particular types of vulnerability of each threatened entity (Alcantara-Ayala, 2002). In this respect, Aysan (1993) divides vulnerability into the following types:

- Lack of access to resources (materials/economic vulnerability)
- Disintegration of social patterns (social vulnerability)
- Lack of strong national and local institutional structures (organizational vulnerability)
- Lack of access to information and knowledge (educational vulnerability)
- Lack of public awareness (attitudinal and motivational vulnerability)
- Limited access to political power and representation (political vulnerability)
- Certain beliefs and customs (cultural vulnerability)
- Weak buildings of weak individuals (physical vulnerability)

The above classification indicates that, vulnerability is not only be resulted by human choices, but also people's natural, economic, cultural, political, and social environment. Therefore, vulnerability cannot be stated as a static and general term, which changes for each society.

Supporting the above approach, Alcantara-Ayala (2002) groups vulnerability types into two categories, which are natural vulnerability and human vulnerability. She claims that; "natural vulnerability depends on the threatening natural hazard (very much related to geographical location), thus, there is volcanic vulnerability, flooding vulnerability, landsliding vulnerability, tsunamis vulnerability, hurricane vulnerability and so on. On contrast, human vulnerability is based on the social, economical, political and cultural systems". Moreover, she states that "vulnerability can be defined as the propensity of an endangered element due to any kind of natural hazard to suffer different degrees of loss or amount of damage depending on its particular social, economic, cultural, and political weaknesses. Total vulnerability is a function of the individual types of vulnerability present in a given area. Such vulnerability determines the magnitude of the disaster, the level of resilience and the recovery process." The graphical description of Alcantara-Ayala's (2002) perspective is demonstrated in the Figure 2.2.

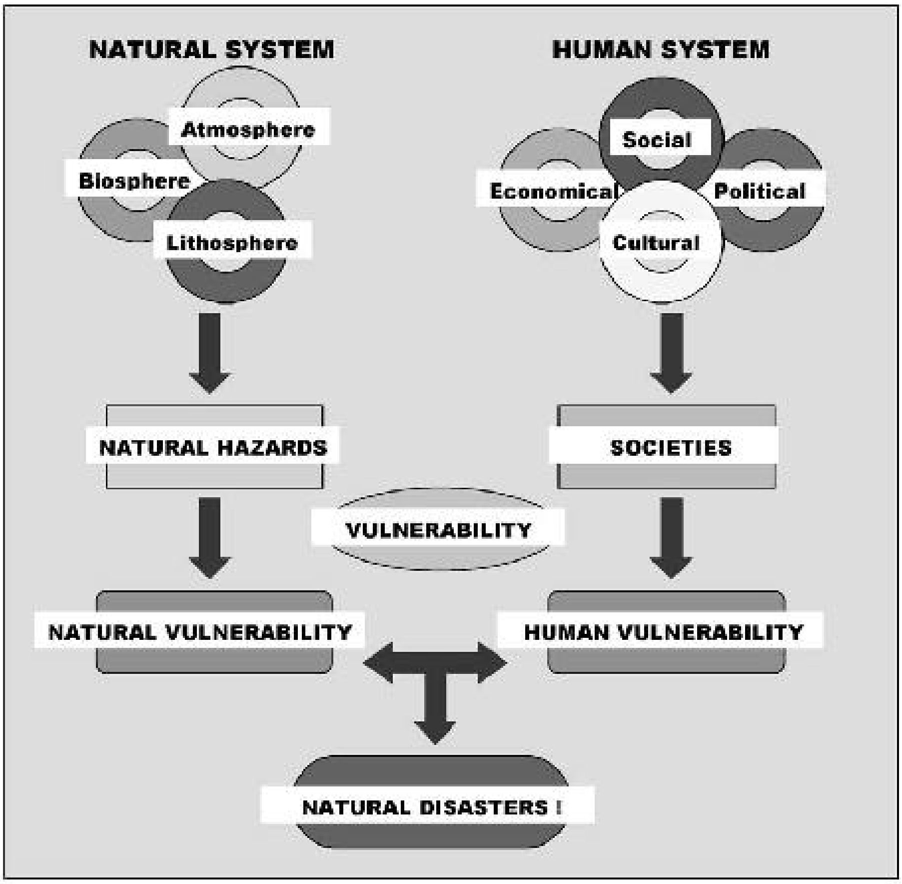

Figure 2.2 The Ingredients of Natural Disasters (Source: Alcantara-Ayala, 2002)

Despite these general and combined approaches, it has been observed in the literature that, the studies generally focus on the explanation of vulnerability by just a specific type of it. In fact, these observed types are on social, economic, and environmental perspectives. One of the examples is Glewwe and Hall's (1998) economical approach. They claim that vulnerable groups may differ across countries, and over time in a given country. They also distinguish vulnerability into two types, one of which concerning specific changes in government programs and the other, more general vulnerability to changes in socio-economic conditions, including inability to adapt to such changes. In fact, they called the first one as “policy-induced vulnerability” and the other one as “market-induced or ‘robust’ vulnerability”. The latter affects the same groups in different countries; in market economies, certain groups are more likely to experience lower income (or increased income uncertainty) during a macroeconomic shock, or are less able to adapt so as to minimize income declines. Such ‘robust’ vulnerability reflects market forces that produce similar interactions between household characteristics and income earning ability (and the ability to adapt) in a rapidly changing economic environment (Glewwe and Hall, 1998). However, “In contrast, policy-induced vulnerability reflects government decisions, which vary widely across countries and thus may not affect the same groups in different countries” (Glewwe and Hall, 1998).

Besides, these complexities on the explanation of vulnerability, the term is usually confused with some other terms like risk, hazard, poverty, and inequality. Despite they are very similar concepts; there is a delicate difference among them. Especially, the concepts of risk and hazard are generally confused with vulnerability, which their differences are presented in Section 2.1.2.

In addition to that, poverty is another concept, which usually confused with vulnerability. The concept of vulnerability although often used as a synonym for poverty, is not the same. Because, since poverty measures are generally fixed in time, it is essentially a static concept. By contrast, vulnerability is more dynamic and better captures change processes as “people move in and out of poverty” (Lipton and Maxwell, 1992). Poverty concerns one’s current socio-economic status, while vulnerability focuses on changes in socio-economic status (Glewwe and Hall, 1998).

Although poor people are usually among the most vulnerable, not all vulnerable people are poor, a distinction which facilitates differentiation among lower-income populations (Moser, 1998). Beside that, still “the most vulnerable countries, as they are the least equipped to mitigate disasters” (El-Sabh, 1994).

Another confused concept, which is also one of the causing factors of poverty, is the inequality (in terms of capacity) in the community. Although, inequality and vulnerability are generally confused, they mostly linked to each other. This can be expressed graphically in Figure 2.3.

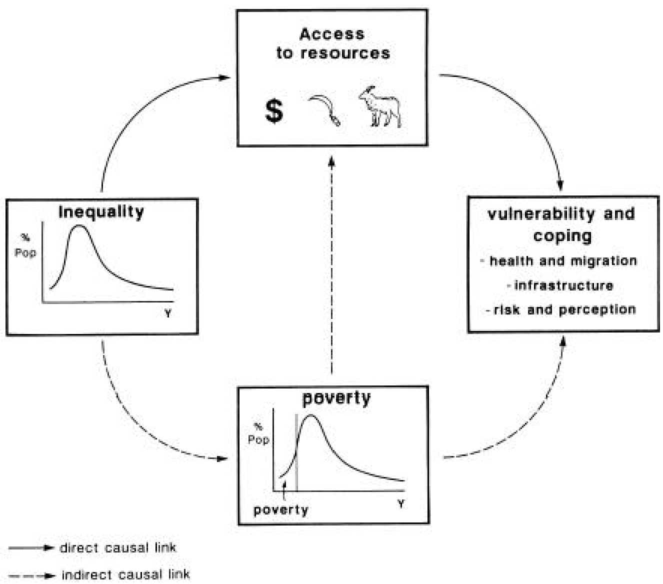

Figure 2.3 Direct and Indirect Links Between Inequality and Vulnerability (Source: Adger, 1999)

As seen from Figure 2.3, there is a chain among inequality, poverty, and vulnerability. In other words, inequality affects vulnerability directly through constraining the options of households and individuals when faced with external shock; and indirectly through its links to poverty and other factors (Adger, 1999).

2.1.2 The Relation Between Risk, Hazard, and Vulnerability

As mentioned previously, the concepts of risk, hazard, and vulnerability are mostly linked to each other, and sometimes they are confused, and their meanings are used interchangeably.

In fact, risk is closely tied to vulnerability and can be seen as a function of vulnerability. Communities who are most vulnerable will also probably be those most at risk to shock or disturbance to normal daily life. Although communities may face the same risk they will not, however, be equally vulnerable. There is thus a complex interaction between the exogenous (external threat/event) and the internal capacity of a community or household to withstand or respond to the event (Vogel, 1997).

The term **Risk** refers to the expected losses from a given hazard to a given element at risk, over a specified future time period. According to the way in which the element at risk is defined, the risk may be measured in terms of expected economic loss, or in terms of numbers of lives lost or the extent of physical damage to property (Coburn et al., 1994).

For example, as Coburn et al. (1994) state that, risk may be expressed as:

“25,000 lives lost over a 30 year period”

or

“75,000 houses experiencing heavy damage or destruction within 25 years” or alternatively on a probabilistic basis:

“75% probability of economic losses to property exceeding 50 million dollars in the town of Puerto Nuevo within the next 10 years”

There are also three essential components in the determination of risk, which is explained by Coburn et al. (1994) as follows:

a) the hazard occurrence probability: the likelihood of experiencing any natural or technological hazard at a location or in a region

b) the elements at risk: identifying and making an inventory of people or buildings or other elements which would be affected by the hazard if it occurred, and where required estimating their economic value

c) the vulnerability of the elements at risk: how damaged the buildings or people or other elements would be if they experienced some level of hazard.

The above-mentioned parameters should be evaluated together, rather than considering one by one. In fact, “… quantifying hazard probability involves assessing not only the probability of, for example, a windstorm occurring, but also the probability of occurrence of windstorms of a range of strengths” (Coburn et al., 1994).

The elements at risk consist of a wide range of things that make up our society – people’s lives and their health are elements at risk; so are their economic activities, their jobs, equipment, crops and livestock. Their houses are clearly elements at risk and so are the roads and services they depend on. The community services – schools, hospitals, religious institutions – are further elements at risk. So, in many cases, is the natural environment (Coburn et al., 1994).

The term **'Hazard'** refers to the extreme natural events, which may affect different places singly or in combination (coastlines, hillsides, earthquake faults, etc.) at different times (season of the year, time of day, etc.) (Blaikie et al., 1994).

There are different kinds of hazard or disaster types, but in general it can be grouped as natural and man-made hazards. As the occurrence time of the natural hazards cannot be pre-defined exactly, their results would be more severe than the man-made hazards. Different parts of the world have experienced natural hazards every year. Alcantara-Ayala (2002) shows this distribution of the disasters from all over the world as in Figure 2.4 and Figure 2.5.

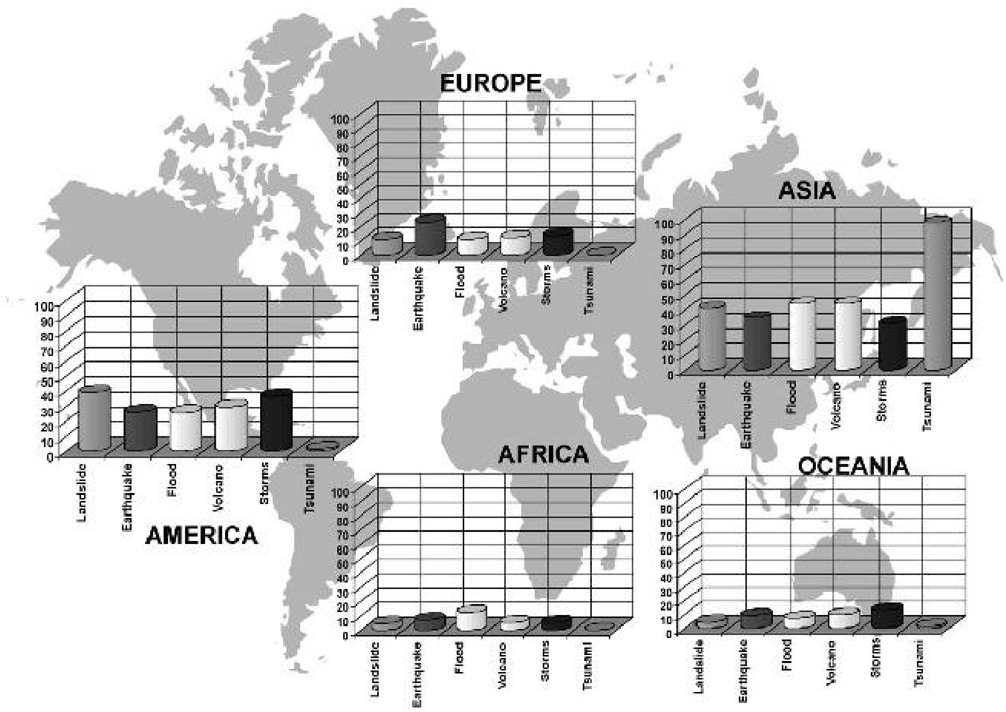

Figure 2.4 Occurrence of Different Types of Disasters by Regions of the Globe (Source: Alcantara-Ayala, 2002)

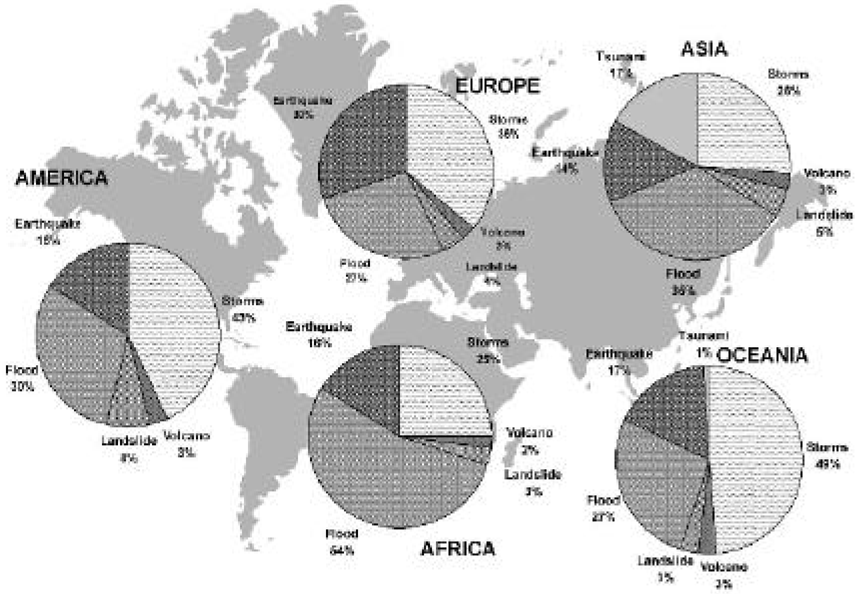

Figure 2.5 Percentage of Geomorphology Related Disasters by Type and Region from 1900 to 1999 (Source: Alcantara-Ayala, 2002)

Like risk, hazard occurrence may be expressed in terms of average expected rate of occurrence of the specified type of event, or on a probabilistic basis. In either case annual recurrence rates are usually used. The inverse of an annual recurrence rate is a return period (Coburn et al., 1994). The following examples are mentioned by Coburn et al. (1994) in terms of their occurrence parameters.

“There is an annual probability of 0.08 of an earthquake with a Magnitude exceeding 7.0 in Eastern Turkey”

this is same as saying:

“The average return period for an earthquake of M = 7.0 in Eastern Turkey is 12.5 years”

However, in these respects, vulnerability is different than risk and hazard. In fact, "'Vulnerability' is defined as the degree of loss to a given element at risk (or set of elements) resulting from a given hazard at a given severity level. (The distinction between this definition and that of risk is important to note. Risk combines the expected losses from all levels of hazard severity, taking account also of their occurrence probability)" (Coburn et al., 1994).

As a result, Figure 2.6 clearly describes the difference and the chain relation among the concepts of risk, hazard, and vulnerability. There is an entangled interaction among these concepts. In fact, one of which's level effects the others.

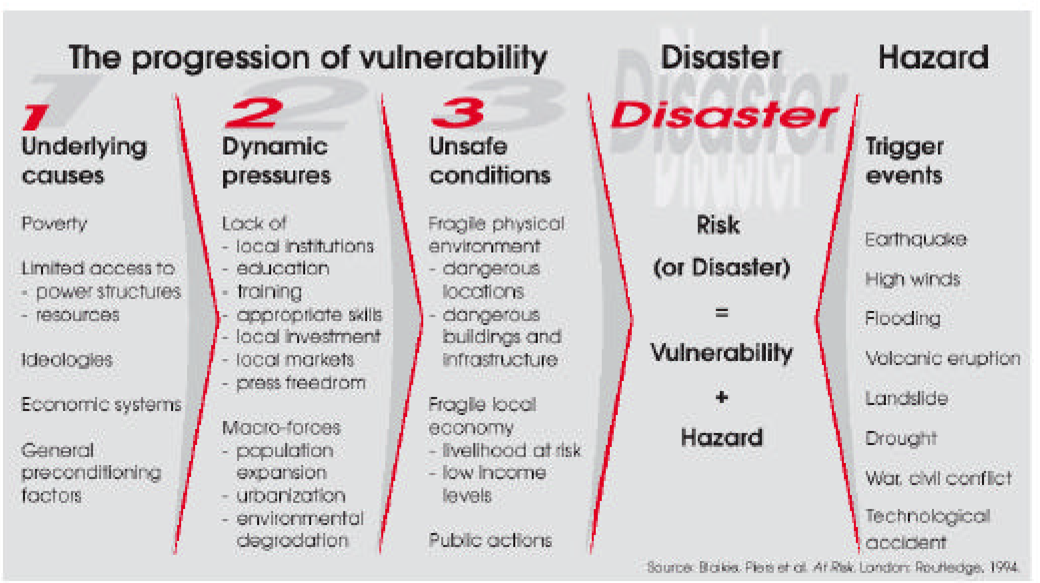

Figure 2.6 The Progression of Vulnerability (Source: Blaikie et al., 1994)

Although, many studies express concern for vulnerable groups, but few specify who is vulnerable, and why they are vulnerable. At this point, the need of the assessment of vulnerability is appeared.

2.1.3 The Need for Vulnerability Assessment

According to Uribe et al. (1999), the vulnerability elements can be described as; the social, material or environmental context represented by the people and the resources and services that can be affected during an event. This corresponds to human activities, the systems created by humans, such as houses, roads, infrastructure, production centers, services, the people that use these systems, as well as the environment.

However, the importance levels of these vulnerability elements change in different communities. In fact Blaikie et al. (1994) claim that, “the degree of Vulnerability and the identification of vulnerable groups will vary from society to society, where very specific differences, based on caste, gender, class, age may have a role”. Nevertheless, generally there are 5 groups most likely to have the least level of protection against hazards and the least amount of reserves for recovery:

- The poorest third of all households
- Women
- Children and youth
- The elderly
- Some no. of minority populations

In order to define these vulnerable groups, there is a valid need for an assessment. However, as Rashed and Weeks (2003) mention that, assessing vulnerability is “… an ill-structured problem”, which “… possess multiple solutions and contain uncertainty about concepts, rules, and principles involved to reach these solutions. Therefore, identifying an appropriate design structure for the assessment procedure from among the competing options is perhaps the most important part in the analysis of vulnerability".

In addition to that, the similarity of the concepts of, risk, hazard, and vulnerability are again confused in terms of assessment approaches. For clearly identification of these differences, the following explanations, stated by Uribe et al. (1999), are important:

"*Risk Assessment:* In its most simple form, it is postulate that a risk is the result corresponding to a threat, vulnerability level and exposure elements and the purpose is to determine the possible social, economic and environmental consequences associated with a particular event.

Hazard Assessment: Process by which the probability that an event occurs is determined for a specific site and time.

Vulnerability Assessment: The process by which the level of exposure is determined."

In a different way, vulnerability assessment (is also called "vulnerability analysis") is described as; "The process of estimating the vulnerability to potential disaster hazards of specified elements at risk" (Coburn et al., 1994).

There are some measures of vulnerability, defined by Vogel (1997) for basis of the assessment, as follows:

- An indicator approach: Number of finite and objective indicators capturing aspects of vulnerability.
- Household modeling approach: Mix of objective data and household and community surveys to develop a sample (model) of

how households respond to risk etc.

- Income estimation approach: Aims at estimating income at an administrative level to see if sufficient income was generated to purchase food for each person.

- Domestic resource capacity approach: Communities' ability to either collectively or individually allocate resources to mitigate a threatening disaster risk.

However, different than these approaches, vulnerability analysis is generally applied with two purposes in the literature. For engineering purposes, vulnerability analysis involves the analysis of theoretical and empirical data concerning the effects of particular phenomena on particular types of structures. For more general socio-economic purposes, it involves consideration of all significant elements in society, including physical, social and economic considerations (both short and long-term), and the extent to which essential services (and traditional and local coping mechanism) are able to continue functioning (Coburn et al., 1994).

Vulnerability for social purposes, as Menoni (2001) states that, was studied and analyzed especially in the social disciplines, like sociology, geography, psychology. However, as he points out that, rarely those studies went further in the attempt to:

- identifying parameters as indicators of vulnerable situations;

- look for units of measure to be able to survey and assign values (in qualitative, semi-qualitative or quantitative way);

- provide an assessment which could be used as the input in damage assessment or scenarios.

Another challenge today in this field of research is also defined to "create ways of analyzing the vulnerability implicit in daily life" (Wisner, 1993). In other words, attention must be paid to people's actual living conditions in order to discern the potentials and weaknesses that could make them particularly vulnerable if an adverse event occurred (Delor and Hubert, 2000).

At this point, the importance of social vulnerability and social vulnerability assessment is clearly appeared. Because, each and every resource, whether they describe vulnerability in the way of environment or man-made structure, they end up with the result of the need of analyzing the social part of the concept. Having basic social information about the people, community's vulnerability can be determined distinctly. Therefore, the social part of the vulnerability assessment must be considered separately.

2.1.4 Description of Social Vulnerability

Later, in the 1960s, the idea of the devastation by natural disasters as a result of the social and economic characteristics of the hazard-prone regions was introduced. However, it was not until the 1970s that the role of economic and social conditions as factors of vulnerability to natural disasters was acknowledged (Alcantara-Ayala, 2002). Many social scientists have moved their attentions to the social characteristics of risk-prone areas after that.

Therefore, the concept of social vulnerability has begun to be used. Social vulnerability is properly defined by Adger (1999) as; "…the exposure of groups or individuals to stress as a result of social and environmental change, where stress refers to unexpected changes and disruption to livelihoods". He also pays an attention to the level of the social vulnerability. In fact he categorizes it in two levels: first one is individual vulnerability and the other one is collective vulnerability of a nation, region or community. In Adger's (1999) perspective "Individual vulnerability is determined by access to resources and the diversity of income sources, as well as by social status of individuals or households within a community. Collective vulnerability of a nation, region or community is determined by institutional and market structures, such as the prevalence of informal and formal social security and insurance, and by infrastructure and income."

There are some main components of social vulnerability, by supporting Adger's perspectives, observed in the literature. The community's literacy level, employment status, income levels, ownership of dwelling, age and sex distributions, religious beliefs, kinship levels, and informal social support networks among the group are one of the examples of these main components.

One of the which, the term informal social support networks is come forward by Dershem and Gzirishvili (1998). They claim that, "… informal social networks significantly decrease the likelihood of respondents evaluating their household food, economic and housing as vulnerable". They also indicate that, during times of crisis and socioeconomic change, kinship and community relations are vital to survival strategies in everyday life and adaptation to social change. In addition, they state that, informal social support networks have been shown to be important resources for surviving disasters, accessing information, influencing socioeconomic status, psychological and emotional well-being, health, obtaining emotional and material support, gaining access to scarce goods and services, handling symptoms of stress, increasing household food production and sales, and adapting to socioeconomic change.

Kalaycioglu and Rittersberger-Tiliç (2002) also mention, the important effect of social support network, however at this time in a model for coping with poverty. This model covers the conditions of Turkey after 1980s, and basically constitute of social environment surrounding components of a person. They claim that, in order to cope with poverty, the surrounding of 'Family Pool' is the first and important trust for people. The other surrounding systems of; townsmen/villagers' networks, neighbors/friends/fictive kinships/helps from the employers, ethnic and religious networks, political parties/organizations/networks, support from NGOs (rather recent), and finally public-state are constitute and complete the model in orderly. However, generally the main trust for people is seen the family pool, most of the times this system works in an interaction with the other surrounding systems. They also mention that, the dominance of women in these interactions among the systems is very important.

In addition to that, they also state the main conditions in which the coping strategies do not work in the large/extended family scale. In fact, these conditions are described as; unemployable household head/or male members of the family/unemployment related to lack of essential skills for the formal sector job; household head/male members of the family not being able to work; intrafamily conflicts; reluctance or inability of the women in the family to built relations with the social environment; not allowing women to get employment outside of home; regional differences for support from ethnic and religious networks; personality differences; culture of poverty/reluctance; lack of knowledge or lack of resources of the family so that it could not develop coping strategies; and the large number of dependent members in the crowded family like old people, very young children and sick members.

As seen from all these approaches, the importance of social vulnerability is very critical. Because, without any investigation and good description in the concerned community, the impact of possible hazards cannot be defined properly. In this respect, there is also an absence of another factor observed in social vulnerability studies, which is analyze of physical factors. In fact, since vulnerability "… is continuously modified by human actions and therefore it varies over space and time" (Rashed and Weeks, 2003), with information about physical factors, social studies could be enriched.

2.2. Spatial Analysis of Vulnerability

Problems of human health, social deprivation, global and local environmental change, industrial and economic development, and a host of other problems demand that we make sense of what is happening in the world around us (UCGIS, 2003). In fact, the researchers have recently understood the importance of the analysis and the modeling of the spatially referenced data. Having this kind of spatial data, the projects on social or economical sciences could get a different perspective, rather than just analyzing the regular statistical information.

The development of the spatial sciences (regional science, (human) geography, regional and urban economics and related subjects) has been affected directly and indirectly by the social and economic sciences. This is hardly a cause for surprise because it is the logical outcome of the fact that there is no specifically spatial theory which is not an integral part of a more general social and/or economic theory. Space is not a phenomenon per se and, thus, cannot be analytically separated from social and/or economic phenomena. All this implies that the spatial sciences have to be considered as special branches of the social and economic sciences (Bahrenberg et.al., 1984).

The term of spatial data is described by Bailey and Gatrell (1995) as; "… data where, in addition to values relating to the primary phenomenon, or phenomena, of interest, the relative spatial locations of observations area also recorded, because these may be of possible importance in interpreting the data".

In other words, as Fotheringham et al. (2000) claim, spatial data comprise observations of some phenomenon that possesses a spatial reference.

Spatial data must be treated differently from other types of data. Stronger relationships exist, sometimes in systematic ways, within and among variables that are near to one another. Because the size and configuration of spatial units varies dramatically (UCGIS, 2003), the analysis of these kinds of data should be considered in a careful and deterministic way.

The term of “data analysis” can be defined as the processing and interpretation of a given set of information or observations (Walford, 1995). Moreover, the spatial data analysis is defined as it; “… involves the accurate description of data relating to a process operating in space, the exploration of patterns and relationships in such data, and the search for explanations of such patterns and relationships” (Bailey and Gatrell, 1995). UCGIS (2003) states that, the term “spatial analysis” encompasses a wide range of techniques for analyzing, computing, visualizing, simplifying, and theorizing about geographic data. Methods of spatial analysis can be as simple as taking measurements from a map or as sophisticated as complex geocomputational procedures based on numerical analysis.

The acquisition of spatial data has undergone significant changes for almost twenty years. To the traditional sources of spatial data, including archival sources (maps, census material, air photographs), field observation (directly observed survey and sample data), and experimental or simulation work (where processes are reproduced and data recorded in a laboratory environment) have been added data collection through remote sensing of the environment by satellite as well as new government and commercial spatially referenced data bases that have been appearing in an ever rising flood (Rhind, 1987).

With these new opportunities for acquiring the sources of spatial data, the spatial analytical techniques, as a part of social and economic studies, have been improved quickly. Spatial analytical techniques are dedicated to the analysis of the spatial order and associations of a phenomenon or variable. Spatial order delineates how geographic entities related to the phenomenon in question are organized in space, while spatial association describes the geographical relationships among phenomena. Therefore, a prerequisite of spatial analysis is that the study phenomenon must be mappable (Chou, 1997). Since the human eye is extremely adept at detecting spatial patterns, the use of maps for this purpose is highly effective.

Chou (1997) claims that, maps alone, however, are often not sufficient for analysis of spatial order and spatial association. Due to the complexity of spatial relationships among geographic entities, certain relationships (patterns) may be obscured or hidden in a generalized map. In addition, interpretation of a spatial relationship pattern by visual examination of a map is usually subjective, that is, perception of any map pattern may vary from person to person.

Therefore, there is a valid need for using spatial analysis not just only using the map capabilities, but also combining the necessary statistical methods with it. In this respect, Geographic Information Systems give an important easiness.

2.3. Importance of Geographic Information Systems

The use of GIS as a visual tool allows the researcher to explore statistical output that would otherwise be difficult to interpret. Representations are mainly displayed as maps in GIS and now allow dynamic and interactive exploration of complex information (Hedquist and Pahle, 2003).

Spatial analysis has been used for many years in various fields. However, the connection to GIS has only recently emerged. The most important contribution that new GIS technology has brought to spatial analysis is the establishment of a link between map-based analysis of spatial patterns and well-developed, rigorous quantitative analytical methods. With appropriate measurements of map features, interpretation of spatial patterns is no longer subjective. Because spatial patterns can be objectively assessed, hypotheses can be formulated and verified. In brief, cumbersome and time-consuming analysis of complicated spatial relationships has become increasingly accessible due to ongoing improvements in GISs (Chou, 1997).

In the future, since the GIS community grows larger, the need to perform spatial statistical analysis on GIS data will become greater. Therefore, it is critical to integrate spatial statistical functions into GIS. This is also very important for social and economical analysis, since their data are aggregated for different geographical areas or zones, like census tracts and counties.

2.4. Vulnerability Assessment and Spatial Data Analysis Examples

Up to this point it has been seen that, the concept of vulnerability is multi dimensional. Like there are different perspectives for describing the vulnerability and vulnerability assessment, there are also different applications to examine the vulnerability in all over the world. However, in terms of vulnerability assessment, generally the applications are in natural disaster research fields. The most helpful examples for constructing a basis for this thesis's implementations are introduced in this part.

First example is a study realized by International Federations of Red Cross and Red Crescent Societies and called ***"The Vulnerability and Capacity Assessment"*** (International Federation of Red Cross and Red

Crescent Societies, 2000). Disaster preparedness is a core activity of the Federation, which after 1999 they realized the necessity of defining vulnerable people in their studies. In this respect, the Vulnerability and Capacity Assessment is used to improve their understanding of the needs of people at the risk of natural and man-made disasters, and thus prepare more appropriate pre-disaster actions to cope with and recover from these hazards. The Assessment was designed by using “The Participatory Rural Appraisal (PRA)” method, which includes tools for examination of socio-economic factors of; physical world, groups of people (social mapping), institutions, time use (historical diagrams), sequences (of activities), and comparisons (on people, activities and objects).

Although, this method is used in different Red Crosses, the most useful examples for the thesis can be given as; the Nepal Red Cross, the Swedish Red Cross, and the Kazakhstan Red Cross’ applications. The Nepal Red Cross conducted two pilots Assessment in different areas with distinct socio-economic profiles, which they realized with the results, vulnerability was interrelated to factors of food production, seasonal migration, landlessness, literacy and access to safe water. These factors were screened through a set of indicators including longevity (life expectancy), knowledge (literacy and education) and access to resources. The Swedish Red Cross’s method is included collecting official statistics; carrying out interviews, study visits, meetings and dialogue with local inhabitants and authorities. As a result of the study, they identified the most vulnerable local groups, and made better relations with local authorities. The Kazakhstan Vulnerability Study involved 2,800 households that were interviewed on issues such as income, food security and health conditions. The study is identified families with five or more children, the elderly and the handicapped as the population groups facing the greatest risk.

The second example is ***“The Vulnerability and Risk Assessment***

Module” which is one of the training modules of “The Disaster Management Training Programme”, which is jointly managed by United Nations Department of Humanitarian Affairs (DHA) and United Nations Development Program (UNDP), with support from the Disaster Management Center of the University of Wisconsin, on behalf of an Inter-Agency Task Force (Coburn et al., 1994). This module examines the scope for measuring the risk of future losses and for using this knowledge to assist in the selection of appropriate disaster mitigation strategy. In the Assessment module, risk maps are used to show the spatial or geographical distribution of expected losses from one or more natural hazards. These mappings are; (a) scenario mapping (the presentation of the impact of a single hazard occurrence), (b) potential loss studies (mapping the effect of expected hazard occurrence probability to show the location of communities likely to suffer heavy losses), and (c) annualized risk mapping (calculation of the probable levels of losses occurring from all levels of hazards over period of time).

Most useful applications of this module are the followings applied in Turkey. As a scenario mapping an application is done for Bursa, Turkey, in which according to earthquake history of the region, the magnitude (Ms=7.2) and location of an expected earthquake are plotted, and the damage distribution resulting from this event is estimated. As a potential loss study mapping, urban earthquake casualties are identified in Turkey, which casualties are defined as those people whose houses are liable to be totally destroyed by the largest expected earthquake. For this purpose, information on, historical records of earthquake, population, and building types are used. As an annualized risk mapping, a study is applied in the form of risk contours for village housing in a particularly high-risk part of Eastern Turkey. Loss is defined as heavy damage or collapse, measured by the proportion of all houses suffering this level of damage.

Besides the above-mentioned risk mappings, the Vulnerability and Risk

Assessment module has another approach, which includes quantifying the vulnerability. In this approach it was stated that for a full definition of vulnerability, the expected damage level at every level of severity of hazard would need to be defined. For this purpose, ***the module is applied to Mexico City***. After a major earthquake in 1985 in Mexico City, the authorities instigated a program of risk reduction measures to protect the city against a recurrence of future disasters (Coburn et al., 1994). A project funded by United Nations Development Program and executed by United Nations Center for Human Settlements (Habitat). The project is involved first identifying the buildings most at risk, by building surveys, and then assessment of human vulnerability, with neighborhood surveys, which interviewing a sample of the residents of the area. The results of the study showed that, 60% of the community is vulnerable for any possible earthquake, since they are low-income, large-size families, and living in tenement buildings.

Another example for the thesis is ***again in Mexico City***. A comprehensive process of risk assessment involving hazard-mapping and vulnerability analysis is carried out in Mexico City (Blaikie et al., 1994). In order to realize this study, series of 'vulnerability strata' are identified. In the first strata the seismic hazards facing Mexico City are mapped with some accuracy in terms of their frequency, severity of impact, damage patterns, type of ground motion and location in relation to topography and soil conditions. In the second strata 17-factors building survey is made, including levels of maintenance, the shape of buildings, building height, and type of construction. In the third strata human vulnerability analysis is covered a bewildering diversity of topics that concern social patterns and institutions, society-wide and intra-household social relations, economic activity, and the psychology of risk. In the last strata direct losses (e.g. of a building or factory in a future disaster), or secondary losses (e.g. fire damage caused by the earthquake), or indirect losses (e.g. the loss of income as a result of the local population not being able to purchase goods due to their temporary loss of income) are determined. These results of the studies are then shared with local authorities.

Another example is **an urban vulnerability assessment methodology application in Los Angeles County**. In fact, the developed methodology incorporates vulnerability analysis with "… spatial multicriteria analysis and fuzzy logic" (Rashed and Weeks, 2003) by GIS in earthquake hazards framework. The methodology, which does not consider social factors, is involved 7 stages, which of the first is the selection of evaluation criteria or measures that determine the scope of analysis. The second stage is the simulation of earthquake hazards through which one can explore the possible effects of earthquake on a particular region according to multiple deterministic and probabilistic scenarios. The third stage is the composition of loss estimates created from each scenario run in stage two, which are transformed into comparable units through a 'fuzzification' process. In the next stage, these fuzzified criteria are compared pairwise using the analytical hierarchy process. The fifth stage is the aggregation of the criteria into a one-dimensional array of rules based on a fuzzy additive weighting method. In the next stage, 'the higher-risk' fuzzy layers are used to locate hot spots of urban vulnerability. The last stage is covered the sensitivity analysis to determine the effects of simulation parameters on the final output.

Another example is a study, which proposes a framework for its analysis within the context of volcanic activity and exemplify their approach by a detailed **study of Furnas**, a village located at the center of a volcano with the same name on the island of Sao Miguel in the Azores (Dibben and Chester, 1999). The methods used included in-depth interviews with permanent residents (n:50), analysis of census records and an examination of the socio-economic history of the town. The interview covered 5 main areas: (1) length of residence and reasons for moving to village; (2) attitudes to the village generally (both its social and physical structure); (3) perceptions of the volcanic hazard and other natural hazards; (4) disaster preparation and (5) attitudes to various hazard mitigation measures. Interviews are also carried out with members of the Civil Defence, local government and survivors of previous earthquakes about particular aspects of hazard planning and personal experiences. The outputs gathered from the surveys showed that, large proportion of population is vulnerable to volcanic activity.

Another example of, ***the Area Vulnerability Assessment Project***, conducted by the Tokyo Metropolitan Government Bureau of City Planning together with the Tokyo Metropolitan University (Uitto, 1998), is very important for its characteristic of integrating GIS technology to the application. It compiles and synthesizes information about four types of impact (building, fire, human, evacuation) that would occur in the event of a re-occurrence of the 1923 earthquake. Vulnerability is measured on a five-point scale for 500 x 500 m grid cells covering the entire metropolitan area. This GIS-based analysis is provided measures of relative risk in different areas. It is intended to assist the authorities to formulate local strategies for disaster response and mitigation.

The last example is based on a "***hypothesis test applications in Peru"*** (Glewwe and Hall, 1998). The data about household characteristics in 1985 and 1990 are used, and correlations are examined between household characteristics (in terms of living standards and economical conditions) and vulnerability. The results of the study showed that, households with a relatively high proportion of elderly, ill and / or invalid members, and households with better-educated heads, are less likely to be vulnerable.

As seen from the above-mentioned descriptions and examples, there are more than a dozen different definitions of vulnerability and its applications in the literature. In fact, the most agreed description is selected for the proposed methodology’s framework in this thesis, which explains vulnerability as ”… the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impacts of natural or man-made hazards” (International Federation of Red Cross and Red Crescent Societies, 2000). In addition to that, the main concern of this thesis, social vulnerability assessment’s description is selected as “…the exposure of groups or individuals to stress as a result of social and environmental change, where stress refers to unexpected changes and disruption to livelihoods” (Adger, 1999). It is also realized that, spatial analysis of vulnerability with GIS capabilities is very important, since vulnerability “… is continuously modified by human actions and therefore it varies over space and time” (Rashed and Weeks, 2003).

Therefore, social vulnerability assessment with the support of spatial analysis is very valid for the pre- and post-disaster planning. However, the real purpose-based applications are absent. Especially, in Turkey, an earthquake-risk-prone country, this need becomes more important. The developed methodology, on social vulnerability assessment, in this thesis helps to respond to this need.

CHAPTER 3

DEVELOPMENT OF SOCIAL VULNERABILITY ASSESSMENT USING GIS FOR PENDIK, ISTANBUL

The determination of social vulnerability analysis and spatial analysis approaches, and observing the examples of these concepts constituted a strong basis for this chapter.

In this chapter, the case study area and its general characteristics are described. In order to reach the aim of the thesis, the developed methodology on Social Vulnerability Assessment's steps are described and applied to the study area. In addition, evaluations from other perspectives and spatial data analyses, using Geographic Information Systems capabilities, are presented.

3.1. Description of the Study Area

3.1.1. Location

Pendik is an administrative district of Istanbul Greater Municipality, located at the southeast part of the city. As seen in Figure 3.1, the district surrounded by, Tuzla district from east, Sultanbeyli district from northwest, Kartal district from west, and Marmara Sea from south. Pendik is spread out to a 156-km^2 area, with a 7.5 km coastline.

Figure 3.1 Location of Pendik (Source: Istanbul Greater Municipality, 2003)

3.1.2. Population

In the early 1920s Pendik was known as a fishing village of not more than two thousand people who lived in one or two floor houses. However, after the Turk-Greek treaty on population exchange at 1923, the demographic structure of Pendik has changed seriously. In addition to that, from 1955 to 1990 the district has experienced an intensive increase in the population due to heavy immigration from Anatolia, as Pendik is a gate for Istanbul from Anatolia. The population was recorded 2.000 at 1927, and this grew to 8.673 at 1955. At 1960 and 1970, the population was doubled in Pendik and reached 389.000 at 2000. Today Pendik is the 11th crowded district from the 32 districts of Istanbul with this population. The changes in the population of Pendik can be seen in Table 3.1.

Table 3.1 The Population Trend (Source: Pendik Municipality, 2003)

Year	Population
1927	2.000
1940	4.172
1950	7.910
1960	13.963
1970	27.494
1980	48.219
1990	295.651
1997	344.064
2000	389.000

The first settlement sites of Pendik were along the coast and along both sides of E-5 Motorway (Figure 3.2). Due to the increasing immigration, the population dynamics and establishment of industry zones have been effected the diffusion of settlement areas. In fact, it has not been able to follow an ordered and planned growth pattern. Therefore, many unauthorized settlements are seen. However, with the zoning and construction plans after 1990s, the enlargement of the city was restrained. Especially, with the housing projects, important steps have been taken, and the residential settlements have been extended to the north of the district.

Figure 3.2 Pendik at 2003 (Source: Pendik Municipality web site, 2003)

Today Pendik is comprised by 30 neighborhoods (Figure 3.3). These neighborhoods are:

Ahmet Yesevi	Bahçelievler	Bati
Çamçesme	Çinardere	Dogu
Dumlupinar	Ertugrulgazi	Esenler
Esenyali	Fatih	Fevzi Çakmak
Güllübaglar	Güzelyali	Harmandere
Kavakpinar	Kaynarca	Kurtköy
Orhangazi	Orta	Ramazanoglu
Sanayi	Sapanbaglari	Sülüntepe
Seyhli	Velibaba	Yayalar
Yeni	Yenisehir	Yesilbaglar

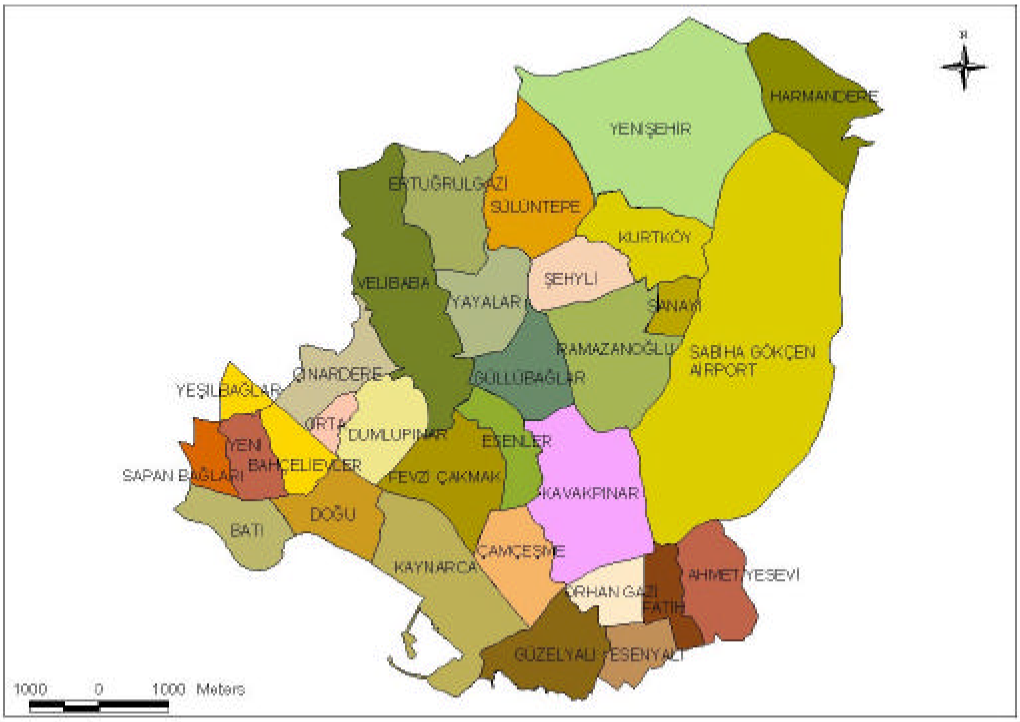

Figure 3.3 Pendik Neighborhoods in 2003

3.1.3. Economy, Transportation, and Culture

Although Pendik has made important progress in industrialization over the past ten years, the surge in population caused mostly by migration from Anatolia, has meant that old levels of prosperity could not be maintained, falling most steeply in the new residential settlements within Pendik (Pendik Municipality, 2003). According to the 1980 Istanbul Development Master Plan, 400 square hectares areas in Kurtköy and Seyhli neighborhoods of Pendik were planned for industrial sites and estates.

Today more than 40 industrial companies are located in this zone. The followings are some of the examples of these companies; Malazlar Match Industry, Alemdar Chemical Company, Ilsan Pharmasuitical Factory, Hacibekir Turkish Delight, Turkish Ytong Brick, Parsan, STFA Construction and Trade, Sulzer Engine Factory, Kavi Cable, Yonca Plastic, Termo Valve Industry, Ipragaz, Pelikan, Insas, and many others on mechanical, textile, chemical, and food industries. There are 226 work places registered to the Istanbul Chamber of Industry, and 3.476 work places registered to the Istanbul Chamber of Commerce. Agriculture is another main activity in Pendik, from the total of 91.248 employees in the sectors of stockbreeding, agriculture, and industry. Especially in the rural areas, 642.2 ha irrigated fields, and 248.2 acres of cultivated field areas exist.

In terms of transportation, Pendik has developed facilities, where the district is reachable by sea, air, and motorway (Figure 3.4). In fact, two major motorways of D-100 and E-5, which connect Istanbul to Anatolia, pass through the district. Besides that all suburban and intercity trains departing from Haydarpasa Station, which is the central train station in the Anatolian side of Istanbul, stop at Pendik Train Station.

In addition to that, Pendik is reachable by sea buses. Moreover, The second airport of Istanbul, Sabiha Gökçen International Airport has been active since January 2001. The airport has been designed to accommodate 3.000.000 international and 500.000 domestic passengers annually. The Sabiha Gökçen International Airport is the first link in the ITEP (Technology Park of the Future) project, which also covers the plans of future technology park, a “silicon valley”, and a university.

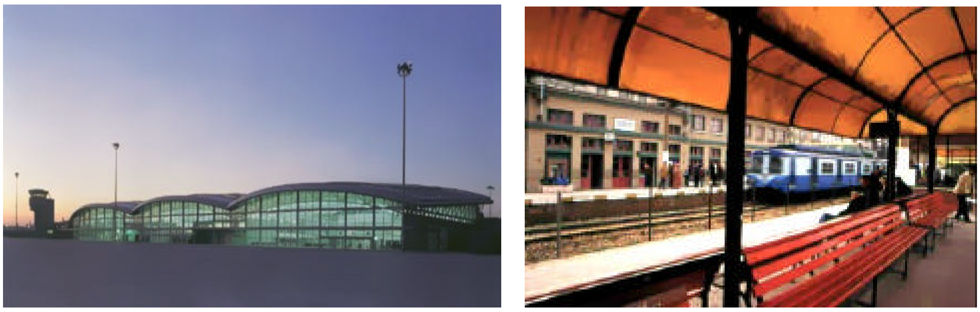

Figure 3.4 Transportation Possibilities in Pendik (Source: Pendik Municipality web site, 2003)

Due to the cultural variety, the social life is lively in Pendik. Especially, people from the Black Sea, east and southeast regions of Turkey, and immigrants from West Thrace (in Greece) put forward demographic diversity of the district. Social life has been enriched by the improvements on cultural and sporting facilities. In fact, Municipality completed 1 million square meters recreational areas in the last ten years. Today there are 10 local newspapers, and 4 local radio stations active in Pendik.

As basic services, there are 26 health and 16 educational units in Pendik. The educational establishments are; 47 primary schools and 16 high schools, with the total number of 83.802 students and 2.395 teachers.

3.2. Social Vulnerability Assessment

The characteristics of Pendik are presented in the previous parts. In addition to all these points, there is also one important factor for selecting Pendik as a case study area. In fact, Pendik is one of the 19 administrative districts of Istanbul, which are in the first-degree earthquake risk zones (Figure 3.5).

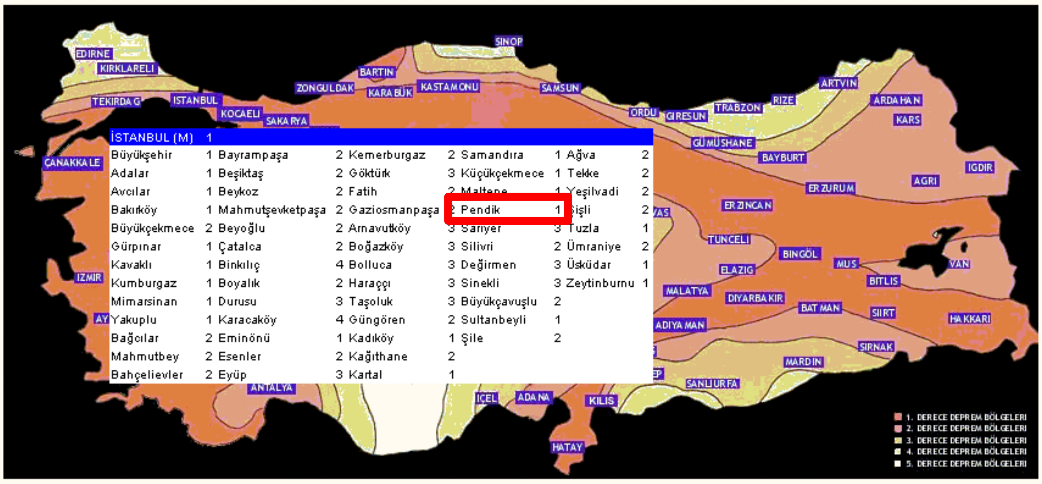

Figure 3.5 Turkey Earthquake Risk Map by Province- and District Base (Source: Istanbul Greater Municipality – Earthquake Special, 2003)

Due to the unbroken faults, after major earthquakes in 1999 (caused 17.000 deaths, and severe social and economical disruptions), Pendik is among the first-degree risk zones with the other districts of Istanbul. These faults are located in Marmara Sea, about 15 km far from Pendik, near the Adalar region. Therefore, according to the experts' predictions, Pendik is one of the most risky districts in Istanbul.

Besides the reason of being among the first-degree earthquake risk zones, on the selection Pendik, previously mentioned reasons could be summarized as follows:

- with a population of 389.000 at 2000, increased from 295.000 at 1990

- having different social groups, due to immigration of people from Black Sea, east and southeast region of Turkey, and West Thrace

- having different income levels, due to the physical characteristics

- many unauthorized settlements and squatter areas exist

- having important motorways, and Sabiha Gökçen International Airport

- having important firms located in industrial zone

3.2.1. Data Collection and Manipulation

In order to develop the methodology in social vulnerability concept, the main data should be based on the study area's socio-economic indicators. These indicators have to express the inhabitants' social and economical status. The below examples can be given as indicators of any study's social and economical database;

As social indicators;

- Education level: the literacy level, the last school which he/she completed

- Employment status: the economic activity in which he/she works for a payment

- Household size: size of the household which the survey is taken from
- Population composition: the distribution of age and sex proportion in the population
- Family composition: determination of families like with young children, grandparents or single parent / large families
- Being a member of an organization: being in any social group
- Leisure times: how he/she spends spare times, in order to be in contact with other people

As economical indicators;

- Employment status: the economic activity, in which he/she works for a payment
- Household income level: the level in terms of monthly or annually income of the household
- Social security: having any insurance –life or health-
- Property rights: owner of any house, good, or household goods
- Life standard: accessibility to healthy water/sanitation, expenditures for heating type

Since the main question of the vulnerability analysis is 'Vulnerable to what?' the above items can be considered as basic indicators for any risk or disaster scenario. Moreover, the indicators can be increased considering each application and study area. In fact, society-wide and intra-household social relations, the psychology of risk, cultural values, or the existence of local institutions can be added to the surveys. However, as Malczewski (1998) recommends that, an indicator (or in his term; a criterion) is considered good if it is: (1) comprehensive (i.e. clearly indicates the achievement of the associated objective), and (2) measurable (i.e. lends itself to a quantification/measurement). In addition he states that, a set of indicators (criteria) is good if it is: (1) complete (i.e. covers all aspects of a decision problem); (2) operational (i.e. is meaningful to a decision situation); (3) decomposable (i.e. is amenable to partitioning into subsets of criteria); (4) non-redundant (i.e. avoids the double counting of decision consequences); and (5) minimal (i.e. has the property of the smallest complete set of criteria characterizing the consequences of a decision).

These necessary data can be collected either from the site by household surveys, or from the central/local authorities' researches. In terms of household surveys, the questions can be in type of close-ended or in-depth style. However, the important thing in such surveys is the sampling size of the population. In fact, the sample should represent all the characteristics of the concerned population. As he sampling processes and methods are very wide concepts and are the out of concern of this thesis, there will not be dwell upon it.

Another way of gathering these data is the central or local authorities' surveys. These surveys can change from country to country and mostly they are in the form of recomposition of census data. In fact, the more detailed census data, the more information about the population can be taken.

Besides having these non-spatial data, the representation of them in spatial context, is a very important factor in such studies. The analysis and presentation of these data is based on how detailed spatial information or spatially referenced layers you have about the area. For example, the analysis can be done in house-based or neighborhood-based. If the province-based information will be enough, then this type of grouping or querying can be used. It just related with how general or detailed information the study requires. These spatial data can be gathered from local authorities or commercial companies.

After having the related data about the study, the next step is the manipulation of them. For this purpose, all the answers of the survey should be calculated and reorganized for each considered group. As the data is made of different variables, reorganization of them should be done considering the objective of the study.

In order to find social vulnerability levels of Pendik inhabitants, data used in the study is compiled from 1990 census data, and surveys from Pendik Municipality assistant mayors, inhabitants, and specialized academicians of the Middle East Technical University. In addition to that, spatial data is gathered from Pendik Municipality and Yalçiner's (2002) study on Pendik. The data used in the study is presented in Table 3.2:

Table 3.2 Data Used in the Study

Data	Source
Public Use Samples from the 1990 Census	State Institute of Statistics, Center for Population and Demographic Analysis
Year 2000 Building Census	State Institute of Statistics, Center for Population and Demographic Analysis
Year 1990 Neighborhood Map (1/25.000)	Pendik Municipality
Year 1997 Neighborhood Map (1/25.000)	Yalçiner's (2002) study
Year 2003 Neighborhood Map (1/25.000)	Pendik Municipality
Year 1990 Neighborhood Units Information	Pendik Municipality
Building Map	Pendik Municipality
Transportation Map	Pendik Municipality

The State Institute of Statistics is a Governmental Organization in Turkey, which is responsible for making statistics available to official bodies and the public concerning the population of Turkey. The Institution also realizes the censuses. In addition to that, Institute supports users, who need to make their own statistical analyses, with sample from the census data. In these samples, identification of persons, addresses, and similar information is not included in the data record.

The data of “Public Use Samples from the 1990 Census” is used in the study, since the year 2000 census samples have not been published officially during the preparation period of this study. The 1990 census data consist of answers of social and economical indicators. The sample used in this study is a five per cent sample, which every 20^{th} household and every 20^{th} individual in the non-household population is copied from the census data to construct the sample. It is also a systematic representative sample, where every household and every individual in the non-household population has an equal probability of selection. The sample data is in numeric dBase file format, and has 51 variables, listed in Table 3.3:

Table 3.3 Variables of “Public Use Samples from the 1990 Census” Data

Name	Description	Name	Description	Name	Description
IL	province code	ILCE	district code	BUCAK	subdistrict code
KOY	village code	MAHALLE	neighborhood code	OZEL	population type
BLDG	type of place	HHOME	is head home	PRESNT	no. of persons present
GUEST	no.of guests present	ABSTR	no.of members of hhold who absent	ABSFOR	no.of members of hhold who are abroad
OWNER	is some member of hhold the owner of the dwelling	OWNANOTHER	is any member of hhold own any other dwelling	SEX	sex
AGE	age	RLTHD	relation to head of hhold	BRTHPR	province of birth
BRTHLEV	administrative level of birthplace	CITIZEN	citizenship	RESPROV	province code of permanent residence
RESDIST	district code within the province	RESLEV	administrative level of permanent residence	RESPRS	repeat of previous 3 items, but refers to 5 years ago
RESDISTS	continue	RESLEVS	continue	LIT	can you read and write
SCHL	school level completed	MARSTAT	martial status	CEBFEM	live-born female children
CEBMAL	live-born male children	NLC	no.of living children	LLB	did you have any birth since 2 years
ALIVENOW	is that child alive now	DAY	date of birth of that child	MO	month of birth of that child
YR	year of birth of that child	LLBSEX	sex of birth of that child	WRKLASTWK	did you work last week for money or payment in kind
KINDWRK	last week's occupation	WRKPLACE	last week's economic activity	EMPSTAT	employment status
WHYNOTWRK	reasons for not working	SEEKJOB	are you looking for a job	MAINOCC	your main occupation
NUFUSCOD	population size of the place	HHNO	household number	KNO	person number within each household
SIRANO	serial number for each record	HHTYPE	household classification	HHSIZE	household size

Since the sample is prepared from the 1990 census data to form a general data for any statistical studies, the below variables are selected considering the thesis's aims, and best representation of the social conditions of Pendik population. These 8 variables also include the following details:

Table 3.4 Selected Variables for the Study Applications

Name	**Description**	**Explanation**
EMPSTAT	employment status	0:employee 1:employer 2:self-employed 3:unpaid family worker 9:not applicable
WHYNOTWRK	reasons for not working	3:retired 4:student 5:housewife 6:rentier 7:other (including disabled and prisoners) 8:unemployed 0:not applicable
SCHL	school level completed (educational level)	0:cannot read and write 1:can do but did not complete primary school 2:completed primary 3:completed middle school 4:completed junior high school 5:completed high school 6,7,8,9:completed high school equivalent 10 to 49: completed higher education schools 50 to 94:completed universities
HHSIZE	household size	no. of people in the household
OWNER	is some member of household the owner of the dwelling	owner of the dwelling (1:yes, 2:no)
OWNANOTHER	is any member of household own any other dwelling	owner of any other dwelling (3:yes, 4:no)
AGE	age	age of persons in the household
SEX	sex	sex (1:male, 2:female)

The above variables are considered as what they are, except the variables of Age and Household Size. In fact, these 2 variables are regrouped as; for the variable of Age; 1-6, 7-17, 18-24, 25-36, 37-54, 55-64, 65-99 years, and for the variable of Household Size; 1-4, 5-12 persons. This regrouping is made according to their distribution in the whole sample data, to avoid the unnecessary workload.

In order to use in the GIS and spatial data analyses, the spatial data of Pendik, means of neighborhood, building types, and transportation maps, are gathered from Pendik Municipality and Yalçiner's (2002) study. Especially, the 1997 Neighborhood Map, which is in the digital format, is made a basis for the reproduction of the other neighborhood maps for 1990 and 2003, in paper format. The 1990 Neighborhood Map is also modified according to the year 2000 neighborhood and district boundaries, to give an opportunity for the future examinations using year 2000 census data and to get evaluations of the local authorities, who have been serving to the district since 1994. In this respect, in the calculation of social vulnerability all 26 neighborhoods' data at year 1990 is used, however, in the representation of the results and in the spatial data analyses 18 neighborhoods, which overlay with the boundary of year 2000, are used. These 18 neighborhoods are; Bahçelievler, Bati, Çamçesme, Çinardere, Dogu, Dumlupinar, Esenyali, Fevzi Çakmak, Güzelyali, Harmandere, Kavakpinar, Kaynarca, Kurtköy, Orta, Seyhli, Velibaba, Yayalar, Yeni, shown Figure 3.6.

The Transportation and Building Maps are also gathered from Pendik Municipality. The other information about building usage types, basically on health and education services, is gathered from State Institute of Statistics' "Year 2000 Building Census" data, but in .xls format.

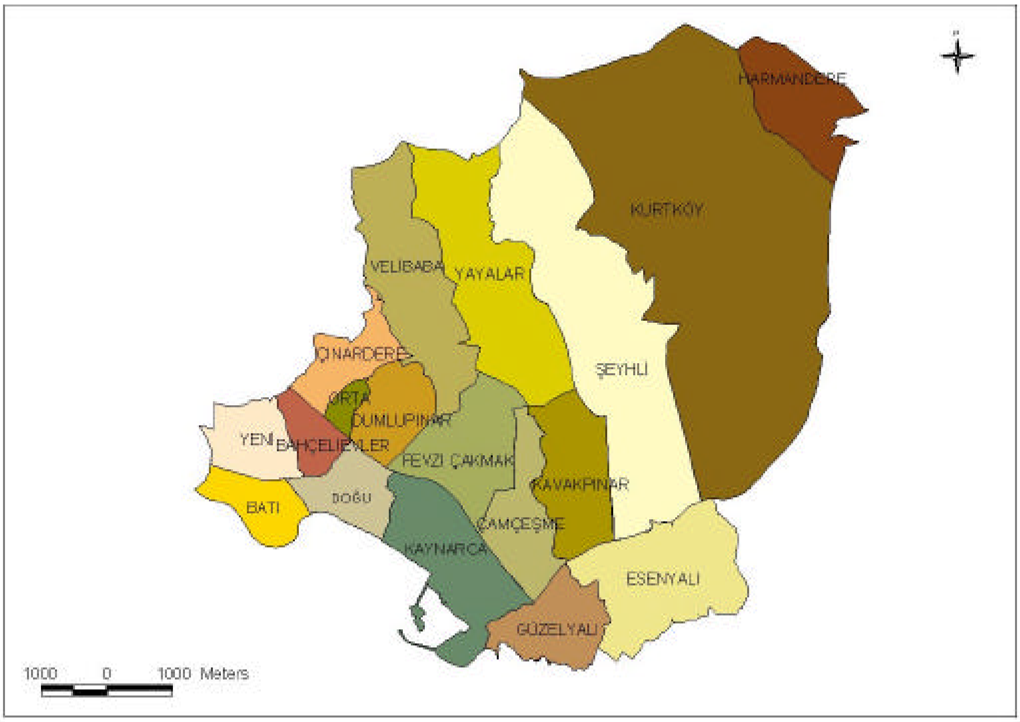

Figure 3.6 Pendik Neighborhoods in 1990

3.2.2. Database Structure

As database is the collection of the data, the structure of it should be built carefully. Constructing a database contains specifying of the data types. Each attribute or variable should be organized and divided into sub variables. If there is a need, the relationships between the variables should be built according to the common fields. For better analysis, the non-spatial and spatial data should be well organized and stored in the database.

In this study, the database was defined, constructed, and manipulated according to purposes of the thesis. As constructing a database includes specifying of the data types, first all the data types were identified. Afterwards, appropriate manipulations were made, such as retrieving the necessary data from the original data to use in the analyses. Then, the attributes of the data were modeled, which means the relationships between attributes were built according to their common fields of 'neighborhood name'. The list of tables used in the study is listed in Table 3.5.

Table 3.5 The Database of the Study

File Name	**No. of Fields**	**No. of Records**	**Description**
variable.distribution.xls	35	27	Distribution of 1990 census sample data's selected variables by neighborhoods
Pendikmahalle.shp	4	27	1997 neighborhoods
Yenimahalle.shp	4	30	2003 neighborhoods
Eskimahalle.shp	10	18	1990 neighborhoods
Mahallecenter.shp	2	18	Centers of the 1990 neighborhood areas
Ulasim.shp	8	9175	Transportation networks
Bina.shp	9	96856	Building types
1990bina.xls	19	226	Building Types, according to the usage, by neighborhood units (residence, commercial, industrial, education, cultural, social, health, sport, governmental, and religious) at 1990 and 2000

As seen in Table 3.5, there are 8 files/tables in the database of the study. From these tables, 7 of them are linked to each other with their common field of ‘neighborhood name’. In addition to these files/tables, some more tables were also made according to calculations of social vulnerability and spatial data analyses. These newly formed tables are explained in the coming parts of this chapter.

After collection, manipulation, and storing of the needed data, the focus can be directed to the statistical approaches to calculate the social vulnerability level of Pendik.

3.2.3. Calculation of Social Vulnerability

The calculation of social vulnerability includes some statistical methods of applications. In the first step of the calculation, all the necessary data is transferred from the original .dbf file to an Excel sheet. Therefore, the Excel sheet results with the variables of Employment Status, Reasons for Not Working, Educational Level (School Level Completed), Household Size, Owner of the Dwelling, Owner of any other Dwelling, Age, and Sex, because of the mentioned reasons in Section 3.2.1. These variables consisted of the values, which were calculated for each sub variable, in terms of 26 neighborhoods. The detailed distribution of these values, for each sub variable and by neighborhoods, is presented in Table 3.6. From the mentioned distribution, the sub variables of ‘Not Applicable’, in the variables of ‘Employment Status’ and ‘Reasons for not Working’, are not considered for the further calculations, as they are not descriptive measures.

Table 3.6 The Distribution of Variables' Values by Pendik Neighborhoods

Neighborhood	Employment Status					Reasons for Not Working							Educational Level								Household Size (person)		Owner of the Dwelling		Own any Other Dwelling		Age (year)							Sex	
	Employee (0)	Employer (1)	Self-employed (2)	Unpaid family worker (3)	NA (9)	Retired (3)	Student (4)	Housewife (5)	Rentier (6)	Other (disabled and prisoners) (7)	Unemployed (8)	NA (0)	Can't read/write (0)	Didn't complete Primary School (1)	Primary School (2)	Middle School (3)	High School (5)	High School Equivalent (6)	Higher Education Schools (11-49)	University (50+)	1 (1-4)	2 (5-14)	Yes (1)	No (2)	Yes (3)	No (4)	**1 (0-6)**	**2 (7-17)**	**3 (18-24)**	**4 (25-36)**	**5 (37-54)**	**6 (55-64)**	**7 (65-99)**	Male (1)	Female (2)
Mahalle 1	47	0	11	0	128	3	8	51	1	4	3	116	73	9	87	10	4	3	0	0	61	125	145	41	13	173	32	50	23	37	23	10	11	90	96
Mahalle 2	113	4	26	1	389	12	55	143	3	4	16	300	173	28	257	32	24	14	3	2	174	359	263	270	127	406	80	160	72	119	81	14	7	277	256
Mahalle 3	78	2	17	1	261	26	35	96	0	3	18	181	88	8	169	45	24	13	6	6	222	137	232	127	41	318	46	84	38	78	79	18	16	185	174
Mahalle 4	140	32	40	5	498	59	92	189	1	12	20	342	134	10	236	87	118	35	29	65	544	171	460	255	203	512	70	133	75	147	167	76	47	360	355
Mahalle 5	33	2	4	1	109	10	18	45	0	6	2	68	40	7	64	16	12	6	1	3	76	73	87	62	29	120	13	33	20	28	39	9	7	76	73
Mahalle 6	216	4	46	6	771	15	71	289	5	12	41	610	384	54	470	68	33	23	2	9	392	651	522	521	186	857	186	274	134	266	128	39	16	536	507
Mahalle 7	115	2	9	0	328	17	36	123	2	0	19	257	159	22	217	35	10	4	3	4	231	223	312	142	80	374	61	130	53	109	75	12	14	228	226
Mahalle 8	106	15	22	2	394	44	57	144	0	14	23	257	120	13	206	72	55	25	14	34	366	173	280	259	118	421	61	112	50	120	126	40	31	277	262
Mahalle 9	163	1	23	0	463	20	40	168	1	9	30	382	241	18	322	41	13	10	3	2	296	354	351	299	106	544	112	176	91	145	104	16	6	339	311
Mahalle 10	291	9	30	3	942	36	94	334	1	17	50	743	509	38	612	69	31	12	2	2	484	791	844	431	113	1162	203	386	158	298	169	41	19	672	603
Mahalle 11	146	7	42	17	583	13	50	233	3	12	40	444	284	21	385	66	26	7	0	6	337	458	403	392	99	696	135	199	110	195	98	39	19	414	381
Mahalle 12	72	5	14	2	180	10	23	70	1	6	4	159	88	7	110	32	21	5	4	6	142	131	153	120	56	217	44	49	46	56	52	16	10	146	127
Mahalle 13	17	0	3	0	85	2	5	27	0	5	8	58	55	5	41	4	0	0	0	0	18	87	105	0	23	82	18	43	10	22	15	6	1	60	45
Mahalle 14	70	2	14	0	262	7	40	93	0	3	12	193	126	14	161	26	11	6	2	2	137	211	204	144	44	304	60	107	39	76	55	9	2	175	173
Mahalle 15	152	3	23	4	554	11	68	179	1	10	32	435	298	29	359	28	17	3	1	1	279	457	457	279	93	643	139	231	72	195	81	10	8	386	350
Mahalle 16	181	8	36	6	562	19	61	206	1	12	22	472	273	26	349	78	45	12	4	6	397	396	276	517	137	656	143	188	114	197	113	23	15	418	375
Mahalle 17	121	2	20	5	304	6	32	116	1	3	16	278	160	10	224	35	14	5	1	3	190	262	316	136	72	380	81	102	77	107	54	24	7	240	212
Mahalle 18	45	1	5	0	153	15	9	58	0	3	11	108	78	6	102	13	3	2	0	0	95	109	99	105	13	191	32	50	24	42	30	14	12	102	102
Mahalle 19	126	5	33	5	433	13	34	153	3	6	31	362	238	14	301	34	10	3	1	1	253	349	488	114	40	562	131	154	66	149	78	14	10	330	272
Mahalle 20	119	4	8	0	388	4	42	132	0	6	30	305	214	36	226	26	11	4	1	1	151	368	419	100	43	476	95	166	60	116	60	16	6	263	256
Mahalle 21	71	13	34	4	226	10	38	109	0	4	6	181	75	7	142	48	40	14	6	16	224	124	246	102	101	247	28	80	34	73	84	29	20	171	177
Mahalle 22	22	1	9	0	67	3	8	26	1	0	6	55	24	5	49	12	6	1	0	2	74	25	30	69	38	61	10	27	11	26	19	4	2	52	47
Mahalle 23	73	0	17	1	294	9	38	104	0	3	15	215	145	11	201	20	6	2	0	0	119	266	306	79	50	335	64	130	40	75	50	18	8	201	184
Mahalle 24	104	5	18	4	363	6	22	136	4	3	19	304	216	22	220	18	12	4	2	0	134	360	388	106	18	476	96	144	64	104	52	20	13	264	230
Mahalle 25	78	2	16	2	322	16	45	116	2	6	17	218	146	18	195	41	16	4	0	0	175	245	251	169	48	372	55	134	50	87	60	22	12	225	195
Mahalle 26	222	9	39	3	637	56	77	228	2	11	38	498	271	23	424	94	56	24	7	11	483	427	501	409	156	754	113	230	98	222	152	53	42	453	457
Total	**2.921**	**138**	**559**	**72**	**9.696**	**442**	**1.098**	**3.568**	**33**	**174**	**529**	**7.541**	**4.612**	**461**	**6.129**	**1.050**	**618**	**241**	**92**	**182**	**6.054**	**7.332**	**8.138**	**5.248**	**2.047**	**11.339**	**2.108**	**3.572**	**1.629**	**3.089**	**2.044**	**592**	**361**	**6.940**	**6.446**
Variable Total					**3.690**							**5.844**								**13.385**		**13.386**		**13.386**		**13.386**							**13.395**		**13.386**

In the next step, all the sub variables' column totals are summed and added into a new cell as a Variable-Total (Table 3.6), to use for the later steps of standardization (Formula 3.1). However, again the sub variables of 'Not Applicable' are not included in this summation.

The second step includes the determination of each sub variables' social vulnerability values. This process involves the subjective decisions on which sub variable has what social vulnerability level in an appropriate range. For the case study applications range of 0 to 1 values (1 expresses the highest level of vulnerability, and 0 expresses the least level of vulnerability) are used. Same values can be given to more than once to the sub variables of the same variable, which belongs to the decision maker's choice. In this study, the below social vulnerability values are appointed to the sub variables, shown in Table 3.7.

Table 3.7 Social Vulnerability Values for Sub Variables

Variable	Sub Variable	Social Vulnerability Value
Employment Status	Employee	0,2
	Employer	0,1
	Self-employed	0,2
	Unpaid family worker	0,3
Reasons for Not Working	Retired	1,0
	Student	0,6
	Housewife	1,0
	Rentier	0,4
	Other (disabled and prisoners)	1,0
	Unemployed	1,0
Educational Level	Can't read/write	1,0
	Didn't complete Primary School	0,9
	Primary School	0,8
	Middle School	0,6
	High School	0,5
	High School Equivalent	0,4
	Higher Education Schools	0,3
	University	0,1
Household Size	1-4 persons	0,3
	5-14 persons	0,8
Owner of the Dwelling	Yes	0,1
	No	0,8
Own any Other Dwelling	Yes	0,1
	No	0,7
Age	0-6 years	1,0
	7-17 years	0,9
	18-24 years	0,4
	25-36 years	0,1
	37-54 years	0,2
	55-64 years	0,7
	65-99 years	1,0
Sex	Male	0,3
	Female	0,6

It is seen in Table 3.7, the persons, who are retired, or housewife, or disabled/prisoner, and unemployed, and can't read or write, and in the age of between 0-6 and 65-99 years, are the most socially vulnerable groups of people. However, it is also decided that, the least vulnerable people are; employer, completed University, has the dwelling and other more dwellings, and in the age of 25-36 years, with the value of “0,1”. The other sub variables are also evaluated and the above values are assigned to them.

This part of the methodology involves subjectivity, which in order to avoid it, 10 more evaluations are also made and integrated into the study. These evaluations are presented in Section 3.2.5.

In the third step of the calculation, each neighborhood value of the variables is standardized. In order to process these values together, this standardization is very valid. For this purpose, the below Formula 3.1 is applied to the data:

$$\begin{array}{c}\text{Standardized}\\ \text{Neighborhood}\\ \text{Value}\end{array} = \frac{\text{Neighborhood Value}}{\text{Variable-Total}} * \begin{array}{l}\text{Social Vulnerability}\\ \text{Value of}\\ \text{Sub Variable}\end{array} \qquad 3.1$$

After applying this formula, the data is converted to the standardized values, which is shown in Table 3.8. In addition to this process, the column totals and row totals are added into new cells.

Until this part, the original data is retrieved, weighted with each sub variable's social vulnerability value, standardized and summed. The last processes that should be performed are to build the relationships between the variables, to define their variable's weights, and finally to calculate the social vulnerability levels of neighborhoods. For building the

Table 3.8 Standardized Values of Pendik’s Each Neighborhood Values

Neighborhood	Employment Status						Reasons for Not Working								Educational Level								
	Employee (0)	Employer (1)	Self-employed (2)	Unpaid family worker (3)	NA (9)	**Total**	Retired (3)	Student (4)	Housewife (5)	Rentier (6)	Other (disabled and prisoners) (7)	Unemployed (8)	NA (0)	**Total**	Can't read /write (0)	Didn't complete Primary School (1)	Primary School (2)	Middle School (3)	High School (5)	High School Equivalent (6)	Higher Education Schools (11-49)	University (50+)	**Total**
Mahalle 1	0,0025	0,0000	0,0006	0,0000		**0,0031**	0,0005	0,0008	0,0087	0,0001	0,0007	0,0005		**0,0113**	0,0055	0,0006	0,0052	0,0004	0,0001	0,0001	0,0000	0,0000	**0,0119**
Mahalle 2	0,0061	0,0001	0,0014	0,0001		**0,0077**	0,0021	0,0056	0,0245	0,0002	0,0007	0,0027		**0,0358**	0,0129	0,0019	0,0154	0,0014	0,0009	0,0004	0,0001	0,0000	**0,0330**
Mahalle 3	0,0042	0,0001	0,0009	0,0001		**0,0053**	0,0044	0,0036	0,0164	0,0000	0,0005	0,0031		**0,0281**	0,0066	0,0005	0,0101	0,0020	0,0009	0,0004	0,0001	0,0000	**0,0207**
Mahalle 4	0,0076	0,0009	0,0022	0,0004		**0,0110**	0,0101	0,0094	0,0323	0,0001	0,0021	0,0034		**0,0574**	0,0100	0,0007	0,0141	0,0039	0,0044	0,0010	0,0006	0,0005	**0,0353**
Mahalle 5	0,0018	0,0001	0,0002	0,0001		**0,0021**	0,0017	0,0018	0,0077	0,0000	0,0010	0,0003		**0,0126**	0,0030	0,0005	0,0038	0,0007	0,0004	0,0002	0,0000	0,0000	**0,0087**
Mahalle 6	0,0117	0,0001	0,0025	0,0005		**0,0148**	0,0026	0,0073	0,0495	0,0003	0,0021	0,0070		**0,0687**	0,0287	0,0036	0,0281	0,0030	0,0012	0,0007	0,0000	0,0001	**0,0655**
Mahalle 7	0,0062	0,0001	0,0005	0,0000		**0,0068**	0,0029	0,0037	0,0210	0,0001	0,0000	0,0033		**0,0310**	0,0119	0,0015	0,0130	0,0016	0,0004	0,0001	0,0001	0,0000	**0,0285**
Mahalle 8	0,0057	0,0004	0,0012	0,0002		**0,0075**	0,0075	0,0059	0,0246	0,0000	0,0024	0,0039		**0,0444**	0,0090	0,0009	0,0123	0,0032	0,0021	0,0007	0,0003	0,0003	**0,0287**
Mahalle 9	0,0088	0,0000	0,0012	0,0000		**0,0101**	0,0034	0,0041	0,0287	0,0001	0,0015	0,0051		**0,0430**	0,0180	0,0012	0,0192	0,0018	0,0005	0,0003	0,0001	0,0000	**0,0412**
Mahalle 10	0,0158	0,0002	0,0016	0,0002		**0,0179**	0,0062	0,0097	0,0572	0,0001	0,0029	0,0086		**0,0845**	0,0380	0,0026	0,0366	0,0031	0,0012	0,0004	0,0000	0,0000	**0,0818**
Mahalle 11	0,0079	0,0002	0,0023	0,0014		**0,0118**	0,0022	0,0051	0,0399	0,0002	0,0021	0,0068		**0,0563**	0,0212	0,0014	0,0230	0,0030	0,0010	0,0002	0,0000	0,0000	**0,0498**
Mahalle 12	0,0039	0,0001	0,0008	0,0002		**0,0050**	0,0017	0,0024	0,0120	0,0001	0,0010	0,0007		**0,0178**	0,0066	0,0005	0,0066	0,0014	0,0008	0,0001	0,0001	0,0000	**0,0161**
Mahalle 13	0,0009	0,0000	0,0002	0,0000		**0,0011**	0,0003	0,0005	0,0046	0,0000	0,0009	0,0014		**0,0077**	0,0041	0,0003	0,0025	0,0002	0,0000	0,0000	0,0000	0,0000	**0,0071**
Mahalle 14	0,0038	0,0001	0,0008	0,0000		**0,0046**	0,0012	0,0041	0,0159	0,0000	0,0005	0,0021		**0,0238**	0,0094	0,0009	0,0096	0,0012	0,0004	0,0002	0,0000	0,0000	**0,0218**
Mahalle 15	0,0082	0,0001	0,0012	0,0003		**0,0099**	0,0019	0,0070	0,0306	0,0001	0,0017	0,0055		**0,0467**	0,0223	0,0019	0,0215	0,0013	0,0006	0,0001	0,0000	0,0000	**0,0477**
Mahalle 16	0,0098	0,0002	0,0020	0,0005		**0,0125**	0,0033	0,0063	0,0352	0,0001	0,0021	0,0038		**0,0507**	0,0204	0,0017	0,0209	0,0035	0,0017	0,0004	0,0001	0,0000	**0,0487**
Mahalle 17	0,0066	0,0001	0,0011	0,0004		**0,0081**	0,0010	0,0033	0,0198	0,0001	0,0005	0,0027		**0,0275**	0,0120	0,0007	0,0134	0,0016	0,0005	0,0001	0,0000	0,0000	**0,0283**
Mahalle 18	0,0024	0,0000	0,0003	0,0000		**0,0027**	0,0026	0,0009	0,0099	0,0000	0,0005	0,0019		**0,0158**	0,0058	0,0004	0,0061	0,0006	0,0001	0,0001	0,0000	0,0000	**0,0131**
Mahalle 19	0,0068	0,0001	0,0018	0,0004		**0,0092**	0,0022	0,0035	0,0262	0,0002	0,0010	0,0053		**0,0384**	0,0178	0,0009	0,0180	0,0015	0,0004	0,0001	0,0000	0,0000	**0,0387**
Mahalle 20	0,0064	0,0001	0,0004	0,0000		**0,0070**	0,0007	0,0043	0,0226	0,0000	0,0010	0,0051		**0,0337**	0,0160	0,0024	0,0135	0,0012	0,0004	0,0001	0,0000	0,0000	**0,0336**
Mahalle 21	0,0038	0,0004	0,0018	0,0003		**0,0064**	0,0017	0,0039	0,0187	0,0000	0,0007	0,0010		**0,0260**	0,0056	0,0005	0,0085	0,0022	0,0015	0,0004	0,0001	0,0001	**0,0189**
Mahalle 22	0,0012	0,0000	0,0005	0,0000		**0,0017**	0,0005	0,0008	0,0044	0,0001	0,0000	0,0010		**0,0069**	0,0018	0,0003	0,0029	0,0005	0,0002	0,0000	0,0000	0,0000	**0,0059**
Mahalle 23	0,0040	0,0000	0,0009	0,0001		**0,0050**	0,0015	0,0039	0,0178	0,0000	0,0005	0,0026		**0,0263**	0,0108	0,0007	0,0120	0,0009	0,0002	0,0001	0,0000	0,0000	**0,0248**
Mahalle 24	0,0056	0,0001	0,0010	0,0003		**0,0071**	0,0010	0,0023	0,0233	0,0003	0,0005	0,0033		**0,0306**	0,0161	0,0015	0,0131	0,0008	0,0004	0,0001	0,0000	0,0000	**0,0322**
Mahalle 25	0,0042	0,0001	0,0009	0,0002		**0,0053**	0,0027	0,0046	0,0198	0,0001	0,0010	0,0029		**0,0313**	0,0109	0,0012	0,0117	0,0018	0,0006	0,0001	0,0000	0,0000	**0,0263**
Mahalle 26	0,0120	0,0002	0,0021	0,0002		**0,0146**	0,0096	0,0079	0,0390	0,0001	0,0019	0,0065		**0,0650**	0,0202	0,0015	0,0253	0,0042	0,0021	0,0007	0,0002	0,0001	**0,0544**
Total	**0,158**	**0,004**	**0,030**	**0,006**		**0,1982**	**0,076**	**0,113**	**0,611**	**0,002**	**0,030**	**0,091**		**0,9215**	**0,345**	**0,031**	**0,366**	**0,047**	**0,023**	**0,007**	**0,002**	**0,001**	**0,8227**

Neighborhood	Household Size (person)			Owner of the Dwelling			Own any Other Dwelling			Age (year)								Sex		
	1 (1-4)	2 (5-14)	**Total**	Yes (1)	No (2)	**Total**	Yes (3)	No (4)	**Total**	**1 (0-6)**	**2 (7-17)**	**3 (18-24)**	**4 (25-36)**	**5 (37-54)**	**6 (55-64)**	**7 (65-99)**	**Total**	Male (1)	Female (2)	**Total**
Mahalle 1	0,0014	0,0075	**0,0088**	0,0011	0,0025	**0,0035**	0,0001	0,0090	**0,0091**	0,0024	0,0034	0,0007	0,0003	0,0003	0,0005	0,0008	**0,0084**	0,0020	0,0043	**0,0063**
Mahalle 2	0,0039	0,0215	**0,0254**	0,0020	0,0161	**0,0181**	0,0009	0,0212	**0,0222**	0,0060	0,0108	0,0022	0,0009	0,0012	0,0007	0,0005	**0,0222**	0,0062	0,0115	**0,0177**
Mahalle 3	0,0050	0,0082	**0,0132**	0,0017	0,0076	**0,0093**	0,0003	0,0166	**0,0169**	0,0034	0,0056	0,0011	0,0006	0,0012	0,0009	0,0012	**0,0141**	0,0041	0,0078	**0,0119**
Mahalle 4	0,0122	0,0102	**0,0224**	0,0034	0,0152	**0,0187**	0,0015	0,0268	**0,0283**	0,0052	0,0089	0,0022	0,0011	0,0025	0,0040	0,0035	**0,0275**	0,0081	0,0159	**0,0240**
Mahalle 5	0,0017	0,0044	**0,0061**	0,0006	0,0037	**0,0044**	0,0002	0,0063	**0,0065**	0,0010	0,0022	0,0006	0,0002	0,0006	0,0005	0,0005	**0,0056**	0,0017	0,0033	**0,0050**
Mahalle 6	0,0088	0,0389	**0,0477**	0,0039	0,0311	**0,0350**	0,0014	0,0448	**0,0462**	0,0139	0,0184	0,0040	0,0020	0,0019	0,0020	0,0012	**0,0434**	0,0120	0,0227	**0,0347**
Mahalle 7	0,0052	0,0133	**0,0185**	0,0023	0,0085	**0,0108**	0,0006	0,0196	**0,0202**	0,0046	0,0087	0,0016	0,0008	0,0011	0,0006	0,0010	**0,0185**	0,0051	0,0101	**0,0152**
Mahalle 8	0,0082	0,0103	**0,0185**	0,0021	0,0155	**0,0176**	0,0009	0,0220	**0,0229**	0,0046	0,0075	0,0015	0,0009	0,0019	0,0021	0,0023	**0,0208**	0,0062	0,0117	**0,0180**
Mahalle 9	0,0066	0,0212	**0,0278**	0,0026	0,0179	**0,0205**	0,0008	0,0284	**0,0292**	0,0084	0,0118	0,0027	0,0011	0,0016	0,0008	0,0004	**0,0268**	0,0076	0,0139	**0,0215**
Mahalle 10	0,0108	0,0473	**0,0581**	0,0063	0,0258	**0,0321**	0,0008	0,0608	**0,0616**	0,0152	0,0259	0,0047	0,0022	0,0025	0,0021	0,0014	**0,0541**	0,0151	0,0270	**0,0421**
Mahalle 11	0,0076	0,0274	**0,0349**	0,0030	0,0234	**0,0264**	0,0007	0,0364	**0,0371**	0,0101	0,0134	0,0033	0,0015	0,0015	0,0020	0,0014	**0,0331**	0,0093	0,0171	**0,0264**
Mahalle 12	0,0032	0,0078	**0,0110**	0,0011	0,0072	**0,0083**	0,0004	0,0113	**0,0118**	0,0033	0,0033	0,0014	0,0004	0,0008	0,0008	0,0007	**0,0107**	0,0033	0,0057	**0,0090**
Mahalle 13	0,0004	0,0052	**0,0056**	0,0008	0,0000	**0,0008**	0,0002	0,0043	**0,0045**	0,0013	0,0029	0,0003	0,0002	0,0002	0,0003	0,0001	**0,0053**	0,0013	0,0020	**0,0034**
Mahalle 14	0,0031	0,0126	**0,0157**	0,0015	0,0086	**0,0101**	0,0003	0,0159	**0,0162**	0,0045	0,0072	0,0012	0,0006	0,0008	0,0005	0,0001	**0,0148**	0,0039	0,0078	**0,0117**
Mahalle 15	0,0063	0,0273	**0,0336**	0,0034	0,0167	**0,0201**	0,0007	0,0336	**0,0343**	0,0104	0,0155	0,0022	0,0015	0,0012	0,0005	0,0006	**0,0318**	0,0087	0,0157	**0,0243**
Mahalle 16	0,0089	0,0237	**0,0326**	0,0021	0,0309	**0,0330**	0,0010	0,0343	**0,0353**	0,0107	0,0126	0,0034	0,0015	0,0017	0,0012	0,0011	**0,0322**	0,0094	0,0168	**0,0262**
Mahalle 17	0,0043	0,0157	**0,0199**	0,0024	0,0081	**0,0105**	0,0005	0,0199	**0,0204**	0,0060	0,0069	0,0023	0,0008	0,0008	0,0013	0,0005	**0,0186**	0,0054	0,0095	**0,0149**
Mahalle 18	0,0021	0,0065	**0,0086**	0,0007	0,0063	**0,0070**	0,0001	0,0100	**0,0101**	0,0024	0,0034	0,0007	0,0003	0,0004	0,0007	0,0009	**0,0089**	0,0023	0,0046	**0,0069**
Mahalle 19	0,0057	0,0209	**0,0265**	0,0036	0,0068	**0,0105**	0,0003	0,0294	**0,0297**	0,0098	0,0103	0,0020	0,0011	0,0012	0,0007	0,0007	**0,0259**	0,0074	0,0122	**0,0196**
Mahalle 20	0,0034	0,0220	**0,0254**	0,0031	0,0060	**0,0091**	0,0003	0,0249	**0,0252**	0,0071	0,0112	0,0018	0,0009	0,0009	0,0008	0,0004	**0,0231**	0,0059	0,0115	**0,0174**
Mahalle 21	0,0050	0,0074	**0,0124**	0,0018	0,0061	**0,0079**	0,0008	0,0129	**0,0137**	0,0021	0,0054	0,0010	0,0005	0,0013	0,0015	0,0015	**0,0133**	0,0038	0,0079	**0,0118**
Mahalle 22	0,0017	0,0015	**0,0032**	0,0002	0,0041	**0,0043**	0,0003	0,0032	**0,0035**	0,0007	0,0018	0,0003	0,0002	0,0003	0,0002	0,0001	**0,0037**	0,0012	0,0021	**0,0033**
Mahalle 23	0,0027	0,0159	**0,0186**	0,0023	0,0047	**0,0070**	0,0004	0,0175	**0,0179**	0,0048	0,0087	0,0012	0,0006	0,0007	0,0009	0,0006	**0,0176**	0,0045	0,0082	**0,0128**
Mahalle 24	0,0030	0,0215	**0,0245**	0,0029	0,0063	**0,0092**	0,0001	0,0249	**0,0250**	0,0072	0,0097	0,0019	0,0008	0,0008	0,0010	0,0010	**0,0223**	0,0059	0,0103	**0,0162**
Mahalle 25	0,0039	0,0146	**0,0186**	0,0019	0,0101	**0,0120**	0,0004	0,0195	**0,0198**	0,0041	0,0090	0,0015	0,0006	0,0009	0,0011	0,0009	**0,0182**	0,0050	0,0087	**0,0138**
Mahalle 26	0,0108	0,0255	**0,0363**	0,0037	0,0244	**0,0282**	0,0012	0,0394	**0,0406**	0,0084	0,0155	0,0029	0,0017	0,0023	0,0028	0,0031	**0,0366**	0,0102	0,0205	**0,0306**
Total	**0,136**	**0,438**	**0,5739**	**0,061**	**0,314**	**0,3744**	**0,015**	**0,593**	**0,6082**	**0,157**	**0,240**	**0,049**	**0,023**	**0,031**	**0,031**	**0,027**	**0,5575**	**0,156**	**0,289**	**0,4445**

relationships between these variables and identifying their weights, the "Pairwise Comparison Method" from the Multicriteria Evaluation technique is used, which is explained in the following part.

3.2.4. Pairwise Comparison Method

Decision Support Systems (DSS) are the most commonly used supporting information systems in planning. DSS are designed to handle ill or semi-structured problems. Thus, they are able to generate a number of alternative scenarios, and support a range of decision-making styles, interactive and recursive decision-making processes. Multicriteria Evalutaion (MCE) may be considered as one of the major classes of DSS (Malczewski, 1998). It is a process for combining data according to their importance and the basic aim of MCE technique is to investigate a number of alternatives in the light of predefined multicriteria and to rank these alternatives according to predefined preferences (Heywood et al., 1995; Lin et al., 1997; Kara, 2001).

The details of DSS or MCE are beyond the scope of this thesis (for detail information see; Malczewski, 1999). However, it should be mentioned that, MCE problems typically involve criteria of varying importance to decision makers. The relative importance of the criteria is achieved by assigning a weight to each criterion. A weight can be defined as a value assigned to an evaluation criterion that indicates its importance relative to other criteria under construction. The larger the weight, the more important is the criterion in the overall evaluation (Malczewski, 1998).

Weights can be entered directly; besides, it is possible to use methods that transform qualitative priority statements into quantitative weights. Methods commonly used to assign criterion weights are as follows: ranking methods, rating methods, trade of analysis method and pairwise comparison method (Malczewski, 1999). Malczewski states that which method to use would depend on the trade-offs; one is willing to make between ease of use, accuracy, the theoretical foundation underlying a given methodology. He points out that if the accuracy and theoretical foundations are the main concern pairwise comparison is more appropriate. Pairwise comparison method was developed in the context of a decision-making process known as the Analytic Hierarchy Process (AHP). This method involves pairwise comparisons, which concern the relative importance of the two criteria involved in determining suitability for the stated objective. A nine-point continuous scale is used for ratings and they transformed to relative weights as output.

The advantages of pairwise comparison method can be summarized as; (a) it allows the comparison of only two criteria at once (thereby eliminating the potential confusion in the evaluation of multiple criteria), (b) it involves the comparison of criteria not the pairwise comparison of alternatives (thus, this approach is of particular importance for problems involving large numbers of alternatives), (c) this method can convert subjective assessments of relative importance into a linear set of weights, and (d) when a large number of criteria is involved, it may more adequately cardinalize the qualitative preferences.

The pairwise comparison procedure consists of three major steps: generation of the pairwise comparison matrix, the criterion weights computation, and the consistency ratio estimation. The method employs an underlying scale with values from 1 to 9 to rate the relative preferences for two criteria (Malczewski, 1998) (Table 3.9).

Table 3.9 Scale for Pairwise Comparison (Source: Malczewski, 1998)

Intensity of Importance	Definition
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very to extremely strong importance
9	Extreme importance

The comparison matrix is reciprocal, that is, if criterion A gets a value of 2 relative to criterion B, criterion B should get a value of 1 when compared to criterion A. So, the reciprocal values of the lower left side of the matrix values are placed at the upper right side of the matrix.

As mentioned above, the first step is the generation of pairwise comparison matrix. The appointed ratings for the study data variables are presented in the matrix, given in Table 3.10.

Table 3.10 The Pairwise Comparison Matrix of the Study Data Variables

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	1	1	1	1	1	1	1	1
Reasons for not Working	1/1	1	7	7	5	6	6	7
Educational Level	1/1	1/7	1	4	2	1	3	2
Household Size	1/1	1/7	1/4	1	2	2	3	3
Owner of the Dwelling	1/1	1/5	1/2	1/2	1	1	1	1
Own any other Dwelling	1/1	1/6	1/1	1/2	1/1	1	1	1
Age	1/1	1/6	1/3	1/3	1/1	1/1	1	2
Sex	1/1	1/7	1/2	1/3	1/1	1/1	1/2	1

The presented matrix in Table 3.10 shows the decisions on the relative importance levels between the variables. For example, it is decided that, the ‘Reasons for not Working’ variable has a ‘very strong importance’ (level 7) than the ‘Educational Level’ variable. It means that, for a person, not having a job is a much more important factor than the educational level, when any hazard is a concern. The reason for this decision can be explained as, when any hazard occurs, earning money is much more important than the person’s literacy level. Because, the person can still meet his/her basic needs for the standard living conditions. Another example can be given for ‘Educational Level’ and ‘Sex’ variables. As seen in the matrix, the person’s educational level has an ‘equal to moderate importance’ than his/her sexuality. Because, it is thought that, when any hazard occurs, whether being graduated from university or primary school, and whether being male or female, could affect the person’s life in equal levels.

This process has the same subjectivity as the sub variables’ social vulnerability value evaluation. Again in order to avoid this subjectivity, 10 more evaluations are made, integrated to the study, and presented in Section 3.2.5.

The second step of the method includes the computation of criterion weights. This step involves the following operations: (a) sum the values in each column of the pairwise comparison matrix; (b) divide each element in the matrix by its column total (resulting matrix is referred to as the normalized pairwise comparison matrix); and (c) compute the average of the elements in each row of the normalized matrix, that is, divide the sum of normalized scores for each row by the number of criteria (for detail information see Malczewski, 1998). These averages provide an estimate of the relative weights of the criteria being compared (Malczewski, 1998). These mentioned-operations are applied and the weights of the 8 criteria are obtained, where they are given in Table 3.11.

Table 3.11 Criterion Weights of the Study Data

Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
0,110	0,385	0,130	0,112	0,066	0,070	0,068	0,058

The third step of the Pairwise Comparison Method covers the estimation of the consistency ratio. In this step the consistency of the comparisons is determined.

It is assumed in all methods that the decision maker was able to express precisely his/her preferences with respect to the evaluation criteria. However, in some situations the decision maker may not be able or is unwilling to provide a precise judgement on the relative importance of evaluation criteria due to limited or imprecise information (Malczewski, 1999). Thus a sensitivity or consistency analysis is required. Many techniques for sensitivity analysis have been proposed which allows analyzing quantitatively the contribution of each weight modifications to the output variance, giving important insights for the optimization of weights (Crosetto et al., 2000:79; Kara, 2001).

In the Pairwise Comparison Method, the consistency ratio (CR) analysis is used for this purpose. The consistency ratio developed in the context of pairwise comparison, indicates the probability that the matrix ratings were randomly generated. The consistency ratio indicates the re-evaluation of matrices with CR ratings greater than 0.1.

This CR analysis involves the following operations: (a) determine the weighted sum vector by multiplying the weight for the first criterion times first column of the original pairwise comparison matrix, then multiply the second weight times the second column, the third criterion times the third column of the original matrix, finally, sum these values over the rows; and (b) determine the consistency vector by dividing the weighted sum vector by the criterion weights determined previously. In order to finalize the processes two more terms are needed to calculate; lambda (?) and the consistency index (CI). The value for lambda is simply the average value of the consistency vector (Malczewski, 1998):

$$l = \frac{TotalofConsistencyVectors}{NumberofVariables} \quad 3.2$$

The calculation of CI is based on the observation that ? is always greater than or equal to the number of criteria under consideration (n) for positive, reciprocal matrices, and ? = n if the pairwise comparison matrix is a consistent matrix. Accordingly, ? – n can be considered as a measure of the degree of inconsistency. This measure can be normalized as follows (Malczewski, 1998):

$$CI = \frac{l - n}{n - 1} \quad 3.3$$

The CI term, referred to as the consistency index, provides a measure of departure from consistency. Further, the consistency ratio (CR), can be calculated as follows (Malczewski, 1998):

$$CR = \frac{CI}{RI} \quad 3.4$$

Where RI is the random index, the consistency index of a randomly generated pairwise comparison matrix. It can be shown that RI depends on the number of elements being compared (Malczewski, 1998) (Table 3.12).

Table 3.12 Random Inconsistency Indices (RI) for n = 1, 2, …, 15 (Source: Malczewski, 1998)

n	RI	n	RI	n	RI
1	0.00	6	1.24	11	1.51
2	0.00	7	1.32	12	1.48
3	0.58	8	1.41	13	1.56
4	0.90	9	1.45	14	1.57
5	1.12	10	1.49	15	1.59

The consistency ratio (CR) is designed in such a way that if CR < 0.10, the ratio indicates a reasonable level of consistency in the pairwise comparisons; if, however, CR = 0.10, the values of the ratio are indicative of inconsistent judgements. In such cases one should reconsider and revise the original values in the pairwise comparison matrix (Malczewski, 1998).

However, Hickey and Jankowski (1997:14; Kara, 2001) emphasize that even though a consistency value is calculated, regardless of its magnitude, the user should not assume that his or her weights are incorrect and must be changed. If the user is satisfied with the final weights, they should be retained. In other words, if this ratio will be appropriate for the survey's objective, then the weights can still be useable.

As a result of the above-mentioned Consistency Ratio analysis, in the study data, the CR value is resulted as 0,097 < 0.10, which indicates a reasonable level of consistency in the pairwise comparisons. Namely, the judgments on the weights of the study data variables are consistent.

After determining the variables' weights, the last calculations for identifying Pendik neighborhoods' social vulnerability levels, by using these weights, can be applicable. For this purpose, the standardized neighborhood total values for each of the variable are multiplied with the dependent variable's weight, which was found previously with the Pairwise Comparison Method. Therefore, the weighted variable values for each of the Pendik neighborhoods are formed. The Table 3.13 presents this result:

Table 3.13 Weighted Variable Values by Pendik Neighborhoods

Neighborhood	Variable's Weight							
	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any Other Dwelling	Age	Sex
	0,110	**0,385**	**0,130**	**0,112**	**0,066**	**0,070**	**0,068**	**0,058**
Mahalle 1	0,0003	0,0044	0,0016	0,0010	0,0002	0,0006	0,0006	0,0004
Mahalle 2	0,0008	0,0138	0,0043	0,0028	0,0012	0,0016	0,0015	0,0010
Mahalle 3	0,0006	0,0108	0,0027	0,0015	0,0006	0,0012	0,0010	0,0007
Mahalle 4	0,0012	0,0221	0,0046	0,0025	0,0012	0,0020	0,0019	0,0014
Mahalle 5	0,0002	0,0049	0,0011	0,0007	0,0003	0,0005	0,0004	0,0003
Mahalle 6	0,0016	0,0265	0,0085	0,0053	0,0023	0,0032	0,0030	0,0020
Mahalle 7	0,0007	0,0120	0,0037	0,0021	0,0007	0,0014	0,0013	0,0009
Mahalle 8	0,0008	0,0171	0,0037	0,0021	0,0012	0,0016	0,0014	0,0010
Mahalle 9	0,0011	0,0166	0,0054	0,0031	0,0014	0,0020	0,0018	0,0012
Mahalle 10	0,0020	0,0325	0,0106	0,0065	0,0021	0,0043	0,0037	0,0024
Mahalle 11	0,0013	0,0217	0,0065	0,0039	0,0017	0,0026	0,0023	0,0015
Mahalle 12	0,0005	0,0069	0,0021	0,0012	0,0005	0,0008	0,0007	0,0005
Mahalle 13	0,0001	0,0030	0,0009	0,0006	0,0001	0,0003	0,0004	0,0002
Mahalle 14	0,0005	0,0092	0,0028	0,0018	0,0007	0,0011	0,0010	0,0007
Mahalle 15	0,0011	0,0180	0,0062	0,0038	0,0013	0,0024	0,0022	0,0014
Mahalle 16	0,0014	0,0195	0,0063	0,0036	0,0022	0,0025	0,0022	0,0015
Mahalle 17	0,0009	0,0106	0,0037	0,0022	0,0007	0,0014	0,0013	0,0009
Mahalle 18	0,0003	0,0061	0,0017	0,0010	0,0005	0,0007	0,0006	0,0004
Mahalle 19	0,0010	0,0148	0,0050	0,0030	0,0007	0,0021	0,0018	0,0011
Mahalle 20	0,0008	0,0130	0,0044	0,0028	0,0006	0,0018	0,0016	0,0010
Mahalle 21	0,0007	0,0100	0,0025	0,0014	0,0005	0,0010	0,0009	0,0007
Mahalle 22	0,0002	0,0026	0,0008	0,0004	0,0003	0,0002	0,0003	0,0002
Mahalle 23	0,0005	0,0101	0,0032	0,0021	0,0005	0,0013	0,0012	0,0007
Mahalle 24	0,0008	0,0118	0,0042	0,0027	0,0006	0,0018	0,0015	0,0009
Mahalle 25	0,0006	0,0120	0,0034	0,0021	0,0008	0,0014	0,0012	0,0008
Mahalle 26	0,0016	0,0250	0,0071	0,0041	0,0019	0,0028	0,0025	0,0018
Total	0,0218	0,3548	0,1069	0,0643	0,0247	0,0426	0,0379	0,0258

The last step of the calculation involves the summation of all the weighted variables' values for each of the neighborhood. This step finalizes the process of calculating the Social Vulnerability Level of Pendik neighborhoods. The Table 3.14 shows the result.

Table 3.14 Social Vulnerability Levels of Pendik Neighborhoods at 1990

Neighborhood	Summation	Social Vulnerability Level
1.Aydinli	0,0003+0,0044+0,0016+0,0010+0,0002+0,0006+0,0006+0,0004 =	**0,0091**
2.Aydintepe	0,008+0,0138+0,0043+0,0028+0,0012+0,0016+0,0015+0,0010 =	**0,0270**
3.Bahçelievler	0,0006+0,0108+0,0027+0,0015+0,0006+0,0012+0,0010+0,0007 =	**0,0190**
4.Bati	0,0012+0,0221+0,0046+0,0025+0,0012+0,0020+0,0019+0,0014 =	**0,0369**
5.Cami	0,0002+0,0049+0,0011+0,0007+0,0003+0,0005+0,0004+0,0003 =	**0,0083**
6.Çamçesme	0,0016+0,0265+0,0085+0,0053+0,0023+0,0032+0,0030+0,0020 =	**0,0525**
7.Çinardere	0,0007+0,0120+0,0037+0,0021+0,0007+0,0014+0,0013+0,0009 =	**0,0227**
8.Dogu	0,0008+0,0171+0,0037+0,0021+0,0012+0,0016+0,0014+0,0010 =	**0,0289**
9.Dumlupinar	0,0011+0,0166+0,0054+0,0031+0,0014+0,0020+0,0018+0,0012 =	**0,0326**
10.Esenyali	0,0020+0,0325+0,0106+0,0065+0,0021+0,0043+0,0037+0,0024 =	**0,0642**
11.Fevzi Çakmak	0,0013+0,0217+0,0065+0,0039+0,0017+0,0026+0,0023+0,0015 =	**0,0415**
12.Güzelyali	0,0005+0,0069+0,0021+0,0012+0,0005+0,0008+0,0007+0,0005 =	**0,0134**
13.Harmandere	0,0001+0,0030+0,0009+0,0006+0,0001+0,0003+0,0004+0,0002 =	**0,0056**
14.Içmeler	0,0005+0,0092+0,0028+0,0018+0,0007+0,0011+0,0010+0,0007 =	**0,0177**
15.Kavakpinar	0,0011+0,0180+0,0062+0,0038+0,0013+0,0024+0,0022+0,0014 =	**0,0363**
16.Kaynarca	0,0014+0,0195+0,0063+0,0036+0,0022+0,0025+0,0022+0,0015 =	**0,0392**
17.Kurtköy	0,0009+0,0106+0,0037+0,0022+0,0007+0,0014+0,0013+0,0009 =	**0,0216**
18.Orta	0,0003+0,0061+0,0017+0,0010+0,0005+0,0007+0,0006+0,0004 =	**0,0112**
19.Seyhli	0,0010+0,0148+0,0050+0,0030+0,0007+0,0021+0,0018+0,0011 =	**0,0295**
20.Sifa	0,0008+0,0130+0,0044+0,0028+0,0006+0,0018+0,0016+0,0010 =	**0,0259**
21.Tuzla Postane	0,0007+0,0100+0,0025+0,0014+0,0005+0,0010+0,0009+0,0007 =	**0,0176**
22.Tuzla Istasyon	0,0002+0,0026+0,0008+0,0004+0,0003+0,0002+0,0003+0,0002 =	**0,0049**
23.Velibaba	0,0005+0,0101+0,0032+0,0021+0,0005+0,0013+0,0012+0,0007 =	**0,0196**
24.Yayalar	0,0008+0,0118+0,0042+0,0027+0,0006+0,0018+0,0015+0,0009 =	**0,0243**
25.Yayla	0,0006+0,0120+0,0034+0,0021+0,0008+0,0014+0,0012+0,0008 =	**0,0223**
26.Yeni	0,0016+0,0250+0,0071+0,0041+0,0019+0,0028+0,0025+0,0018 =	**0,0468**

After the calculations, the social vulnerability levels for Pendik neighborhoods for year 1990 are determined. From this result, it can be seen that the most vulnerable neighborhoods are Esenyali and Çamçesme, with the social vulnerability values of 0.0642 and 0.0525, while the others follow these neighborhoods. Tuzla Istasyon, Harmandere, Cami, Aydinli, Orta, and Güzelyali neighborhoods (with the social vulnerability values of 0.0049, 0.0056, 0.0083, 0.0091, 0.0112, and 0.0134) appear to be the least vulnerable parts of the district comparing with other neighborhoods. These results are also visualized with GIS technology and presented in Figure 3.7:

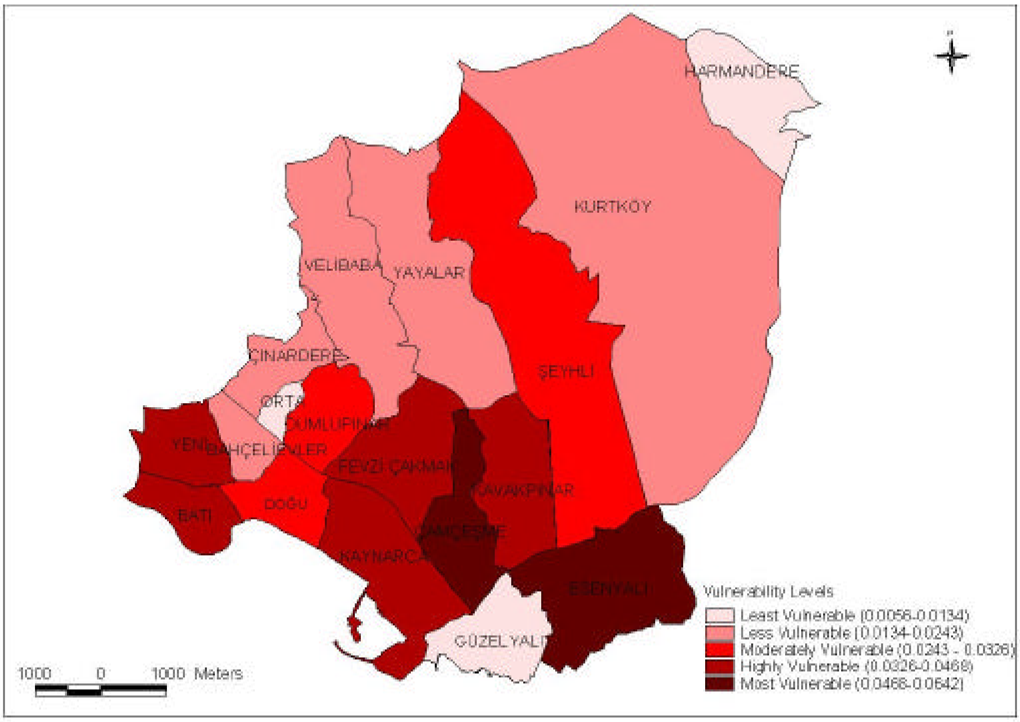

Figure 3.7 Social Vulnerability Levels of Pendik Neighborhoods in 1990

The Figure 3.7 shows that, the southeast neighborhoods of the district are the most and highly social vulnerable for any possible hazard. However, the north neighborhoods of Pendik are the least and less vulnerable regions. The detailed discussions on these results are given in last part of this Chapter.

3.2.5. Assessing Social Vulnerability by Different Perspectives

In this part of the study, in order to avoid the subjectivity, on the determination of sub variables' social vulnerability values and on the evaluation of pairwise comparison matrix, 10 more evaluations are utilized in the study. These 10 evaluations are gathered; 2 from inhabitants of Pendik, 3 from assistant mayors of Pendik, and 5 from specialized academicians, on sociology, psychology, urban planning, and civil engineering, of the Middle East Technical University.

These evaluations are collected from these 10 people, by standard evaluation matrices (see Appendix A). The first evaluation is gathered for the Social Vulnerability Values of Sub Variables.

In order to integrate these evaluations into the study to define Pendik neighborhoods' Social Vulnerability Levels, "the Delphi Method" (Malczewski, 1998) is applied, which means the average of these 10 appointed values are calculated and presented in Table 3.15.

Table 3.15 Average of the 10 Persons' Ratings on Social Vulnerability Values of Sub Variables

Variable	Sub Variable	Social Vulnerability Value
Employment Status	Employee	0,6
	Employer	0,6
	Self-employed	0,6
	Unpaid family worker	0,7
Reasons for Not Working	Retired	0,7
	Student	0,6
	Housewife	0,6
	Rentier	0,4
	Other	0,7
	Unemployed	0,6
Educational Level	Can't read/write	0,7
	Didn't complete Primary School	0,7
	Primary School	0,7
	Middle School	0,6
	High School	0,6
	High School Equivalent	0,5
	Higher Education Schools	0,5
	University	0,4
Household Size	1-4 persons	0,5
	5-14 persons	0,7
Owner of the Dwelling	Yes	0,5
	No	0,6
Own any Other Dwelling	Yes	0,4
	No	0,7
Age	0-6 years	0,7
	7-17 years	0,7
	18-24 years	0,6
	25-36 years	0,6
	37-54 years	0,7
	55-64 years	0,7
	65-99 years	0,8
Sex	Male	0,6
	Female	0,8

As seen from Table 3.15, the average evaluation on Sub

Variables' Social Vulnerability Values gives interesting results. In fact, according to it, the most vulnerable persons are appointed as 'Female' and in the age of '65-99 years'. The least vulnerable persons are also identified, as they are 'Rentier', graduated from 'University', and 'Owner of some Dwelling'. In the next step, same calculations, explained in Section 3.2.3, are done using these average evaluation values. In this respect, standardized values are gathered by applying the Formula 3.1, and presented in Table 3.16.

The same procedure of Social Vulnerability calculation, explained in Section 3.2.4 is applied. For this purpose, the Pairwise Comparison Matrix is generated (Section 3.2.4), according to 10 persons' evaluations (Appendix B).

In order to integrate these evaluations into the study calculations, the previously mentioned Delphi Method is applied, and 10 evaluations' average values, which are given in Table 3.17, are obtained.

Table 3.17 Average of 10-Evaluation's Ratings on Pairwise Comparison Method

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	1	6	5	4	4	4	6	5
Reasons for not Working	1/6	1	3	4	3	3	6	6
Educational Level	1/5	1/3	1	4	4	5	5	7
Household Size	1/4	1/4	1/4	1	3	4	5	5
Owner of the Dwelling	1/4	1/3	1/4	1/3	1	2	4	4
Own any other Dwelling	1/4	1/3	1/5	1/4	1/2	1	4	4
Age	1/6	1/6	1/5	1/5	1/4	1/4	1	3
Sex	1/5	1/6	1/7	1/5	1/4	1/4	1/3	1

Table 3.16 Standardized 10-Evaluations Values of Pendik’s Each Neighborhood Values

Neighborhood	Employment Status						Reasons for Not Working							
	Employee (0)	Employer (1)	Self-employed (2)	Unpaid family worker (3)	NA (9)	Total	Retired (3)	Student (4)	Housewife (5)	Rentier (6)	Other (disabled and prisoners) (7)	Unemployed (8)	NA (0)	Total
Mahalle 1	0,0076	0,0000	0,0018	0,0000		**0,0094**	0,0004	0,0008	0,0052	0,0001	0,0005	0,0003		**0,0073**
Mahalle 2	0,0184	0,0007	0,0042	0,0002		**0,0234**	0,0014	0,0056	0,0147	0,0002	0,0005	0,0016		**0,0241**
Mahalle 3	0,0127	0,0003	0,0028	0,0002		**0,0160**	0,0031	0,0036	0,0099	0,0000	0,0004	0,0018		**0,0188**
Mahalle 4	0,0228	0,0052	0,0065	0,0009		**0,0354**	0,0071	0,0094	0,0194	0,0001	0,0014	0,0021		**0,0395**
Mahalle 5	0,0054	0,0003	0,0007	0,0002		**0,0065**	0,0012	0,0018	0,0046	0,0000	0,0007	0,0002		**0,0086**
Mahalle 6	0,0351	0,0007	0,0075	0,0011		**0,0444**	0,0018	0,0073	0,0297	0,0003	0,0014	0,0042		**0,0447**
Mahalle 7	0,0187	0,0003	0,0015	0,0000		**0,0205**	0,0020	0,0037	0,0126	0,0001	0,0000	0,0020		**0,0204**
Mahalle 8	0,0172	0,0024	0,0036	0,0004		**0,0236**	0,0053	0,0059	0,0148	0,0000	0,0017	0,0024		**0,0299**
Mahalle 9	0,0265	0,0002	0,0037	0,0000		**0,0304**	0,0024	0,0041	0,0172	0,0001	0,0011	0,0031		**0,0280**
Mahalle 10	0,0473	0,0015	0,0049	0,0006		**0,0542**	0,0043	0,0097	0,0343	0,0001	0,0020	0,0051		**0,0555**
Mahalle 11	0,0237	0,0011	0,0068	0,0032		**0,0349**	0,0016	0,0051	0,0239	0,0002	0,0014	0,0041		**0,0364**
Mahalle 12	0,0117	0,0008	0,0023	0,0004		**0,0152**	0,0012	0,0024	0,0072	0,0001	0,0007	0,0004		**0,0119**
Mahalle 13	0,0028	0,0000	0,0005	0,0000		**0,0033**	0,0002	0,0005	0,0028	0,0000	0,0006	0,0008		**0,0049**
Mahalle 14	0,0114	0,0003	0,0023	0,0000		**0,0140**	0,0008	0,0041	0,0095	0,0000	0,0004	0,0012		**0,0161**
Mahalle 15	0,0247	0,0005	0,0037	0,0008		**0,0297**	0,0013	0,0070	0,0184	0,0001	0,0012	0,0033		**0,0312**
Mahalle 16	0,0294	0,0013	0,0059	0,0011		**0,0377**	0,0023	0,0063	0,0211	0,0001	0,0014	0,0023		**0,0335**
Mahalle 17	0,0197	0,0003	0,0033	0,0009		**0,0242**	0,0007	0,0033	0,0119	0,0001	0,0004	0,0016		**0,0180**
Mahalle 18	0,0073	0,0002	0,0008	0,0000		**0,0083**	0,0018	0,0009	0,0060	0,0000	0,0004	0,0011		**0,0102**
Mahalle 19	0,0205	0,0008	0,0054	0,0009		**0,0276**	0,0016	0,0035	0,0157	0,0002	0,0007	0,0032		**0,0249**
Mahalle 20	0,0193	0,0007	0,0013	0,0000		**0,0213**	0,0005	0,0043	0,0136	0,0000	0,0007	0,0031		**0,0221**
Mahalle 21	0,0115	0,0021	0,0055	0,0008		**0,0199**	0,0012	0,0039	0,0112	0,0000	0,0005	0,0006		**0,0174**
Mahalle 22	0,0036	0,0002	0,0015	0,0000		**0,0052**	0,0004	0,0008	0,0027	0,0001	0,0000	0,0006		**0,0045**
Mahalle 23	0,0119	0,0000	0,0028	0,0002		**0,0148**	0,0011	0,0039	0,0107	0,0000	0,0004	0,0015		**0,0176**
Mahalle 24	0,0169	0,0008	0,0029	0,0008		**0,0214**	0,0007	0,0023	0,0140	0,0003	0,0004	0,0020		**0,0195**
Mahalle 25	0,0127	0,0003	0,0026	0,0004		**0,0160**	0,0019	0,0046	0,0119	0,0001	0,0007	0,0017		**0,0210**
Mahalle 26	0,0361	0,0015	0,0063	0,0006		**0,0445**	0,0067	0,0079	0,0234	0,0001	0,0013	0,0039		**0,0434**
Total	**0,475**	**0,022**	**0,091**	**0,014**		**0,6020**	**0,053**	**0,113**	**0,366**	**0,002**	**0,021**	**0,054**		**0,6094**

Neighborhood	Educational Level									Household Size (person)		
	Can't read /write (0)	Didn't complete Primary School (1)	Primary School (2)	Middle School (3)	High School (5)	High School Equivalent (6)	Higher Education Schools (11-49)	University (50+)	Total	1 (1-4)	2 (5-14)	Total
Mahalle 1	0,0038	0,0005	0,0045	0,0004	0,0002	0,0001	0,0000	0,0000	**0,0096**	0,0023	0,0065	**0,0088**
Mahalle 2	0,0090	0,0015	0,0134	0,0014	0,0011	0,0005	0,0001	0,0001	**0,0272**	0,0065	0,0188	**0,0253**
Mahalle 3	0,0046	0,0004	0,0088	0,0020	0,0011	0,0005	0,0002	0,0002	**0,0178**	0,0083	0,0072	**0,0155**
Mahalle 4	0,0070	0,0005	0,0123	0,0039	0,0053	0,0013	0,0011	0,0019	**0,0334**	0,0203	0,0089	**0,0293**
Mahalle 5	0,0021	0,0004	0,0033	0,0007	0,0005	0,0002	0,0000	0,0001	**0,0074**	0,0028	0,0038	**0,0067**
Mahalle 6	0,0201	0,0028	0,0246	0,0030	0,0015	0,0009	0,0001	0,0003	**0,0532**	0,0146	0,0340	**0,0487**
Mahalle 7	0,0083	0,0012	0,0113	0,0016	0,0004	0,0001	0,0001	0,0001	**0,0232**	0,0086	0,0117	**0,0203**
Mahalle 8	0,0063	0,0007	0,0108	0,0032	0,0025	0,0009	0,0005	0,0010	**0,0259**	0,0137	0,0090	**0,0227**
Mahalle 9	0,0126	0,0009	0,0168	0,0018	0,0006	0,0004	0,0001	0,0001	**0,0334**	0,0111	0,0185	**0,0296**
Mahalle 10	0,0266	0,0020	0,0320	0,0031	0,0014	0,0004	0,0001	0,0001	**0,0657**	0,0181	0,0414	**0,0594**
Mahalle 11	0,0149	0,0011	0,0201	0,0030	0,0012	0,0003	0,0000	0,0002	**0,0406**	0,0126	0,0240	**0,0365**
Mahalle 12	0,0046	0,0004	0,0058	0,0014	0,0009	0,0002	0,0001	0,0002	**0,0136**	0,0053	0,0069	**0,0122**
Mahalle 13	0,0029	0,0003	0,0021	0,0002	0,0000	0,0000	0,0000	0,0000	**0,0055**	0,0007	0,0045	**0,0052**
Mahalle 14	0,0066	0,0007	0,0084	0,0012	0,0005	0,0002	0,0001	0,0001	**0,0178**	0,0051	0,0110	**0,0162**
Mahalle 15	0,0156	0,0015	0,0188	0,0013	0,0008	0,0001	0,0000	0,0000	**0,0381**	0,0104	0,0239	**0,0343**
Mahalle 16	0,0143	0,0014	0,0183	0,0035	0,0020	0,0004	0,0001	0,0002	**0,0402**	0,0148	0,0207	**0,0355**
Mahalle 17	0,0084	0,0005	0,0117	0,0016	0,0006	0,0002	0,0000	0,0001	**0,0231**	0,0071	0,0137	**0,0208**
Mahalle 18	0,0041	0,0003	0,0053	0,0006	0,0001	0,0001	0,0000	0,0000	**0,0105**	0,0035	0,0057	**0,0092**
Mahalle 19	0,0124	0,0007	0,0157	0,0015	0,0004	0,0001	0,0000	0,0000	**0,0311**	0,0095	0,0183	**0,0277**
Mahalle 20	0,0112	0,0019	0,0118	0,0012	0,0005	0,0001	0,0000	0,0000	**0,0268**	0,0056	0,0192	**0,0249**
Mahalle 21	0,0039	0,0004	0,0074	0,0022	0,0018	0,0005	0,0002	0,0005	**0,0169**	0,0084	0,0065	**0,0149**
Mahalle 22	0,0013	0,0003	0,0026	0,0005	0,0003	0,0000	0,0000	0,0001	**0,0050**	0,0028	0,0013	**0,0041**
Mahalle 23	0,0076	0,0006	0,0105	0,0009	0,0003	0,0001	0,0000	0,0000	**0,0199**	0,0044	0,0139	**0,0184**
Mahalle 24	0,0113	0,0012	0,0115	0,0008	0,0005	0,0001	0,0001	0,0000	**0,0255**	0,0050	0,0188	**0,0238**
Mahalle 25	0,0076	0,0009	0,0102	0,0018	0,0007	0,0001	0,0000	0,0000	**0,0215**	0,0065	0,0128	**0,0193**
Mahalle 26	0,0142	0,0012	0,0222	0,0042	0,0025	0,0009	0,0003	0,0003	**0,0458**	0,0180	0,0223	**0,0404**
Total	**0,241**	**0,024**	**0,321**	**0,047**	**0,028**	**0,009**	**0,003**	**0,005**	**0,6785**	**0,226**	**0,383**	**0,6095**

Neighborhood	Owner of the Dwelling			Own any Other Dwelling			Age (year)								Sex		
	Yes (1)	No (2)	Total	Yes (3)	No (4)	Total	1 (0-6)	2 (7-17)	3 (18-24)	4 (25-36)	5 (37-54)	6 (55-64)	7 (65-99)	Total	Male (1)	Female (2)	Total
Mahalle 1	0,0054	0,0018	**0,0073**	0,0004	0,0090	**0,0094**	0,0017	0,0026	0,0010	0,0017	0,0012	0,0005	0,0007	**0,0094**	0,0040	0,0057	**0,0098**
Mahalle 2	0,0098	0,0121	**0,0219**	0,0038	0,0212	**0,0250**	0,0042	0,0084	0,0032	0,0053	0,0042	0,0007	0,0004	**0,0265**	0,0124	0,0153	**0,0277**
Mahalle 3	0,0087	0,0057	**0,0144**	0,0012	0,0166	**0,0179**	0,0024	0,0044	0,0017	0,0035	0,0041	0,0009	0,0010	**0,0180**	0,0083	0,0104	**0,0187**
Mahalle 4	0,0172	0,0114	**0,0286**	0,0061	0,0268	**0,0328**	0,0037	0,0070	0,0034	0,0066	0,0087	0,0040	0,0028	**0,0361**	0,0161	0,0212	**0,0374**
Mahalle 5	0,0032	0,0028	**0,0060**	0,0009	0,0063	**0,0071**	0,0007	0,0017	0,0009	0,0013	0,0020	0,0005	0,0004	**0,0075**	0,0034	0,0044	**0,0078**
Mahalle 6	0,0195	0,0234	**0,0429**	0,0056	0,0448	**0,0504**	0,0097	0,0143	0,0060	0,0119	0,0067	0,0020	0,0010	**0,0516**	0,0240	0,0303	**0,0543**
Mahalle 7	0,0117	0,0064	**0,0180**	0,0024	0,0196	**0,0219**	0,0032	0,0068	0,0024	0,0049	0,0039	0,0006	0,0008	**0,0226**	0,0102	0,0135	**0,0237**
Mahalle 8	0,0105	0,0116	**0,0221**	0,0035	0,0220	**0,0255**	0,0032	0,0059	0,0022	0,0054	0,0066	0,0021	0,0019	**0,0272**	0,0124	0,0157	**0,0281**
Mahalle 9	0,0131	0,0134	**0,0265**	0,0032	0,0284	**0,0316**	0,0059	0,0092	0,0041	0,0065	0,0054	0,0008	0,0004	**0,0323**	0,0152	0,0186	**0,0338**
Mahalle 10	0,0315	0,0193	**0,0508**	0,0034	0,0608	**0,0641**	0,0106	0,0202	0,0071	0,0133	0,0088	0,0021	0,0011	**0,0633**	0,0301	0,0360	**0,0662**
Mahalle 11	0,0151	0,0176	**0,0326**	0,0030	0,0364	**0,0394**	0,0071	0,0104	0,0049	0,0087	0,0051	0,0020	0,0011	**0,0394**	0,0186	0,0228	**0,0413**
Mahalle 12	0,0057	0,0054	**0,0111**	0,0017	0,0113	**0,0130**	0,0023	0,0026	0,0021	0,0025	0,0027	0,0008	0,0006	**0,0136**	0,0065	0,0076	**0,0141**
Mahalle 13	0,0039	0,0000	**0,0039**	0,0007	0,0043	**0,0050**	0,0009	0,0022	0,0004	0,0010	0,0008	0,0003	0,0001	**0,0058**	0,0027	0,0027	**0,0054**
Mahalle 14	0,0076	0,0065	**0,0141**	0,0013	0,0159	**0,0172**	0,0031	0,0056	0,0017	0,0034	0,0029	0,0005	0,0001	**0,0173**	0,0078	0,0103	**0,0182**
Mahalle 15	0,0171	0,0125	**0,0296**	0,0028	0,0336	**0,0364**	0,0073	0,0121	0,0032	0,0087	0,0042	0,0005	0,0005	**0,0365**	0,0173	0,0209	**0,0382**
Mahalle 16	0,0103	0,0232	**0,0335**	0,0041	0,0343	**0,0384**	0,0075	0,0098	0,0051	0,0088	0,0059	0,0012	0,0009	**0,0392**	0,0187	0,0224	**0,0411**
Mahalle 17	0,0118	0,0061	**0,0179**	0,0022	0,0199	**0,0220**	0,0042	0,0053	0,0034	0,0048	0,0028	0,0013	0,0004	**0,0223**	0,0108	0,0127	**0,0234**
Mahalle 18	0,0037	0,0047	**0,0084**	0,0004	0,0100	**0,0104**	0,0017	0,0026	0,0011	0,0019	0,0016	0,0007	0,0007	**0,0103**	0,0046	0,0061	**0,0107**
Mahalle 19	0,0182	0,0051	**0,0233**	0,0012	0,0294	**0,0306**	0,0068	0,0080	0,0030	0,0067	0,0041	0,0007	0,0006	**0,0299**	0,0148	0,0163	**0,0310**
Mahalle 20	0,0157	0,0045	**0,0201**	0,0013	0,0249	**0,0262**	0,0050	0,0087	0,0027	0,0052	0,0031	0,0008	0,0004	**0,0259**	0,0118	0,0153	**0,0271**
Mahalle 21	0,0092	0,0046	**0,0138**	0,0030	0,0129	**0,0159**	0,0015	0,0042	0,0015	0,0033	0,0044	0,0015	0,0012	**0,0175**	0,0077	0,0106	**0,0182**
Mahalle 22	0,0011	0,0031	**0,0042**	0,0011	0,0032	**0,0043**	0,0005	0,0014	0,0005	0,0012	0,0010	0,0002	0,0001	**0,0049**	0,0023	0,0028	**0,0051**
Mahalle 23	0,0114	0,0035	**0,0150**	0,0015	0,0175	**0,0190**	0,0033	0,0068	0,0018	0,0034	0,0026	0,0009	0,0005	**0,0193**	0,0090	0,0110	**0,0200**
Mahalle 24	0,0145	0,0048	**0,0192**	0,0005	0,0249	**0,0254**	0,0050	0,0075	0,0029	0,0047	0,0027	0,0010	0,0008	**0,0246**	0,0118	0,0137	**0,0256**
Mahalle 25	0,0094	0,0076	**0,0170**	0,0014	0,0195	**0,0209**	0,0029	0,0070	0,0022	0,0039	0,0031	0,0011	0,0007	**0,0210**	0,0101	0,0117	**0,0217**
Mahalle 26	0,0187	0,0183	**0,0370**	0,0047	0,0394	**0,0441**	0,0059	0,0120	0,0044	0,0099	0,0079	0,0028	0,0025	**0,0455**	0,0203	0,0273	**0,0476**
Total	**0,304**	**0,235**	**0,5392**	**0,061**	**0,593**	**0,6541**	**0,110**	**0,187**	**0,073**	**0,138**	**0,107**	**0,031**	**0,022**	**0,6675**	**0,311**	**0,385**	**0,6963**

The weights of the variables, given in Table 3.18, are determined.

Table 3.18 Criterion Weights of 10-Evaluations

Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
0,335	0,189	0,169	0,113	0,074	0,063	0,033	0,025

Therefore, the weights of variables of ‘Employment Status’ and ‘Reasons for not Working’ are appeared to be the most weighted indicators. However, the variable of ‘Sex’ results as the least weighted variable. Although, this result is gathered from 10 different persons and will not be changed, there is still a need to apply the consistency ratio analysis. As mentioned previously, this analysis is necessary to determine how consistent our evaluation is. The computations, to find out the consistency ratio value, are done, by applying the calculations explained in Section 3.2.4. According to these calculations the result of ‘CR = 0,140’ is gathered. This value is higher compared to the limit value of Consistency Ratio, which is ‘ < 0,10’. Therefore, this judgment is called an inconsistent evaluation. However, because of already mentioned reasons, the level of inconsistency can be disregarded for this part (especially if there is such a slight difference), in order to be able to integrate these 10 evaluations to the study.

The last step in the calculation of the Social Vulnerability Level by using 10 evaluations is the multiplication of these weights with the total variables’ values and summation of them for each neighborhood. These processes are applied and presented in Table 3.19.

Table 3.19 Social Vulnerability Levels of Pendik Neighborhoods According to 10 Different Evaluations

Neighborhood	Variable's Weight								Social Vulnerability Level
	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any Other Dwelling	Age	Sex	
	0,335	0,189	0,169	0,113	0,074	0,063	0,033	0,025	
Mahalle 1	0,0032	0,0014	0,0016	0,0010	0,0005	0,0006	0,0003	0,0002	**0,0088**
Mahalle 2	0,0079	0,0046	0,0046	0,0029	0,0016	0,0016	0,0009	0,0007	**0,0246**
Mahalle 3	0,0053	0,0035	0,0030	0,0017	0,0011	0,0011	0,0006	0,0005	**0,0169**
Mahalle 4	0,0119	0,0075	0,0056	0,0033	0,0021	0,0021	0,0012	0,0009	**0,0346**
Mahalle 5	0,0022	0,0016	0,0013	0,0008	0,0004	0,0004	0,0002	0,0002	**0,0072**
Mahalle 6	0,0149	0,0085	0,0090	0,0055	0,0032	0,0032	0,0017	0,0014	**0,0472**
Mahalle 7	0,0069	0,0039	0,0039	0,0023	0,0013	0,0014	0,0007	0,0006	**0,0210**
Mahalle 8	0,0079	0,0057	0,0044	0,0026	0,0016	0,0016	0,0009	0,0007	**0,0254**
Mahalle 9	0,0102	0,0053	0,0056	0,0033	0,0020	0,0020	0,0011	0,0008	**0,0303**
Mahalle 10	0,0182	0,0105	0,0111	0,0067	0,0038	0,0040	0,0021	0,0017	**0,0580**
Mahalle 11	0,0117	0,0069	0,0069	0,0041	0,0024	0,0025	0,0013	0,0010	**0,0368**
Mahalle 12	0,0051	0,0023	0,0023	0,0014	0,0008	0,0008	0,0004	0,0004	**0,0135**
Mahalle 13	0,0011	0,0009	0,0009	0,0006	0,0003	0,0003	0,0002	0,0001	**0,0045**
Mahalle 14	0,0047	0,0030	0,0030	0,0018	0,0010	0,0011	0,0006	0,0005	**0,0157**
Mahalle 15	0,0100	0,0059	0,0064	0,0039	0,0022	0,0023	0,0012	0,0010	**0,0328**
Mahalle 16	0,0126	0,0063	0,0068	0,0040	0,0025	0,0024	0,0013	0,0010	**0,0370**
Mahalle 17	0,0081	0,0034	0,0039	0,0024	0,0013	0,0014	0,0007	0,0006	**0,0218**
Mahalle 18	0,0028	0,0019	0,0018	0,0010	0,0006	0,0007	0,0003	0,0003	**0,0094**
Mahalle 19	0,0093	0,0047	0,0053	0,0031	0,0017	0,0019	0,0010	0,0008	**0,0277**
Mahalle 20	0,0071	0,0042	0,0045	0,0028	0,0015	0,0016	0,0009	0,0007	**0,0233**
Mahalle 21	0,0067	0,0033	0,0029	0,0017	0,0010	0,0010	0,0006	0,0005	**0,0176**
Mahalle 22	0,0017	0,0009	0,0008	0,0005	0,0003	0,0003	0,0002	0,0001	**0,0048**
Mahalle 23	0,0050	0,0033	0,0034	0,0021	0,0011	0,0012	0,0006	0,0005	**0,0172**
Mahalle 24	0,0072	0,0037	0,0043	0,0027	0,0014	0,0016	0,0008	0,0006	**0,0223**
Mahalle 25	0,0054	0,0040	0,0036	0,0022	0,0013	0,0013	0,0007	0,0005	**0,0190**
Mahalle 26	0,0149	0,0082	0,0077	0,0046	0,0027	0,0028	0,0015	0,0012	**0,0436**
Total	0,2017	0,1152	0,1147	0,0689	0,0399	0,0412	0,0220	0,0174	**0,6209**

The final results are presented in Figure 3.8 with the help of GIS technology.

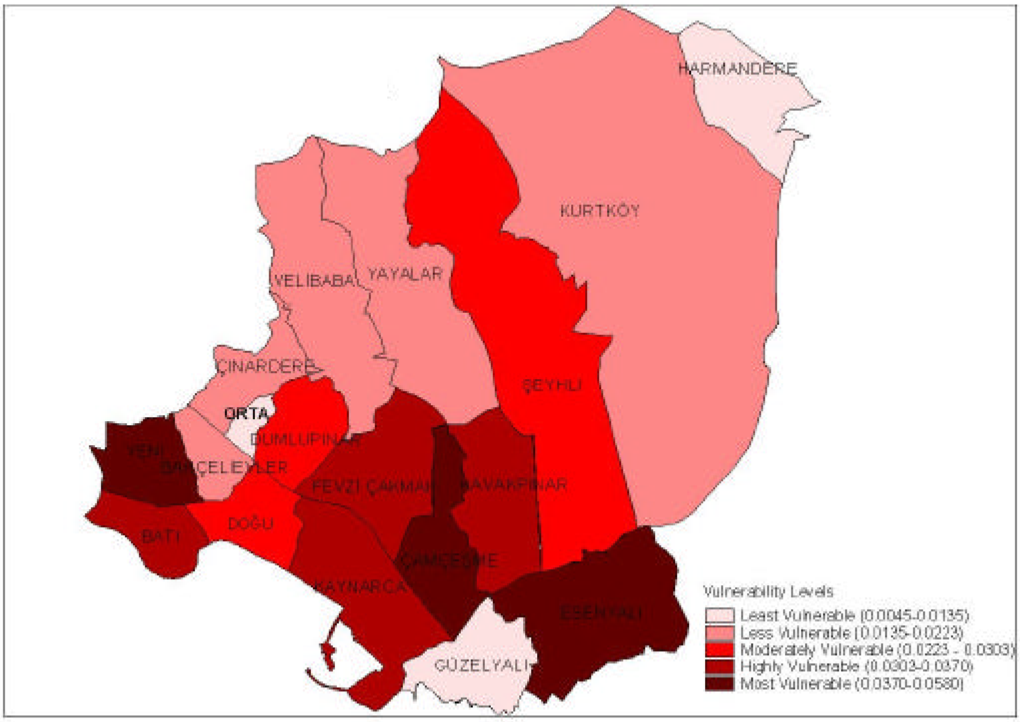

Figure 3.8 Social Vulnerability Levels of Pendik Neighborhoods, by Using 10 Different Persons' Evaluations

Figure 3.8 shows that, the levels of Social Vulnerability in Pendik are not changed compared to the previously calculated levels. In fact, just one difference appears, where the neighborhood of 'Yeni' is turned from the level of 'Highly Vulnerable' to 'Most Vulnerable'. The discussion on these results is mentioned in the last part of this Chapter.

i. Statistical Operations on 10-Evaluations Data

After calculation of the Social Vulnerability levels of Pendik neighborhoods with 10 persons' evaluations, some statistical operations are also done. The purpose of applying these statistics is to see the distribution of the values from their mean. By doing so, these 10 evaluations are assessed, whether they give meaningful inputs or they are totally different evaluations in terms of appointed ratings.

In this respect, first the standard deviations of the average values, of 10 evaluations, are calculated, which express how the data spread about the mean value. Then, the coefficient of variation of these values is found, which is a unitless measure of dispersion. In order to find these measures, the below formulas are applied to the 10-evaluations data.

$$s = \frac{\sqrt{\sum (x-\overline{x})^2}}{(n-1)} \tag{3.5}$$

$$d = \frac{s}{m} \tag{3.6}$$

The results of these computations are given in Table 3.20.

Table 3.20 Standard Deviations and Coefficient of Variations of 10-Evaluations' Sub Variables' Social Vulnerability Values

Variable	Sub Variable	Standard Deviation	Coefficient of Variation
Employment Status	Employee	0,2	0,3
	Employer	0,2	0,4
	Self-employed	0,3	0,5
	Unpaid family worker	0,2	0,3
Reasons for Not Working	Retired	0,2	0,4
	Student	0,2	0,3
	Housewife	0,3	0,4
	Rentier	0,2	0,6
	Other	0,4	0,5
	Unemployed	0,3	0,5
Educational Level	Can't read/write	0,2	0,4
	Didn't complete Primary School	0,2	0,3
	Primary School	0,2	0,2
	Middle School	0,1	0,2
	High School	0,1	0,2
	High School Equivalent	0,1	0,2
	Higher Education Schools	0,2	0,4
	University	0,2	0,5
Household Size	1-4 persons	0,2	0,3
	5-14 persons	0,2	0,4
Owner of the Dwelling	Yes	0,2	0,4
	No	0,2	0,3
Own any Other Dwelling	Yes	0,2	0,5
	No	0,2	0,3
Age	0-6 years	0,3	0,5
	7-17 years	0,2	0,3
	18-24 years	0,1	0,2
	25-36 years	0,1	0,2
	37-54 years	0,1	0,1
	55-64 years	0,1	0,2
	65-99 years	0,2	0,3
Sex	Male	0,1	0,2
	Female	0,1	0,2

From the results presented in Table 3.20, it is seen that the ratings on the sub variables are approximately in the same range. However, the ratings on the sub variables of 'Self-Employed', 'Rentier', 'Other', 'Unemployed', 'University' 'Own any other Dwelling-Yes' and '0-6 years' have high coefficient of variations of '0,6' and '0,5' values.

The same calculations are also applied to the data of 10 evaluations on the Pairwise Comparison. The below Tables 3.21 and 3.22 present the results.

Table 3.21 Standard Deviations of 10-Evaluations' Pairwise Comparison Values

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	0	2	2	2	3	2	3	3
Reasons for not Working	2	0	3	3	2	3	2	2
Educational Level	2	3	0	3	3	3	3	2
Household Size	2	3	3	0	2	2	2	3
Owner of the Dwelling	3	2	3	2	0	2	3	3
Own any other Dwelling	2	3	3	2	2	0	3	3
Age	3	2	3	2	3	3	0	3
Sex	3	2	2	3	3	3	3	0

Table 3.22 Coefficient of Variations of 10-Evaluations' Pairwise Comparison Values

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	0	0,4	0,4	0,6	0,7	0,6	0,4	0,7
Reasons for not Working	13,9	0	1,0	0,8	0,5	0,8	0,4	0,3
Educational Level	10,5	8,9	0	0,8	0,7	0,7	0,6	0,2
Household Size	9,8	13,6	12,7	0	0,6	0,6	0,5	0,6
Owner of the Dwelling	11,7	5,3	10,8	5,3	0	1,0	0,7	0,7
Own any other Dwelling	9,5	8,0	15,0	9,8	4,6	0	0,7	0,9
Age	15,1	14,7	13,6	11,1	10,1	11,2	0	1,0
Sex	16,7	13,0	10,7	16,2	11,1	13,7	8,4	0

It is seen that, the ratings on the Pairwise Comparison Matrices are assigned dispersed values. Especially, the comparative values of 'Owner of the Dwelling – Own any other Dwelling', 'Reasons for not Working – Educational Level', and 'Own any other Dwelling – Sex' are given very high coefficient of variation values. It means that, the comments and the ratings on these comparative values are quite different in this 10-persons group.

According to these results, the need of extracting the outliers is appeared. In fact, by doing so the sensitivity of the ratings could be determined. For this purpose, the outliers of the ratings on Sub Variables Social Vulnerability evaluations (from 10-Evaluations) are extracted, the mean of this new data is calculated, and presented in Table 3.23.

Table 3.23 Social Vulnerability Values without Outliers of 10-Evaluations Data

Variable	Sub Variable	Social Vulnerability Value	Social Vulnerability Value without Outliers
Employment Status	Employee	0,6	0,6
	Employer	0,6	0,5
	Self-employed	0,6	0,5
	Unpaid family worker	0,7	0,7
Reasons for Not Working	Retired	0,7	0,7
	Student	0,6	0,6
	Housewife	0,6	0,6
	Rentier	0,4	0,4
	Other	0,7	0,6
	Unemployed	0,6	0,6
Educational Level	Can't read/write	0,7	0,7
	Didn't complete Primary School	0,7	0,6
	Primary School	0,7	0,6
	Middle School	0,6	0,7
	High School	0,6	0,6
	High School Equivalent	0,5	0,6
	Higher Education Schools	0,5	0,5
	University	0,4	0,4
Household Size	1-4 persons	0,5	0,5
	5-14 persons	0,7	0,6
Owner of the Dwelling	Yes	0,5	0,5
	No	0,6	0,7
Own any Other Dwelling	Yes	0,4	0,4
	No	0,7	0,7
Age	0-6 years	0,7	0,6
	7-17 years	0,7	0,8
	18-24 years	0,6	0,6
	25-36 years	0,6	0,6
	37-54 years	0,7	0,7
	55-64 years	0,7	0,7
	65-99 years	0,8	0,8
Sex	Male	0,6	0,6
	Female	0,8	0,8

The new results point out that there is a need to find out again the standard deviation and coefficient of variation of the new data, since most of the values are very close to the previously calculated 10-Evaluations' Sub Variables' Social Vulnerability values. These calculations are presented in the Table 3.24.

Table 3.24 Standard Deviations and Coefficient of Variations of Sub Variables' Values without Outliers

Variable	Sub Variable	Standard Deviation	Coefficient of Variation	Standard Deviation without Outliers	Coefficient of Variation without Outliers
Employment Status	Employee	0,16	0,29	0,11	0,18
	Employer	0,21	0,39	0,12	0,24
	Self-employed	0,27	0,46	0,15	0,28
	Unpaid family worker	0,21	0,31	0,15	0,21
Reasons for Not Working	Retired	0,24	0,37	0,15	0,22
	Student	0,19	0,33	0,11	0,19
	Housewife	0,27	0,44	0,22	0,35
	Rentier	0,25	0,62	0,13	0,32
	Other	0,35	0,51	0,30	0,48
	Unemployed	0,32	0,53	0,27	0,43
Educational Level	Can't read/write	0,24	0,36	0,20	0,30
	Didn't complete Primary School	0,23	0,34	0,17	0,28
	Primary School	0,15	0,23	0,08	0,14
	Middle School	0,10	0,17	0,05	0,08
	High School	0,13	0,23	0,08	0,14
	High School Equivalent	0,12	0,24	0,06	0,10
	Higher Education Schools	0,19	0,41	0,13	0,28
	University	0,21	0,50	0,15	0,38
Household Size	1-4 persons	0,16	0,31	0,13	0,24
	5-14 persons	0,25	0,37	0,17	0,27
Owner of the Dwelling	Yes	0,20	0,38	0,16	0,30
	No	0,22	0,34	0,15	0,23
Own any Other Dwelling	Yes	0,19	0,45	0,12	0,29
	No	0,18	0,28	0,13	0,19
Age	0-6 years	0,34	0,46	0,27	0,42
	7-17 years	0,23	0,31	0,17	0,23
	18-24 years	0,14	0,23	0,10	0,17
	25-36 years	0,10	0,17	0,05	0,09
	37-54 years	0,09	0,14	0,00	0,00
	55-64 years	0,14	0,19	0,09	0,12
	65-99 years	0,22	0,27	0,11	0,14
Sex	Male	0,13	0,23	0,08	0,14
	Female	0,12	0,15	0,05	0,07

According to the results presented in Table 3.24, most of the sub variables' coefficient of variation values is in the same acceptable range. In fact, the Sub Variables' Social Vulnerability Values without outliers can be usable for further calculations. However, the sub variables of 'Housewife', 'Other', 'Unemployed', 'University', and '0-6 years' have high coefficient of variation values. Therefore, these sub variables' median values (in the middle values) are going to be considered for further calculations, since these sub variables' mean values are sensitive for the outliers and the median values of them will be more robust. The Table 3.25 presents these mentioned median values.

Table 3.25 Median Values of Sub Variables' Values without Outliers

Variable	Reasons for not Working			Educational Level	Age
Sub Variable	Housewife	Other	Unemployed	University	0-6 years
Median Values	0,6	0,8	0,7	0,3	0,8

This process is also repeated for the ratings on Pairwise Comparison by extracting the outliers and calculating the mean values. In fact, Table 3.26 presents these computations' results.

Table 3.26 Pairwise Comparison Matrix Mean Values without Outliers of 10-Evaluations Data

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	1	5	5	3	5	4	6	6
Reasons for not Working	1/5	1	5	5	4	3	5	6
Educational Level	1/5	1/5	1	5	4	5	6	7
Household Size	1/3	1/5	1/5	1	3	4	4	5
Owner of the Dwelling	1/5	1/4	1/4	1/3	1	4	3	4
Own any other Dwelling	1/4	1/3	1/5	1/4	1/4	1	4	4
Age	1/6	1/5	1/6	1/4	1/3	1/4	1	5
Sex	1/6	1/6	1/7	1/5	1/4	1/4	1/5	1

This new result on Pairwise Comparison Matrix also indicates the need of finding out the standard deviation and coefficient of variation of the new data, as most of them are same with the previously calculated 10-Evaluations' Pairwise Comparison values (Table 3.27 and Table 3.28).

Table 3.27 Standard Deviations of 10-Evaluations' Pairwise Comparison Values without Outliers

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	0	2	1	1	2	2	2	2
Reasons for not Working	2	0	3	2	1	1	1	2
Educational Level	1	3	0	2	2	2	1	1
Household Size	1	2	2	0	1	2	2	3
Owner of the Dwelling	2	1	2	1	0	3	1	2
Own any other Dwelling	2	1	2	2	3	0	2	3
Age	2	1	1	2	1	2	0	1
Sex	2	2	1	3	2	3	1	0

Table 3.28 Coefficient of Variations of 10-Evaluations' Pairwise Comparison Values without Outliers

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	0	0,3	0,3	0,3	0,4	0,4	0,3	0,4
Reasons for not Working	8,1	0	0,6	0,4	0,3	0,3	0,3	0,3
Educational Level	7,3	14,4	0	0,5	0,5	0,5	0,2	0,2
Household Size	3,0	10,8	11,9	0	0,3	0,5	0,4	0,6
Owner of the Dwelling	9,4	4,0	7,8	2,3	0	0,7	0,4	0,6
Own any other Dwelling	6,5	3,0	12,1	7,3	11,3	0	0,6	0,7
Age	10,6	6,5	5,0	6,9	3,9	9,0	0	0,2
Sex	14,4	11,5	9,1	14,9	8,8	10,7	5,8	0

According to these results, some of the comparative variables' coefficient of variation values are in the acceptable range of ‘0,1-0,3’. In fact, the Pairwise Comparison Values without outliers can be usable for the further calculations. However, the comparative variables of ‘Employment Status – Owner of the Dwelling/Own any other Dwelling/Sex’, ‘Reasons for not Working – Educational Level/Household Size’, ‘Educational Level – Household Size/Owner of the Dwelling/Own any other Dwelling’, ‘Household Size - Own any other Dwelling/Age/Sex’, ‘Owner of the Dwelling – Own any other Dwelling/Age/Sex’, and ‘Own any other Dwelling – Age/Sex’ have high coefficient of variation values of ‘0,4-0,7’. Therefore, these comparative variables’ median values, due to previously mentioned reasons, are going to be considered for further calculations and presented in Table 3.29.

Table 3.29 Median Values of Pairwise Comparison Values without Outliers

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status					6	5		7
Reasons for not Working			5	6				
Educational Level		1/5		5	4	5		
Household Size		1/6	1/5			4	5	5
Owner of the Dwelling	1/6		1/4			4	2	3
Own any other Dwelling	1/5		1/5	1/4	1/4		3	2
Age				1/5	1/2	1/3		
Sex	1/7			1/5	1/3	1/2		

As a result of all these statistical computations, the values for Sub Variables’ Social Vulnerability Values and Pairwise Comparison Matrix are reformed. Therefore, more realistic Social Vulnerability calculations are done using these newly formed 10-Evaluations values. The same Social Vulnerability calculations, (mentioned in Section 3.2.3, 3.2.4, and at the beginning of this Section) are applied to this data and the results are presented in Table 3.30.

Table 3.30 Social Vulnerability Levels of Pendik Neighborhoods According to 10 Different Evaluations' Final Statistics

Neighborhood	Variable's Weight								Social Vulnerability Level
	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any Other Dwelling	Age	Sex	
	0,339	0,204	0,167	0,110	0,066	0,048	0,043	0,023	
Mahalle 1	0,0031	0,0015	0,0015	0,0009	0,0005	0,0005	0,0004	0,0002	**0,0086**
Mahalle 2	0,0077	0,0050	0,0042	0,0025	0,0016	0,0012	0,0012	0,0006	**0,0240**
Mahalle 3	0,0052	0,0039	0,0028	0,0016	0,0010	0,0009	0,0008	0,0004	**0,0167**
Mahalle 4	0,0113	0,0082	0,0053	0,0031	0,0020	0,0016	0,0016	0,0009	**0,0340**
Mahalle 5	0,0022	0,0018	0,0012	0,0007	0,0004	0,0003	0,0003	0,0002	**0,0071**
Mahalle 6	0,0146	0,0093	0,0083	0,0048	0,0031	0,0024	0,0024	0,0012	**0,0462**
Mahalle 7	0,0068	0,0042	0,0036	0,0020	0,0013	0,0011	0,0010	0,0005	**0,0206**
Mahalle 8	0,0077	0,0062	0,0041	0,0024	0,0016	0,0012	0,0012	0,0006	**0,0251**
Mahalle 9	0,0101	0,0058	0,0052	0,0030	0,0019	0,0015	0,0015	0,0008	**0,0298**
Mahalle 10	0,0180	0,0116	0,0103	0,0059	0,0036	0,0031	0,0029	0,0015	**0,0568**
Mahalle 11	0,0114	0,0076	0,0064	0,0036	0,0023	0,0019	0,0018	0,0010	**0,0360**
Mahalle 12	0,0050	0,0025	0,0022	0,0012	0,0008	0,0006	0,0006	0,0003	**0,0132**
Mahalle 13	0,0011	0,0011	0,0009	0,0005	0,0003	0,0002	0,0003	0,0001	**0,0044**
Mahalle 14	0,0046	0,0033	0,0028	0,0016	0,0010	0,0008	0,0008	0,0004	**0,0154**
Mahalle 15	0,0098	0,0065	0,0059	0,0034	0,0021	0,0017	0,0017	0,0009	**0,0321**
Mahalle 16	0,0124	0,0069	0,0063	0,0036	0,0025	0,0018	0,0018	0,0009	**0,0363**
Mahalle 17	0,0080	0,0037	0,0036	0,0021	0,0012	0,0011	0,0010	0,0005	**0,0213**
Mahalle 18	0,0028	0,0021	0,0016	0,0009	0,0006	0,0005	0,0005	0,0002	**0,0093**
Mahalle 19	0,0090	0,0052	0,0048	0,0028	0,0016	0,0015	0,0014	0,0007	**0,0270**
Mahalle 20	0,0071	0,0046	0,0042	0,0024	0,0014	0,0013	0,0012	0,0006	**0,0228**
Mahalle 21	0,0063	0,0036	0,0027	0,0015	0,0010	0,0008	0,0008	0,0004	**0,0171**
Mahalle 22	0,0017	0,0009	0,0008	0,0004	0,0003	0,0002	0,0002	0,0001	**0,0047**
Mahalle 23	0,0049	0,0036	0,0031	0,0018	0,0010	0,0009	0,0009	0,0005	**0,0167**
Mahalle 24	0,0070	0,0041	0,0040	0,0023	0,0013	0,0012	0,0011	0,0006	**0,0217**
Mahalle 25	0,0053	0,0044	0,0034	0,0019	0,0012	0,0010	0,0010	0,0005	**0,0186**
Mahalle 26	0,0146	0,0090	0,0072	0,0041	0,0026	0,0021	0,0021	0,0011	**0,0429**

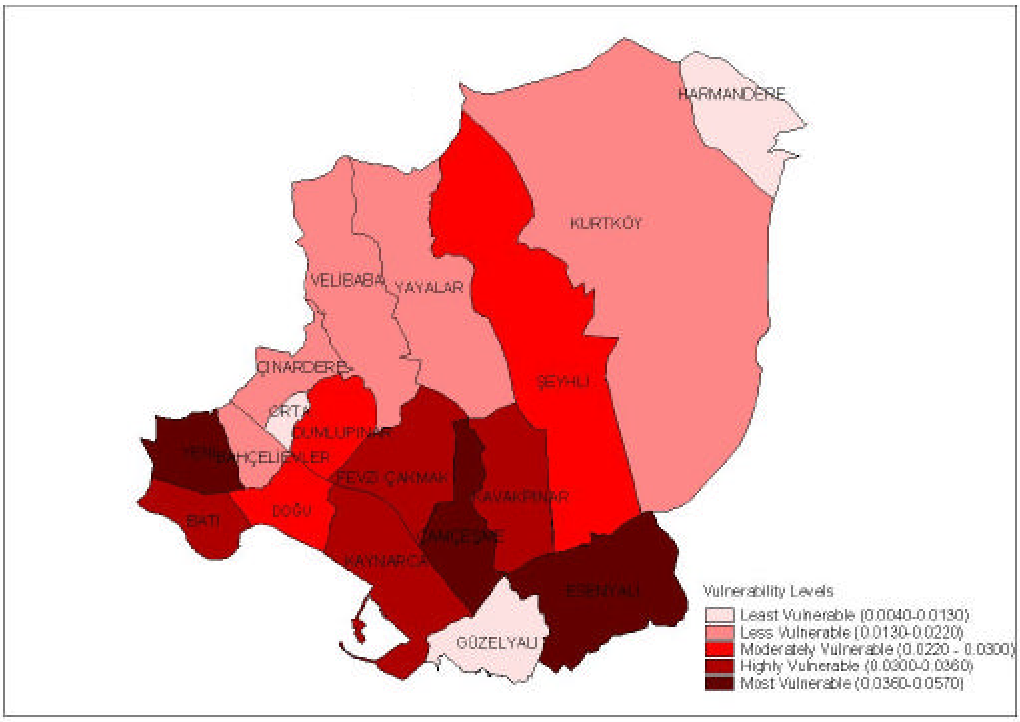

Figure 3.9 Social Vulnerability Levels of Pendik Neighborhoods, by Considering Final Statistics of 10 Persons' Evaluations

The above statistical calculation results show that, the 10 evaluations give meaningful ratings for the assessment, since no different levels are gathered with these calculations (Figure 3.9). In fact, the standard deviation, the coefficient of variation and the median of the data show that, the 10 evaluations' average values are appropriate for integrating them into the study to avoid the subjectivity of the calculation of Social Vulnerability in Pendik.

Up till now, the methodology's statistical computations are explained and examined. However, just doing the statistical calculations, the social vulnerability cannot be expressed adequately. The process should be supported by spatially referenced data analyses. In order to do that, GIS is not only a handy tool for visualization of the results, but also is a very useful tool for applying the analyses. In the next part the spatial analyses, which are used in this methodology; with the help of GIS capabilities are explained.

3.2.6 Spatial Data Analyses

The spatial data analysis is very important. Especially, in the projects on social sciences, spatial data analysis can give a different perspective.

Bailey and Gatrell (1995) state that the spatial data analysis involves the accurate description of data relating to a process operating in space, the exploration of patterns and relationships in such data, and the search for explanations of such patterns and relationships. As UCGIS (2003) claims that spatial analysis encompasses a wide range of techniques for analyzing, computing, visualizing, simplifying, and theorizing about geographic data. However, the spatial data analysis methods can be grouped into the following classes: the first ones which are essentially concerned with *visualizing* spatial data, the second ones which are *exploratory*, concerned with summarizing and investigating map pattern and relationships, and the last ones which rely on the specification of a statistical *model* and the estimation of parameters.

Although, the details of the differences between these classes will not be mentioned in this thesis, the decision, which affects the selection of the exploratory methods to use in the thesis, should be explained. The exploratory methods involve seeking good description of data, thus helping the analyst to develop hypothesis about, and appropriate models for, such data (Bailey and Gatrell, 1995). Besides, such methods emphasize graphical views of the data, which are designed to highlight particular features and allow the analyst to detect pattern, relationships, unusual values, and so on. Moreover, they involve a significant degree of ‘value-added’ data manipulations.

These exploratory methods can be applied with spatial data in the form of point, spatially continuous, and area. The selection of the mentioned patterns is based on the spatial data that you have. If there is a building data and a related survey, then appropriate exploratory methods should be applied in the point pattern. In this thesis's applications, the area data and related exploratory methods (Proximity Measures, Spatial Moving Averages, Median Polish, Kernel Estimation, and Spatial Correlations) are considered, since the methodology is applied to the neighborhood-based census sample data.

The first step in exploring the area data is, defining the spatial proximity measures between each of the areas. As these methods' aim is to find out the relationships between the features, this definition process made a basis for the other methods.

3.2.6.1. Proximity Measures

Measuring the spatial proximity between the features of point pattern is very easy, because of its nature. However, when the area data is considered, the spatial proximity between the features cannot be just measured by using their geographical centers. Because, in doing so some aspects of the spatial nature of these areas would be disregarded.

For this purpose, there is a tool, which allows the analyst to define spatial proximity in a more general way. This is called spatial proximity matrix (W). It is basically a (n x n) matrix, each element of which; w_{ij}, represents a measure of the spatial proximity of areas A_i and A_j. Bailey and Gatrell (1995) state that, the choice of w_{ij} will depend upon the sort of data that one is dealing with and the particular mechanism through which one expects spatial dependence to arise. They also indicate that, some possible criteria might be:

$w_{ij} = \{ 1$ centroid of A_j is one of the k nearest centroids to that A_i

$\{ 0$ otherwise

$w_{ij} = \{ 1$ centroid of A_j is within some specified distance of that of A_i

$\{ 0$ otherwise

$w_{ij} = \{ d^{y}_{ij}$ if inter-centroid distance d < d (d > 0; ? < 0)

$\{ 0$ otherwise

$w_{ij} = \{ 1$ A_j shares common boundary with A_i

$\{ 0$ otherwise

$w_{ij} = \dfrac{l_{ij}}{l_i}$ where l_{ij} is the length of common boundary between A_i and A_j and l_i is the perimeter of A_i

Hybrid measures based on these various criteria can also be used: for example, combinations of length of shared boundary and distance between centroids (Bailey and Gatrell, 1995). From the above-mentioned criteria, the below ones are decided, according to the study's aims, to be used for the Pendik data.

$w_{ij} = \{ 1$ centroid of A_j is one of the 10 nearest centroids to that A_i

$\{ 0$ otherwise

$w_{ij} = \{ 1$ centroid of A_j is within 3 km distance of that of A_i

$\{ 0$ otherwise

$w_{ij} = \{ 1$ A_j shares common boundary with A_i

$\{ 0$ otherwise

Therefore, the following Spatial Proximity Matrices are obtained considering the above-mentioned criteria. The first matrix is based on the criterion of ’10 nearest neighborhoods from the considered neighborhood’ (Table 3.31). The values are appointed according to the proximity of 10 neighborhoods for each of the neighborhood from their centroids.

Table 3.31 Proximity Matrix by ’10 Nearest Neighborhoods’

Neighborhood	3.Bahcelievler	4.Bati	6.Çamçesme	7.Çinardere	8.Dogu	9.Dumlupinar	10.Esenyali	11.FevziÇakmak	12.Güzelyali	13.Harmandere	15.Kavakpinar	16.Kaynarca	17.Kurtköy	18.Orta	19.Seyhli	23.Velibaba	24.Yayalar	26.Yeni
3.Bahcelievler	1	1	0	1	1	1	0	1	0	0	0	1	0	1	0	1	0	1
4.Bati	1	1	1	1	1	1	0	1	0	0	0	1	0	1	0	0	0	1
6.Çamçesme	0	0	1	0	1	1	1	1	1	0	1	1	0	1	1	0	0	0
7.Çinardere	1	1	0	1	1	1	0	1	0	0	0	0	0	1	0	1	1	1
8.Dogu	1	1	1	1	1	1	0	1	0	0	0	1	0	1	0	0	0	1
9.Dumlupinar	1	1	0	1	1	1	0	1	0	0	0	1	0	1	0	1	0	1
10.Esenyali	0	0	1	0	1	1	1	1	1	0	1	1	1	0	1	0	0	0
11.FevziÇakmak	1	0	1	1	1	1	0	1	1	0	1	1	0	1	0	0	0	0
12.Güzelyali	0	0	1	0	1	1	1	1	1	0	1	1	0	1	1	0	0	0
13.Harmandere	0	0	1	0	0	1	1	1	0	1	1	0	1	0	1	1	1	0
15.Kavakpinar	0	0	1	0	1	1	1	1	1	0	1	1	0	0	1	0	1	0
16.Kaynarca	1	1	1	0	1	1	0	1	1	0	1	1	0	1	0	0	0	0
17.Kurtköy	0	0	1	0	0	1	1	1	0	1	1	0	1	0	1	1	1	0
18.Orta	1	1	0	1	1	1	0	1	0	0	0	1	0	1	0	1	0	1
19.Seyhli	0	0	1	1	0	1	1	1	0	0	1	0	1	0	1	1	1	0
23.Velibaba	1	0	0	1	1	1	0	1	0	0	0	0	0	1	1	1	1	1
24.Yayalar	1	0	1	1	0	1	0	1	0	0	1	0	0	1	1	1	1	0
26.Yeni	1	1	0	1	1	1	0	1	0	0	0	1	0	1	0	1	0	1

The second matrix is formed according to the criterion of ‘neighborhoods within 3 km distance of the considered neighborhood’. The values of this matrix are given, by defining the neighborhoods, which are in the 3 km radius circle from the considered neighborhood’s centroid. This 3 km distance is selected according to the general standards of people’s daily interaction zones for shopping, education and health services (Aydin, 1971). The matrix is presented in Table 3.32.

Table 3.32 Proximity Matrix of 'Neighborhoods within 3 km Distance'

Neighborhood	3.Bahcelievler	4.Bati	6.Çamçesme	7.Çinardere	8.Dogu	9.Dumlupinar	10.Esenyali	11.FevziÇakmak	12.Güzelyali	13.Harmandere	15.Kavakpinar	16.Kaynarca	17.Kurtköy	18.Orta	19.Seyhli	23.Velibaba	24.Yayalar	26.Yeni
3.Bahcelievler	1	1	0	1	1	1	0	1	0	0	0	1	0	1	0	1	0	1
4.Bati	1	1	0	1	1	1	0	0	0	0	0	1	0	1	0	0	0	1
6.Çamçesme	0	0	1	0	1	1	1	1	1	0	1	1	0	0	1	0	0	0
7.Çinardere	1	1	0	1	1	1	0	1	0	0	0	0	0	1	0	1	1	1
8.Dogu	1	1	1	1	1	1	0	1	0	0	0	1	0	1	0	0	0	1
9.Dumlupinar	1	1	1	1	1	1	0	1	0	0	1	1	0	1	0	1	1	1
10.Esenyali	0	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0
11.FevziÇakmak	1	0	1	1	1	1	0	1	1	0	1	1	0	1	1	1	1	0
12.Güzelyali	0	0	1	0	0	0	1	1	1	0	1	1	0	0	0	0	0	0
13.Harmandere	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
15.Kavakpinar	0	0	1	0	0	1	1	1	1	0	1	1	0	0	1	0	0	0
16.Kaynarca	1	1	1	0	1	1	0	1	1	0	1	1	0	1	0	0	0	0
17.Kurtköy	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0
18.Orta	1	1	1	1	1	1	0	1	0	0	0	1	0	1	0	1	1	1
19.Seyhli	0	0	1	0	0	0	0	1	0	0	1	0	1	0	1	1	1	0
23.Velibaba	1	0	0	1	0	1	0	1	0	0	0	0	0	1	1	1	1	0
24.Yayalar	0	0	0	1	0	1	0	1	0	0	0	0	0	1	1	1	1	0
26.Yeni	1	1	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	1

The third matrix is based on the criteria of 'neighborhoods sharing a common boundary' (Table 3.33). The below matrix is formed according to the neighborhoods, which are in the condition of sharing at least one common boundary.

Table 3.33 Proximity Matrix of ’Neighborhoods Sharing a Common Boundary’

Neighborhood	3.Bahcelievler	4.Bati	6.Çamçesme	7.Çinardere	8.Dogu	9.Dumlupinar	10.Esenyali	11.FevziÇakmak	12.Güzelyali	13.Harmandere	15.Kavakpinar	16.Kaynarca	17.Kurtköy	18.Orta	19.Seyhli	23.Velibaba	24.Yayalar	26.Yeni
3.Bahcelievler	1	1	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	1
4.Bati	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
6.Çamçesme	0	0	1	0	0	0	1	1	1	0	1	1	0	0	0	0	1	0
7.Çinardere	1	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0
8.Dogu	1	1	0	0	1	1	0	1	0	0	0	1	0	1	0	0	0	1
9.Dumlupinar	1	0	0	1	1	1	0	1	0	0	0	0	0	1	0	1	0	0
10.Esenyali	0	0	1	0	0	0	1	0	1	0	1	0	1	0	1	0	0	0
11.FevziÇakmak	0	0	1	0	1	1	0	1	0	0	1	1	0	0	0	1	1	0
12.Güzelyali	0	0	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0
13.Harmandere	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
15.Kavakpinar	0	0	1	0	0	0	1	1	1	0	1	0	0	0	1	0	1	0
16.Kaynarca	0	0	1	0	1	0	0	1	1	0	0	1	0	0	0	0	0	0
17.Kurtköy	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	0	0	0
18.Orta	1	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0
19.Seyhli	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	1	0
23.Velibaba	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1	1	0
24.Yayalar	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1	1	1	0
26.Yeni	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1

The above matrices are formed according to the mentioned criteria, in the light of the best representation of study’s aims. Since these matrices are one of the base data for the coming analyses, after this point the concentration can be directed to application of the first analysis of Spatial Moving Averages Method.

3.2.6.2. Spatial Moving Averages Method

After the proximity matrices, the first explorative spatial data analysis, Spatial Moving Averages Method, can be applied as a part of the methodology. The purpose for integrating this method to the methodology is to estimate global variations and trends in the values of an attribute over the neighboring areas. In fact, with the Spatial Moving Averages Method, how the mean value (μ_I) of the attribute of interest varies across the study region can be calculated and presented.

The spatial proximity matrix W provides a flexible method of defining a suitable set of weights for 'neighboring' areas and the smoothed estimate is then:

$$m_i = \frac{\sum_{j=1}^{n} w_{ij} y_j}{\sum_{j=1}^{n} w_{ij}} \qquad 3.7$$

Using the above formula, the calculations can be made and the outputs yield a smoother picture of spatial variations than a map of raw data and serve to highlight broad regional trends.

The first application of the method is done for the proximity matrix of '10 Nearest Neighborhoods'. According to the computations of the above formula, the below results are gathered (Table 3.34), and presented in Figure 3.10.

Table 3.34 Spatial Moving Averages Method Results for the Criteria of '10 Nearest Neighborhoods'

Neighborhood	Spatial Moving Averages Value
3.Bahçelievler	0,0298
4.Bati	0,0331
6.Çamçesme	0,0349
7.Çinardere	0,0284
8.Dogu	0,0331
9.Dumlupinar	0,0298
10.Esenyali	0,0360
11.Fevzi Çakmak	0,0297
12.Güzelyali	0,0349
13.Harmandere	0,0328
15.Kavakpinar	0,0362
16.Kaynarca	0,0312
17.Kurtköy	0,0328
18.Orta	0,0298
19.Seyhli	0,0345
23.Velibaba	0,0276
24.Yayalar	0,0289
26.Yeni	0,0298

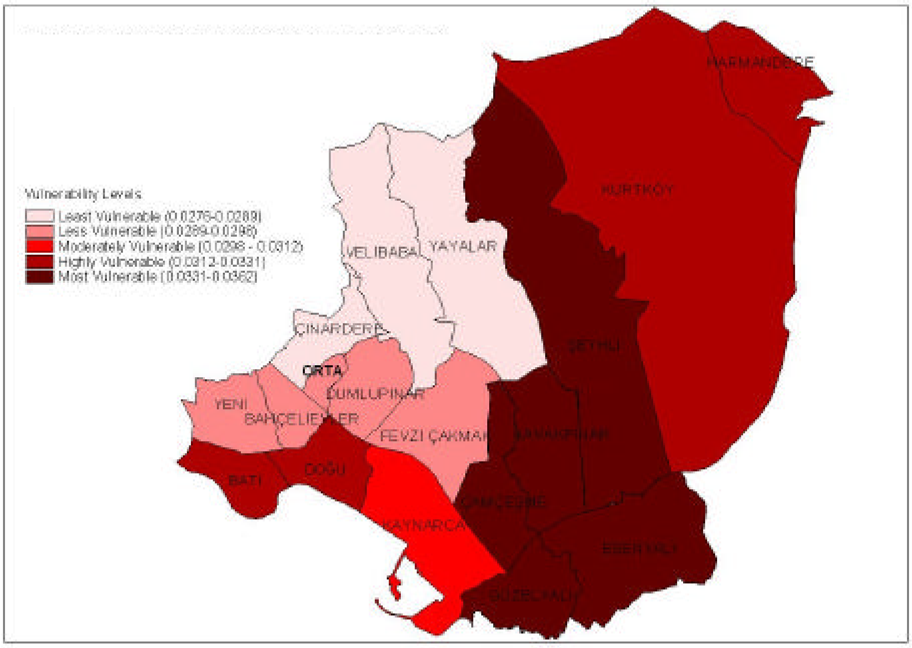

Figure 3.10 Spatial Moving Averages Method Results for the Criteria of '10 Nearest Neighborhoods'

Since the discussions of all methods take place together in the last part of this chapter, the comments on this result will be mentioned in that part. However, it is obviously clear that, the southeast part of the district is the most vulnerable region, contrary to the northwest part of the district.

The second application of Spatial Moving Averages Methods is for the criteria of 'Neighborhoods within 3 km Distance'. The method's computations are applied to the proximity matrix of this criterion, and the results of this process are presented in Table 3.35.

Table 3.35 Spatial Moving Averages Method Results for the Criteria of 'Neighborhoods within 3 km Distance'

Neighborhood	Spatial Moving Averages Value
3.Bahçelievler	0,0298
4.Bati	0,0297
6.Çamçesme	0,0376
7.Çinardere	0,0284
8.Dogu	0,0331
9.Dumlupinar	0,0317
10.Esenyali	0,0416
11.Fevzi Çakmak	0,0285
12.Güzelyali	0,0412
13.Harmandere	0,0136
15.Kavakpinar	0,0386
16.Kaynarca	0,0312
17.Kurtköy	0,0189
18.Orta	0,0313
19.Seyhli	0,0322
23.Velibaba	0,0251
24.Yayalar	0,0259
26.Yeni	0,0283

This result is also presented in Figure 3.11.

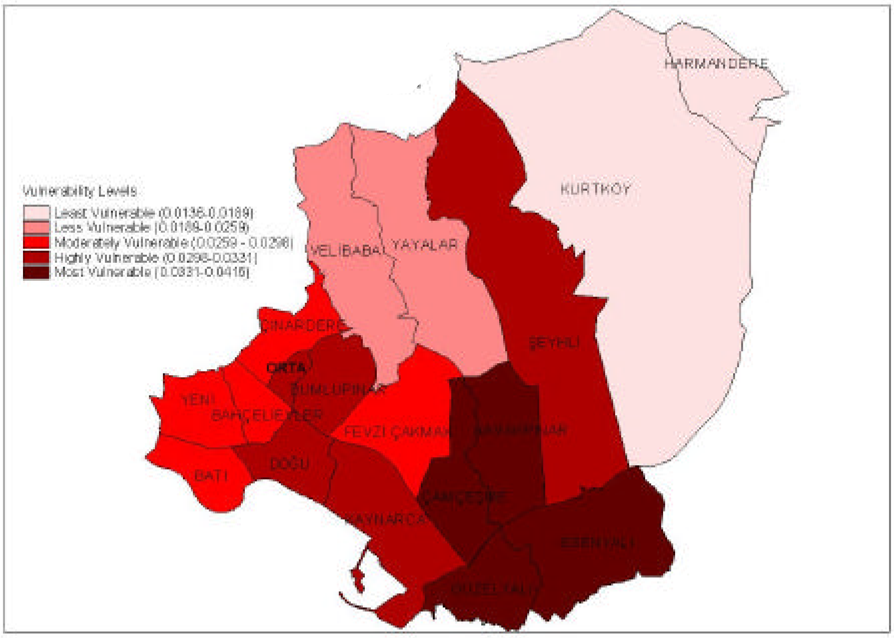

Figure 3.11 Spatial Moving Averages Method Results for the Criteria of 'Neighborhoods within 3 km Distance'

The result of this application also shows that, the southeast part of the district is the most vulnerable part. However, different from the previous criterion, in this criterion the northeast part of the district appears to be the least vulnerable region. Again the detailed discussions on these results are mentioned in the last part of the chapter.

The third application of Spatial Moving Averages Method is done for the criteria of 'Neighborhoods Sharing a Common Boundary'. In fact, the related proximity matrix is used for the computations. The results of this application are shown in Table 3.36. The graphical representation of the results is presented in Figure 3.12.

Table 3.36 Spatial Moving Averages Method Results for the Criteria of 'Neighborhoods Sharing a Common Boundary'

Neighborhood	Spatial Moving Averages Value
3.Bahçelievler	0,0283
4.Bati	0,0375
6.Çamçesme	0,0388
7.Çinardere	0,0210
8.Dogu	0,0320
9.Dumlupinar	0,0251
10.Esenyali	0,0362
11.Fevzi Çakmak	0,0344
12.Güzelyali	0,0411
13.Harmandere	0,0136
15.Kavakpinar	0,0374
16.Kaynarca	0,0351
17.Kurtköy	0,0302
18.Orta	0,0229
19.Seyhli	0,0352
23.Velibaba	0,0282
24.Yayalar	0,0340
26.Yeni	0,0329

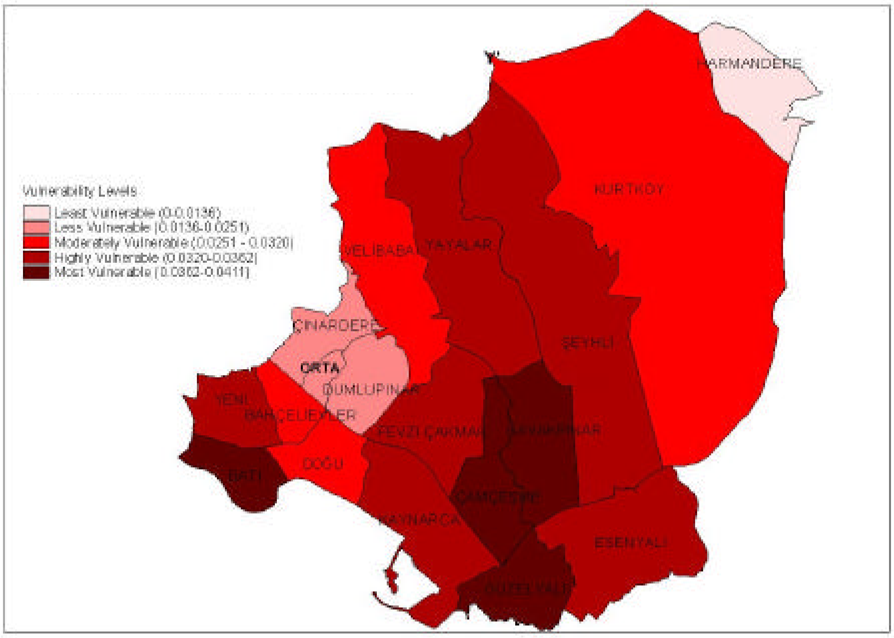

Figure 3.12 Spatial Moving Averages Method Results for the Criteria of 'Neighborhoods Sharing a Common Boundary'

In this criterion, the same comment is continued, where the southeast part of the district is the most and highly vulnerable region. The least vulnerable part is appeared to be the north part of the district.

From all the criteria in the method, there is one common result, which is the southeast neighborhoods are generally formed as the most vulnerable part of the district. The least and less vulnerable neighborhoods intensively take part at the north and northwest of the district. Although, the discussions about these outputs are mentioned in the last part of this Chapter, one thing should be stated that, from all the criteria, the second criterion of ‘Neighborhoods within 3 km Distance’ gives the most appropriate results for the further analyses. Because, this criterion mainly determines the neighborhoods by their existence in a specific distance. It means that, in this distance the interaction of the neighborhoods can be identified appropriately. However, with the other two criteria, the interactions between neighborhoods cannot be determined as needed, due to the general approach of them. For example the first one is based on 10 nearest neighborhoods, and the other one is based on a situation of sharing a common boundary, which are very general grouping criteria for such a data.

3.2.6.3. Median Polish Method

Another explorative spatial data analysis is Median Polish Method. Bailey and Gatrell (1995) state that, when our data, y_i, are on a regular grid a simple technique which may help to identify broad spatial trends in mean (μ_i) and which is more resistant to extreme values or outliers in the data is median polishing. For this reason, this method can also be called filtering method, and identified as helpful for the exploration of global trends.

In this method, y_{ij} (our data in the form of a regular r x s matrix) is treated as if they are cell entries in a two- way table, and then to obtain an additive decomposition of each cell entry into with using the below formula:

$$y_{ij} = \mu + \mu_i + \mu_j + e_{ij} \qquad 3.8$$

In the above formula, μ is some fixed overall effect, μ_i and μ_j is fixed row and column effects, and e_{ij} is a random error.

Median polish estimates the first order effects using medians rather than means, and will in general be more robust to extreme values. From the point of view of exploration this sort of row/column trend decomposition may be useful since it is more flexible than imposing a simple trend 'model' such as a linear or quadratic surface over the whole study area (Bailey and Gatrell, 1995).

Bailey and Gatrell (1995) explain the algorithm steps as follows. Firstly an extra (r + 1)th row and (s + 1)th column is added to the table and initialized with zero values. Then each cell value is replaced by the difference between y_{ij} and the median of its row i.e. the median of (y_{i1}, …, y_{is}). The value of $y_{i.s+1}$ is then set equal to its previous value plus the median of the row. This process is repeated but working through the columns rather than the rows and including row the (s + 1)th column. In other words, the medians of the columns in the body of the new table are obtained, subtracted from the corresponding elements in the table and added to the value in the corresponding element of the (r + 1)th row; also the median of the (s + 1)th column is found and subtracted from each element in this column and also added to the value of the cell $y_{r+1.s+1}$. The procedure is now repeated for the rows, again including the (r + 1)th row, followed by the columns again and so on. This process continues until no cell value changes by more than some small tolerance. Thus the original table is replaced by a table of residuals and the extra column contains robust estimates of the μ_i, the extra row similarly for the μ_j, with the (r + 1.s

+ 1) cell containing an estimate of μ. The estimated or 'fitted' value for each cell mean μ_{ij} is then just the sum of these estimates $\mu + \mu_i + \mu_j$.

This method can be applied to the data in the form of area by assigning each area to the closest cell of some suitably chosen grid, which has been overlaid on the areas. It should not be forgotten that, each cell of the grid should correspond to a single area as much as possible. After having the values from the regularly divided map, a table should be formed using these values. Having the results from the above-mentioned calculations, the GIS mapping capabilities can also be used for the representation of these outputs.

In this respect, two different grids are applied to Pendik, and the computations are made according to the gathered values from these grids. The first grid applied to the study area is a 10x10 (means 1km x 1 km) regularly divided grid, and presented in Figure 3.13.

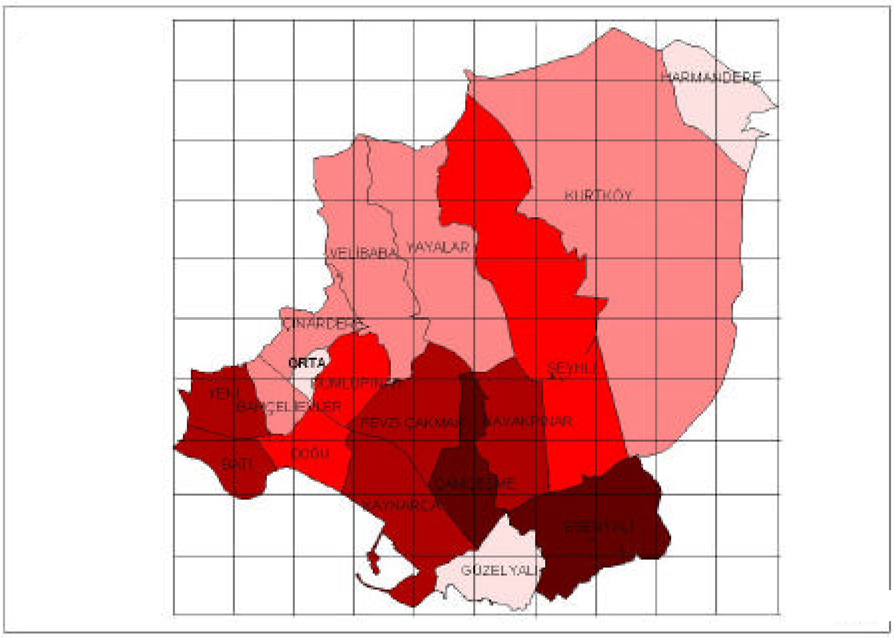

Figure 3.13 10x10 Grid for Median Polish Method

After this step, the 10x10 matrix is formed according to the overlay of each cell with neighborhoods. The Social Vulnerability Value of each neighborhood is used for the appointment of the values of related cells, as shown in Table 3.37.

Table 3.37 Original 10x10 Matrix of Median Polish Method

0	0	0	0	0	0,0216	0,0216	0,0216	0,0056	0,0056
0	0	0	0	0,0295	0,0216	0,0216	0,0216	0,0056	0,0056
0	0	0,0196	0,0243	0,0295	0,0295	0,0216	0,0216	0,0216	0,0216
0	0	0,0196	0,0196	0,0243	0,0295	0,0216	0,0216	0,0216	0,0216
0	0	0,0227	0,0196	0,0243	0,0295	0,0295	0,0216	0,0216	0,0216
0,0468	0,0227	0,0227	0,0326	0,0415	0,0243	0,0295	0,0216	0,0216	0,0216
0,0468	0,019	0,0326	0,0415	0,0415	0,0363	0,0295	0,0216	0,0216	0
0,0369	0,0369	0,0289	0,0392	0,0525	0,0363	0,0295	0,0642	0	0
0	0	0	0,0392	0,0392	0,0134	0,0642	0,0642	0,0642	0
0	0	0	0,0392	0,0134	0,0134	0,0642	0,0642	0	0

The necessary processes are applied 4 times, so that there is no cell value changed by more than a small tolerance. Therefore, the original table is replaced by a table of residuals and the extra column and row, which the estimated value for each cell's mean can be obtained by the summation of them. The result matrix of the Median Polish Method is presented in Table 3.38.

Table 3.38 Result of Median Polish Method for 10x10 Matrix

0,0432	0,0432	0,0376	0,0349	0,0297	0,0297	0,0308	0,0356	0,0376	0,0376
0,0432	0,0432	0,0376	0,0349	0,0297	0,0297	0,0308	0,0356	0,0376	0,0376
0,0272	0,0272	0,0216	0,0189	0,0137	0,0137	0,0148	0,0196	0,0216	0,0216
0,0292	0,0292	0,0236	0,0209	0,0157	0,0157	0,0168	0,0216	0,0236	0,0236
0,0272	0,0272	0,0216	0,0189	0,0137	0,0137	0,0148	0,0196	0,0216	0,0216
0,0261	0,0261	0,0205	0,0178	0,0126	0,0126	0,0137	0,0185	0,0205	0,0205
0,0242	0,0242	0,0186	0,0159	0,0107	0,0107	0,0118	0,0166	0,0186	0,0186
0,0199	0,0199	0,0143	0,0116	0,0064	0,0064	0,0075	0,0123	0,0143	0,0143
0,0272	0,0272	0,0216	0,0189	0,0137	0,0137	0,0148	0,0196	0,0216	0,0216
0,0432	0,0432	0,0376	0,0349	0,0297	0,0297	0,0308	0,0356	0,0376	0,0376

As seen in Table 3.38, this method smoothed the original matrix very much. Especially, in the middle part of the matrix, the original values are changed distinctly. For this purpose, another grid of 5x5 grid (means 2kmx2km) is applied to the study area. The mentioned grid is shown in Figure 3.14.

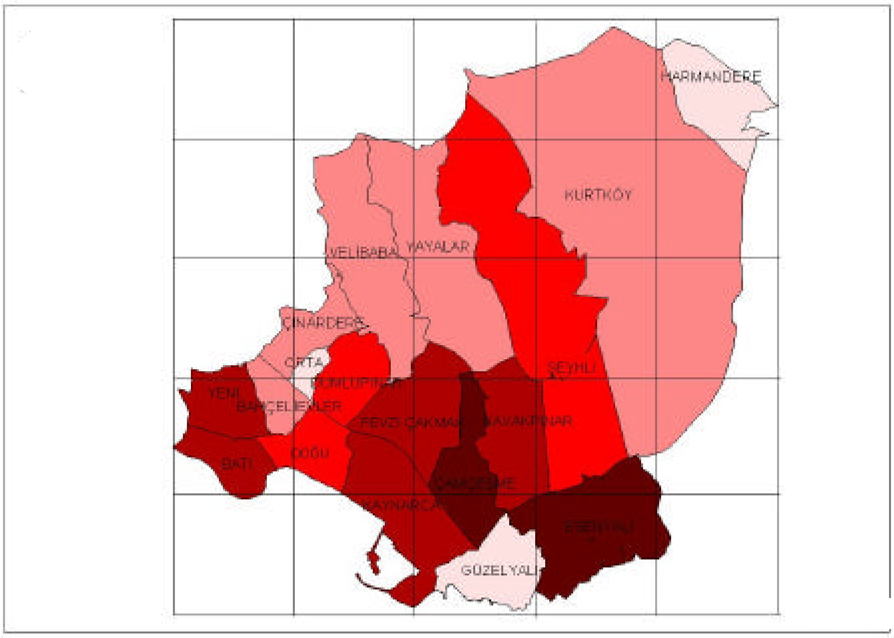

Figure 3.14 5x5 Grid for Median Polish Method

According to this grid, the overlaid Social Vulnerability Values of each neighborhood are appointed to the related cell, and the below matrix is formed.

Table 3.39 Original 5x5 Matrix of Median Polish Method

0	0	0,0216	0,0216	0,0056
0	0,0196	0,0295	0,0216	0,0216
0,0227	0,0196	0,0243	0,0295	0,0216
0,0369	0,0392	0,0363	0,0295	0,0216
0	0,0392	0,0134	0,0642	0

The same computations are done for this 5x5 matrix for 4 times, until there is no cell value changed by more than a small tolerance. Thus, the original table is resulted in Table 3.40.

Table 3.40 Result of Median Polish Method for 5x5 Matrix

0,0134	0,0134	0,0118	0,0066	0,0145
0,0072	0,0072	0,0056	0,0004	0,0083
0,0041	0,0041	0,0025	-0,0027	0,0052
-0,0079	-0,0079	-0,0095	-0,0147	-0,0068
0,0134	0,0134	0,0118	0,0066	0,0145

The above matrix shows that, the Median Polish Method with 5x5 matrix is again generalized the original values too effectually. In fact, the most and the highly vulnerable cells no more exist by this method. Therefore, as this method gives very generalized pictures of the original data, the Median Polish Method can be ignored for giving inputs for the methodology.

3.2.6.4. Kernel Estimation Method

Another type of explorative spatial analysis is called Kernel Estimation Technique. Bailey and Gatrell (1995) state that Kernel estimation was originally developed to obtain a smooth estimate of a univariate or multivariate probability density from an observed sample of observations; in other words, a smooth histogram. The purpose for integrating this method to the methodology is to explore global trends in data.

The method can be applied as; if s represents a general location in study region and s_1, …, s_n are the locations of the n observed events then the intensity, ?(s), at s is estimated by:

$$l_t(s) = \sum_{i=1}^{n} 1/t^2 k((s - s_i)/t) y_i \quad 3.9$$

Here k() is a suitably chosen bivariate probability density function, known as the kernel, which is symmetric about the origin. The parameter $\tau > 0$ is known as the bandwidth and determines the amount of smoothing- essentially it is the radius of a disc centered on s within which points s_i will contribute ‘significantly’ to $?_\tau(s)$ (Bailey and Gatrell, 1995).

On a suitably chosen fine grid over the study area, the values of $?_\tau(s)$ can be examined for chosen kernel and bandwidth to provide a useful visual indication of the variation in the intensity. Since this method needs to be applied in point pattern, for the area data applications the centroids of the areas can be considered.

The detailed calculations of this method will not be emphasized in this thesis (for more information see; Bailey and Gatrell, 1995). However, the easy way of applying this method can be found in the GIS software’s spatial analysis modules. Although, most of the GIS softwares have spatial analysis modules, the very well known is ESRI’s ArcGIS Spatial Analyst Tool. This tool especially contains a Kernel Estimation analysis function. Therefore, in this part of the methodology, the method can easily be applicable by centroids of area-based data with using this tool.

In this respect, in the application of this analysis, the above-mentioned Tool is used. Six alternatives for bandwidth and kernel values are examined. These are; τ=261;k=31, τ=500;k=30, τ=500;k=60, τ=1000;k=30, τ=1500;k=30, and τ=1500;k=60. From these analysis, the below presented τ=1500;k=30, and τ=1500;k=60 values give the most meaningful results.

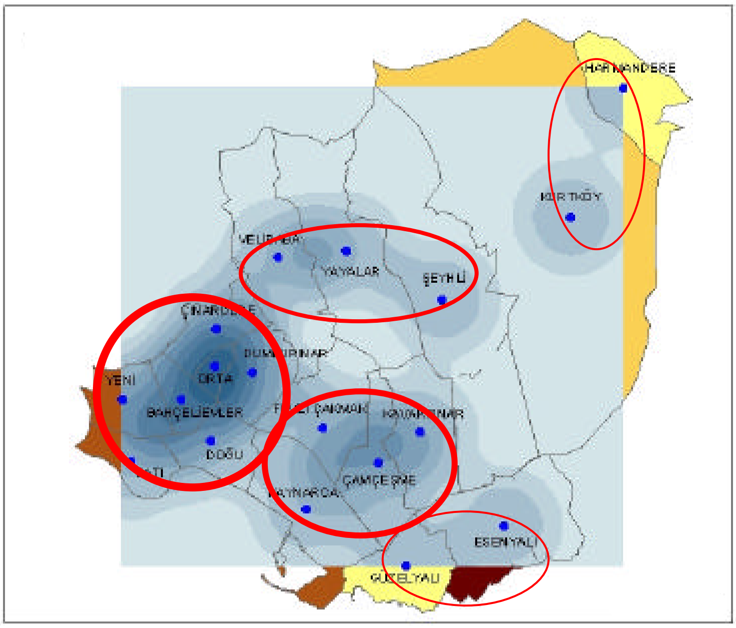

Figure 3.15 Kernel Estimation Method Results by τ=1500;k=30

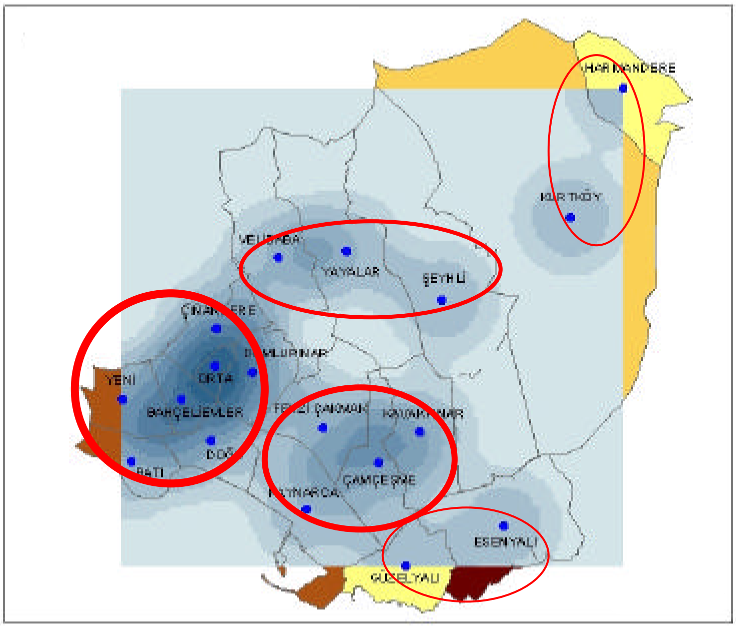

Figure 3.16 Kernel Estimation Method Results by τ=1500;k=60

Although, the discussions on these results are given at last part of this chapter, it's clearly seen from Figure 3.15 and Figure 3.16 that, Orta-Dumlupinar-Çinardere-Bahçelievler-Dogu-Bati-Yeni neighborhoods formed the 1st group, Çamçesme-Kavakpinar-Fevzi Çakmak-Kaynarca neighborhoods formed the 2nd group, Velibaba-Yayalar-Seyhli neighborhoods formed the 3rd group, Güzelyali-Esenyali neighborhoods formed the 4th group, and Kurtköy-Harmandere neighborhoods formed the 5th group.

3.2.6.5. Spatial Correlations

The Spatial Correlation method is different from the previously mentioned methods. Because, the previous methods involve estimating the way in which the mean or expected value of the process varies in the study region. However, this spatial correlation method contains exploring the spatial dependence of deviations in attribute values from their mean. It also involves the correlation between values of the same variable at different spatial locations. In other words, it is useful for exploration of spatial interactions.

There are two measures, which can be used for this method. They are called Moran's I and Geary's C. In Moran's I for a spatial proximity matrix W spatial correlation in attribute values y_i can be estimated as follows:

$$|I| \leq (n / \sum_{i \neq j} \sum w_{ij}) * (((\sum_{i=1}^{n} (\sum_{j=1}^{n} w_{ij}(y_i - y))^2) / (\sum_{i=1}^{n} (y_i - y)^2))^{1/2} \qquad 3.10$$

The theoretical bound for the above formula is the restriction of the result values into a (-1, 1) range. In this respect, the Moran's I measure is applied to the spatial proximity matrix of 'Neighborhoods within 3 km Distance', with the explained reasons in Section 3.2.4.2. According to the matrix and the above-mentioned computations, the result of Moran's I is obtained as '1,00'. This result indicates that, the Social

Vulnerability Levels of 18 neighborhoods are in strong relation between each other.

The other measure, Geary's C is for a spatial proximity matrix W spatial correlation in attribute values y_i is estimated as:

$$C = ((n-1)\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_i - y_j)^2)/(2(\sum_{i=1}^{n} y_i - y)^2)(\sum_{i \neq j}\sum w_{ij})) \qquad 3.11$$

The Geary's C is also applied to estimate the spatial correlation in attribute values for a spatial proximity matrix of 'Neighborhoods within 3 km Distance', and the result of 'Geary's C = 0,72' is obtained. This result also indicates that, there is a quite strong relation between the neighborhoods.

Another technique in this method is producing a correlogram. It is a generalization of I or C to estimate spatial correlation at different spatial lags. Bailey and Gatrell (1995) state that, this may be performed by simply calculating either of them using the proximity matrix appropriate for that lag, $W^{(k)}$. After these calculations, a correlogram where the spatial correlation at a particular spatial lag is plotted against the lag, can be constructed. With the results of the correlogram, the correlation between the lags can be identified.

In this respect, correlogram for the spatial lags of 1, 2, and 3 is performed, by using the 'Neighborhoods within 3 km Distance' proximity matrix. This proximity matrix, which was formed based on the 3 km distance from the considered neighborhood's centroid, is modified according to the lags. In fact, the matrix is reformed for lags of 2 and 3, by considering these combined 2/3 neighborhoods as one and the centroid of this new neighborhood is a base point for the selection of neighborhoods. The below Moran's I formula is used for the computations of these mentioned spatial lags, to construct the correlogram.

$$I^{(k)} = (n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}{}^{(k)}(y_i - y)(y_j - y)) / ((\sum_{i=1}^{n}(y_i - y)^2)(\sum\sum_{i \neq j} w_{ij}{}^{(k)})) \qquad 3.12$$

Next the above formula is computed for the lag of 1. In this lag all the neighborhoods are in concern. However, in the lag 2, the neighborhoods are combined as; 'Bahçelievler-Orta', 'Bati-Yeni', 'Çamçesme-Esenyali', 'Çinardere-Velibaba', 'Dogu-Dumlupinar', 'Fevzi Çakmak-Kaynarca', 'Güzelyali-Kavakpinar', 'Harmandere-Kurtköy', 'Seyhli-Yayalar', and the calculations are done according to these groups (Figure 3.17).

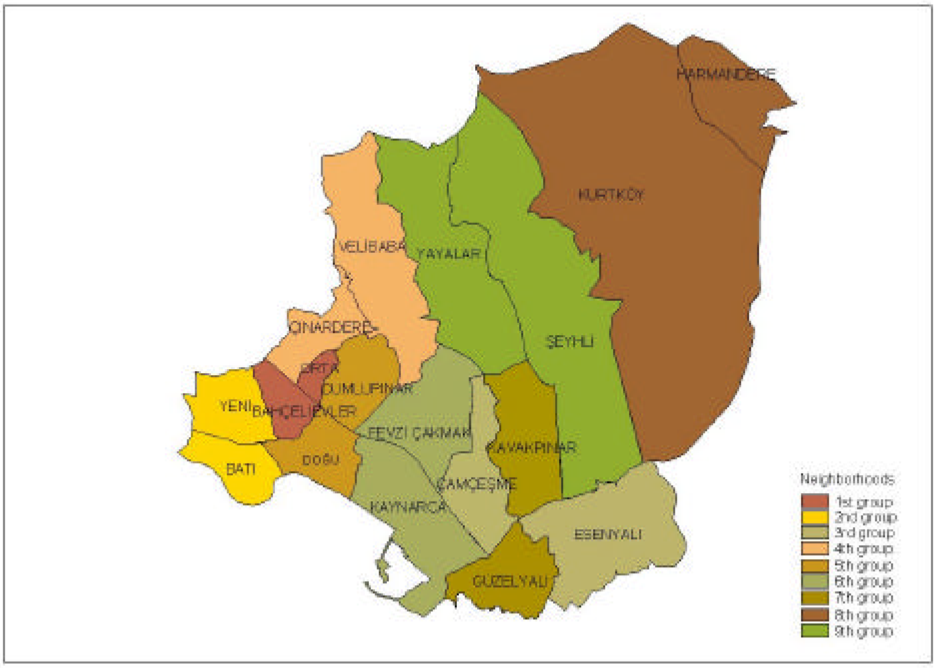

Figure 3.17 Neighborhoods for Spatial Correlations Lag 2

Besides that, in the lag 3, the neighborhoods are grouped and computed as; 'Bahçelievler- Bati-Yeni', 'Çamçesme- Fevzi Çakmak- Kavakpinar', 'Çinardere-Velibaba- Yayalar', 'Dogu-Dumlupinar- Orta', 'Esenyali- Güzelyali- Kaynarca', and 'Harmandere-Kurtköy-Seyhli' (Figure 3.18).

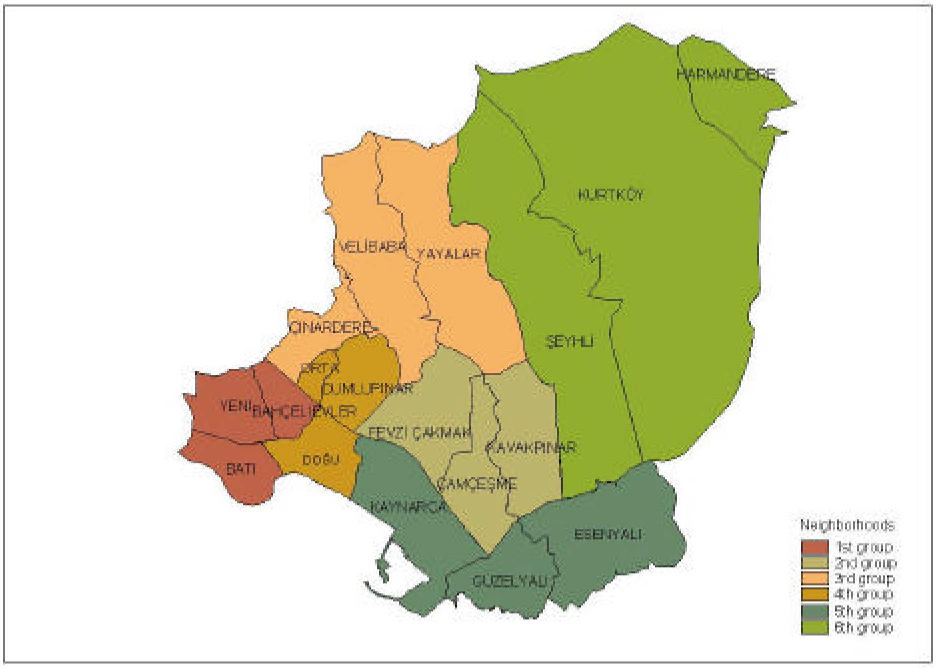

Figure 3.18 Neighborhoods for Spatial Correlations Lag 3

The results of these spatial lags are presented in Table 3.41.

Table 3.41 Moran's I Results for The Spatial Lags

Moran's I - Lag 1	1,00
Moran's I - Lag 2	0,744
Moran's I - Lag 3	0,971

Therefore, the below correlogram is formed, and presented in Figure 3.19.

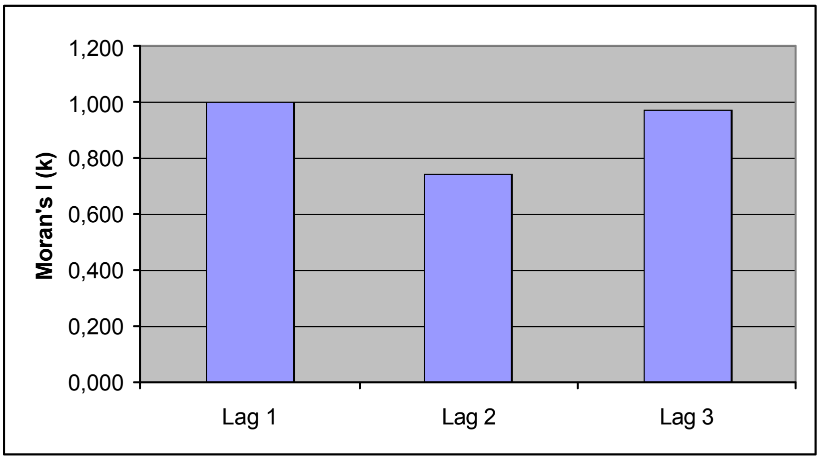

Figure 3.19 Correlogram for Social Vulnerability Levels in Pendik

Although, the discussions on these results are given in next part of the chapter, the above correlogram indicates that, similar neighborhoods in terms of their Social Vulnerability Levels are located near. The increasing positive correlations at lags (close to the value of “1”) are indicators of heterogeneity in the data and evidence of regional trend.

3.2.7. Discussions of the Results

In this part of the chapter, the case study results of the Social Vulnerability Assessment, Spatial Data Analyses, and 10 Evaluations are discussed.

The Statistical Computations are the main part of the Methodology. The steps of the computation are explained in Section 3.2.3 and Section 3.2.4, and the result gathered from case study applications is presented in Figure 3.7. According to the result, it is clearly seen that the southeast part of the district is more socially vulnerable for any possible hazard. Especially, ‘Esenyali’ and ‘Çamçesme’ neighborhoods are the most vulnerable in the district. In addition to that, the central part (also the old settlement) of the district, namely ‘Kaynarca’, ‘Dogu’, ‘Bati’, ‘Yeni’, and ‘Fevzi Çakmak’ neighborhoods, are highly vulnerable, which means that, in these neighborhoods, the total number of people for variables, rated as high vulnerable, is more than the other neighborhoods. In fact, it can be said that, these highly vulnerable neighborhoods have more people who have the characteristics of not having a job, in low educational level and have big sized families.

Nevertheless, the north part of the district shows the least and less vulnerability. In fact, ‘Harmandere’, ‘Kurtköy’, ‘Yayalar’, and ‘Velibaba’ neighborhoods are appeared to be the less vulnerable part of Pendik. In addition to that, the ‘Güzelyali’ neighborhood surprisingly appears as the least vulnerable, contrarily its surrounded neighborhoods in highly and the most vulnerable. The results indicate that, these neighborhoods have fewer people in the categories of determining high vulnerability. In fact, these neighborhoods can be determined as more well-being neighborhoods, since they have more people who are working, in good educational level, have small sized family, and have at least one dwelling.

Besides these results, the subjectivity on the appointing the ratings for sub variables’ and variables’ weights are mentioned from the beginning of Chapter 3. The importance of this point is very crucial for the Social Vulnerability Assessments. Because, the determination of social indicators for the vulnerability analysis is already very hard, in fact, the assessment of social vulnerability is much more crucial by applying comparable methods. In these sensible conditions, the subjectivity on the assessment could not be acceptable. In this respect, for this methodology, 10 more persons’ evaluations (Section 3.2.5), on the sub variables’ and variables’ weights are integrated into the methodology and applied to the study area. After collection of these evaluations by standard matrices (Appendix 1 and Appendix 2), the average of these ratings are used in the computations of social vulnerability assessment, and the result is presented in Figure 3.8. It is seen that, there is no difference appeared than the original result. In fact, most of the neighborhoods have the same level of social vulnerability comparing with the previous calculation.

There is only one, ‘Yeni’ neighborhood’s social vulnerability level is turned from highly vulnerable to most vulnerable. The reason for this transformation can be explained by the differentiated weights of the variables. According to the 10 persons’ evaluations, the weights of the variables of ‘Employment Status’, and ‘Reasons for not Working’ are very different than the original ratings. In fact, ‘Employment Status’ variable’s rating is turned from ‘0,110’ to ‘0,335’, and ‘Reasons for not Working’ variable’s rating is changed from ‘0,385’ to ‘0,189’. It means that, in the 10 persons’ evaluations the importance of people’s employment status is increased. However, the importance of the effect of people who have not a job is decreased. More clearly, in the 10 persons’ evaluations, persons who have a job are resulted as a causing factor for social vulnerability than persons who have not a job.

Except the neighborhood of ‘Yeni’, this result indicates that, the 10 persons’ evaluations are in the same range comparing with the original evaluation. However, since there are 10 different evaluations in consideration and quite different opinions are in existence, the need of the determination of ratings’ dispersion is appeared. In this respect, some statistical measures are examined. Applying these statistical operations (Section 3.2.5), and performing the same computations of social vulnerability assessment, the result of Figure 3.9 is obtained. According to this result, it can be seen that, these 10 different ratings and the dispersion of the data are almost in the same range. Therefore, it indicates that, 10 persons’ evaluations are appropriate for integrating them into the study. In fact, by doing so the previously mentioned subjectivity of the assessment can be eradicated.

Although, the above results show the social vulnerability levels in Pendik neighborhoods, in order to understand properly the causing factors of them and to comment on them, there is a strong need to see the psychical effects and relationships between neighborhoods. Because, statistical computations cannot be enough to determine the social vulnerability on its own. Since our concern is determining the social part of the vulnerability, the people’s social relations are very critical. In fact, as these social relations come true in spatially, the interaction zones of neighborhoods are the key basis for expressing the social relations between them. In this respect, there are several explorative spatial data analyses become a part of the methodology and applied to the study area.

In the first step, the *spatial proximity matrices* are formed for the 3 criteria of ’10 nearest neighborhoods from the considered neighborhood’, ‘Neighborhoods within 3 km distance of the considered neighborhood’, and ‘Neighborhoods sharing a common boundary’ (Section 3.2.6.1).

According to these matrices, the second method of *spatial moving averages method* is applied (Section 3.2.6.2). This method is very helpful to see the smoother picture of spatial variations than a map of raw data. It is also useful to understand the regional trends of Pendik neighborhoods. After the necessary computations, the results are gathered, and it is seen that, the three criteria give different results, however generally the southeast part of the district is appeared as most vulnerable. In the first criterion of ‘10 Nearest Neighborhoods’, especially the southeast part’s neighborhoods, namely ‘Çamçesme’, ‘Kavakpinar’, ‘Seyhli’, ‘Esenyali’, and ‘Güzelyali’ neighborhoods are resulted as most vulnerable. In this result, the effects of ‘Esenyali’ and ‘Çamçesme’ neighborhoods’ social vulnerability levels are quite clear (Figure 3.10). In fact, since the neighborhoods’ social vulnerability levels are used in the computation of the analysis, these two neighborhoods’ high vulnerability levels are affected the other ones strongly. However, the north and the west parts of the district’s neighborhoods are affected from each others in a good way, and grouped as generally least and less vulnerable. Especially, the neighborhoods of ‘Velibaba’ and ‘Yayalar’ are strongly affected by ‘Orta’ neighborhood.

The second criterion of spatial moving averages method, the ‘Neighborhoods within 3 km Distance’ criterion, is more logical. In fact, since the neighborhoods are affected to each other within a specific distance, this result is more reasonable for showing the relationships between neighborhoods. In this criterion, again the southeast part neighborhoods are most vulnerable (Figure 3.11). For the previously mentioned reason, the effects of ‘Esenyali’ and ‘Çamçesme’ neighborhoods are very strong. Especially, for the ‘Güzelyali’ neighborhood, the effects of its surrounded 5 neighborhoods shifted this neighborhood’s vulnerability from ‘least’ to ‘most’. In addition to that, the ‘Orta’ neighborhood’s surrounded neighborhoods’ moderately and high vulnerability values are seen very effective. The ‘Kurtköy’ neighborhood’s condition is also interesting. Since the neighborhood’s center is just in relation with ‘Harmandere’ neighborhood, its social vulnerability level is changed from less to least.

In the third criterion, the ‘Neighborhoods Sharing a Common Boundary’, of Spatial Moving Averages Method, the southeast part again is seen as most and highly vulnerable, but this time more diffused than the others (Figure 3.12). It can be easily seen that, the neighborhoods, which share at least one common boundary, are affected to each other very strongly. However, since the neighborhoods’ boundaries are in different sizes and most of them are quite broad, the analysis result cannot be considered as logical. In fact, for example ‘Seyhli’ and ‘Fevzi Çakmak’ neighborhoods’ influencing areas are different, since ‘Seyhli’ neighborhood shares its boundaries with 4 neighborhoods in very wide sizes, but ‘Fevzi Çakmak’ neighborhood shares its boundaries with 6 neighborhoods in less sizes. Therefore, it can be said that, this criterion result is not appropriate for the analysis.

From all these 3 criteria results, it is clear that, the criterion of 'Neighborhoods within 3 km Distance' gives more realistic and appropriate outputs for the further analyses. In other words, this criterion is more logical than the others, since these two criteria are based on general grouping approaches. In fact, with these two criteria, the relationships between the neighborhoods and the regional trends cannot be expressed properly.

The second method of explorative spatial data analyses is *median polish method*. This method is also useful for understanding regional trends as spatial moving averages method. As explained and applied to the study area in Section 3.2.6.3, this method is applied with two different grid sizes. After the necessary computations, these two applications give different results. In the 10x10 matrix application, the original matrix is smoothed very much. Especially, the middle and the lower parts of the matrix values are changed distinctly (Table 3.38). In fact, for these parts the levels of most and highly vulnerability is turned to less and least vulnerability. The same outputs also appeared for 5x5 matrix application (Table 3.40). In fact, besides the generalization of the original matrix, the cells of most or highly vulnerable no more exist. From all these outputs, it is clear that, this Median Polish Method gives very generalized pictures for the original Pendik neighborhoods' social vulnerability levels data, since it is resistant to the outliers of the data and irregular shapes of the neighborhoods. Although, this method cannot give any contribution to the methodology and its results are ignored for the case study, it may work in more regular-shaped area-based studies.

The third method of the explorative spatial data analyses is the *kernel estimation method*, which is helpful to get a visual indication of the variation in the intensity of the considered data. In the study, this method is applied for six different kernel and bandwidth values (Section 3.2.6.4) by using GIS software capabilities, and from these six alternatives, the two applications (with τ=1500;k=30 and τ=1500;k=60) are resulted with the most meaningful and usable outputs (Figure 3.15 and 3.16). These applications give similar results for the considered values, as these two figures show, there is a global intensity trend for the neighborhoods of 'Orta', 'Dumlupinar', 'Çinardere', and 'Bahçelievler'. Addition to that 'Yeni', 'Bati', and 'Dogu' neighborhoods, 'Çamçesme', 'Kavakpinar', 'Fevzi Çakmak', and 'Kaynarca' neighborhoods, 'Güzelyali' and 'Esenyali' neighborhoods, 'Velibaba', 'Yayalar', 'Seyhli' neighborhoods, and 'Kurtköy', 'Harmandere' neighborhoods are following these ones. From all these Kernel Estimation Method's outputs, it can easily be stated that, this method is very explanatory in the determination of the neighborhoods' intensity trend areas, in terms of their central points.

The last method from explorative spatial data analyses is *spatial correlation,* which is different from the other mentioned ones, due to its features of exploring the spatial dependence of deviations in attribute values from their mean, and containing the correlation between values of the same variable at different spatial locations. The two measures of 'Moran's I' and 'Geary's C' (Section 3.2.6.5), are resulted with the values of '1 and 0,72', which indicate a strong relationship among Pendik neighborhoods. The result of the correlogram, built by 'Moran's I' measure and 'Neighborhoods within 3 km Distance' proximity matrix, at 3 different spatial lags is helped to estimate spatial correlation at these lags. In fact, the correlogram (Figure 3.19) indicates that, similar neighborhoods, in terms of their Social Vulnerability Levels, are located in the near areas. In addition to that, the increasing positive correlations at these 3 lags (close to the value of '1') are indicatives of heterogeneity in the data and the evidence of regional trend. Therefore, this analysis gives very helpful outputs on the determination of the regional trend, namely the trend of neighborhoods having similar social vulnerability levels locate close to each other.

All these mentioned explorative spatial data analyses approved that; the social vulnerability levels of neighborhoods cannot be just described with the statistical calculations. In fact, they are very helpful to understand the global trends and spatial interactions of the study data.

Besides the calculation of social vulnerability and explorative spatial data analyses in Pendik, there are two more important points, which need to be considered for the case study. The first one is the determination of the physical effects of some basic service locations and transportation opportunities. For this purpose, some GIS Analyses are applied in the study area and explained in the next Chapter. The second point is the expressiveness level of 1990 Census Sample Data' income-level-based variables for the Pendik neighborhoods. In order to identify this issue, a different approach is examined for the study data, and presented in Chapter 4.

CHAPTER 4

SUPPLEMENTARY ANALYSES OF SOCIAL VULNERABILITY IN GIS FOR PENDIK, ISTANBUL

In this chapter, the Geographic Information Systems Analyses are performed to find out the relation between Social Vulnerability and physical effects of basic services. Moreover, a different approach on defining the Variables of Social Vulnerability Assessment is examined.

4.1. GIS Analyses' Results

As mentioned in the previous chapter, the GIS Analyses are valid, besides Spatial Data Analyses, for the explanation of causing reasons of social vulnerability levels in Pendik. They are also helpful for determining social interaction zones between the neighborhoods. Especially, some basic service locations, such as education and health centers', and transportation opportunities or limitations are very important to identify these zones, since they are the key factors which serves the inhabitants' daily necessities.

In this respect, some GIS Analyses are applied to the study area, to identify these psychical factors. In these GIS applications, the presentations of the results are very important. In fact, in the visualization of these maps, from the general cartographic and psychological rules stated by MacEachren (1995); the effect of color, pattern, scale, and darkness discriminations, especially categorizations are used for the best representation and perception.

The first analysis is for the representation of Pendik neighborhoods' 1990 populations. The below Figure 4.1 shows the distribution.

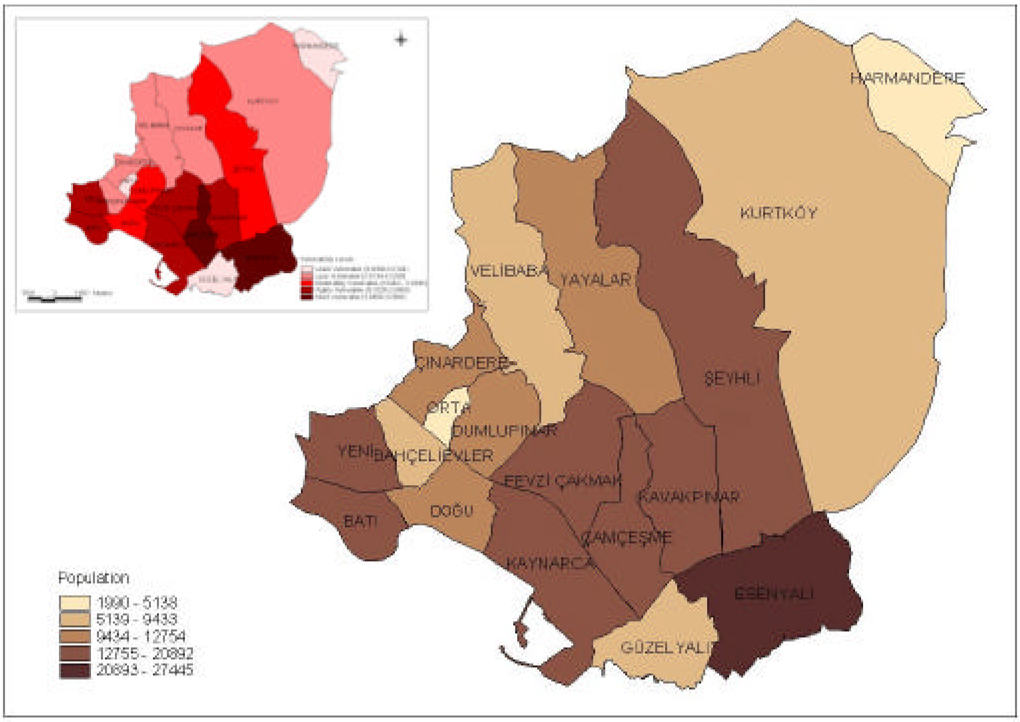

Figure 4.1 1990 Population Distribution by Pendik Neighborhoods

It is seen from Figure 4.1 that, 'Esenyali' neighborhood is the most crowded neighborhood, with the population of 27.445 people. This is followed by 'Çamçesme' neighborhood with 20.892 people. The neighborhoods of 'Yeni', 'Kavakpinar', and 'Kaynarca' are successor of these two neighborhoods. However, 'Harmandere' neighborhood is seen as the least crowded neighborhood with the population of 1.990 people. 'Orta' and 'Güzelyali' neighborhoods are followed this neighborhood with the populations of 5.138 and 7.370. From the results of this analysis, it can be stated that, the neighborhoods' populations are very important factors on defining the social vulnerability levels of them. In fact, as it is seen from the social vulnerability map in the north part of Figure 4.1, this population distribution shows that, the most vulnerable neighborhoods are the ones, which have the most inhabitants. Contrarily, the least vulnerable neighborhoods are the ones, which are the least crowded neighborhoods.

In the second analysis, building densities are examined by neighborhoods. For this purpose, first of all, the distribution of buildings is presented in Figure 4.2.

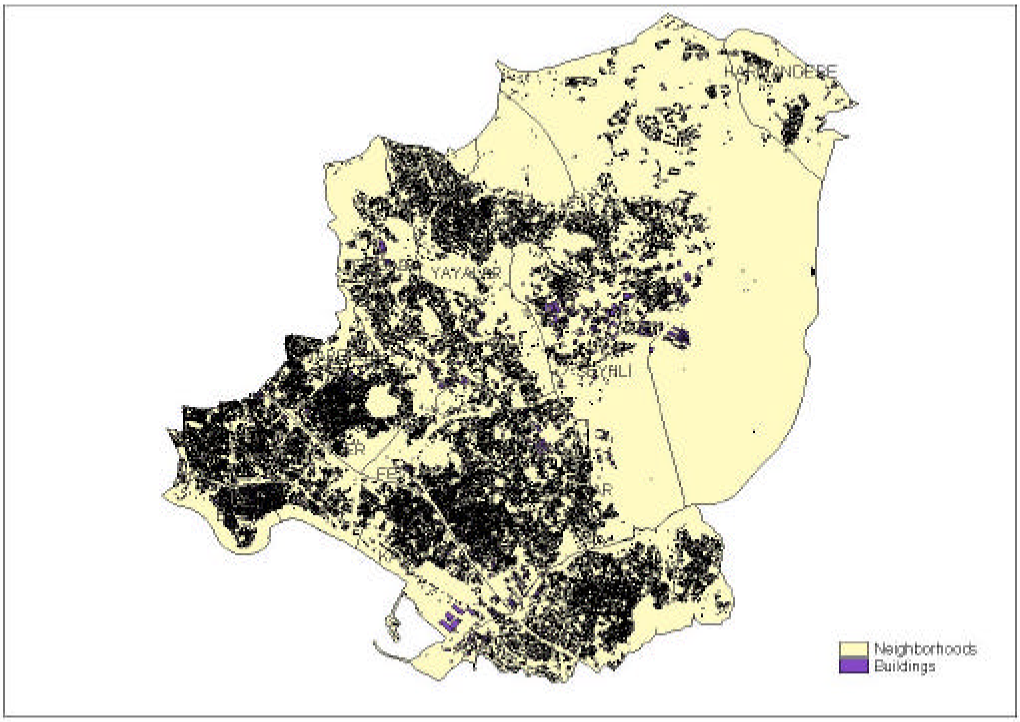

Figure 4.2 Buildings at Pendik Neighborhoods

In the next step, the total number of buildings, from this distribution and State Institute of Statistics' "Year 2000 Building Census" data, is calculated for each neighborhood and the result is presented in Figure 4.3.

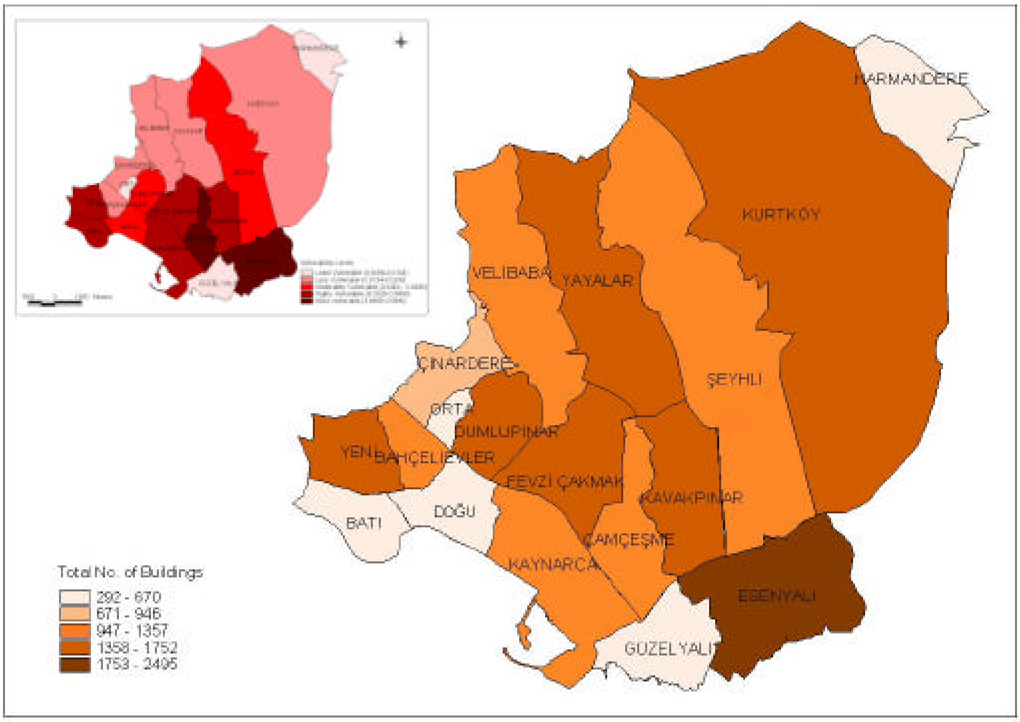

Figure 4.3 Number of Buildings in Pendik Neighborhoods

As seen from Figure 4.3, more buildings exist in 'Esenyali' neighborhood with the total of 2.495. The neighborhoods of 'Yayalar' and 'Yeni' with the number of 1.752 and 1.705 buildings follow this neighborhood. Nevertheless, 'Harmandere' neighborhood is seen as having the least total number of buildings, which is 292. In addition to that, neighborhoods of 'Orta' and 'Dogu' are appeared also the ones with fewer buildings of 578 and 593. This analysis's results are indicated similar outputs with the previous analysis. In fact, the neighborhoods of 'Esenyali' and 'Harmandere' are given parallel results. However, the order changes for the other neighborhoods. In fact, it can still be indicated that, as seen from the social vulnerability map in the north part of Figure 4.3, there is a positive relationship among the neighborhood's population, the existent buildings in that neighborhood, and the neighborhood's social vulnerability levels.

The third analysis is covered the examination of building usage types. In fact, the basic factors and services, which form social relationships of inhabitants by their necessities, are especially examined. First, commercial and industrial building usages are determined and presented in Figure 4.4.

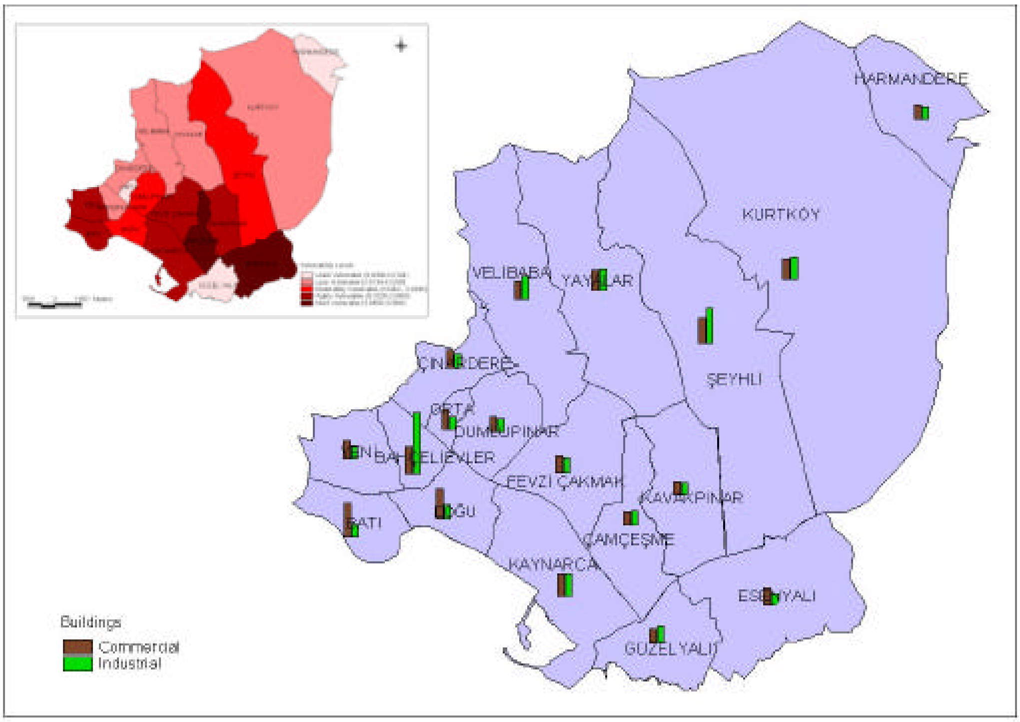

Figure 4.4 Number of Commercial and Industrial Buildings in Pendik Neighborhoods

Figure 4.4 indicates that, the distributions of the commercial and industrial buildings differ by neighborhoods. In fact, for the commercial facilities, the neighborhoods of 'Bati', 'Dogu', 'Bahçelievler', 'Kaynarca' and 'Seyhli' have more buildings. It means that, the first three neighborhoods form the commercial center of the district. Also, 'Seyhli' and 'Kaynarca' neighborhoods serve for the other surrounding neighborhoods. In terms of industrial usage of the buildings, the neighborhoods' distributions show variation. In fact, although 'Bahçelievler' neighborhood has 170 buildings, the neighborhoods of 'Seyhli', 'Kurtköy', and 'Kavakpinar ' have the numbers of 81, 36, and 1 industrial building respectively. Therefore, generally the neighborhoods of ‘Bahçelievler’ and ‘Seyhli’ are the centers for Pendik inhabitants’ commercial and industrial requirements. Addition to that, ‘Bati’ and ‘Dogu’ neighborhoods, as the old settlement areas, are seen important, which the people of Pendik prefer for shopping.

Another building usage analysis is applied for education centers, and the result is presented in Figure 4.5.

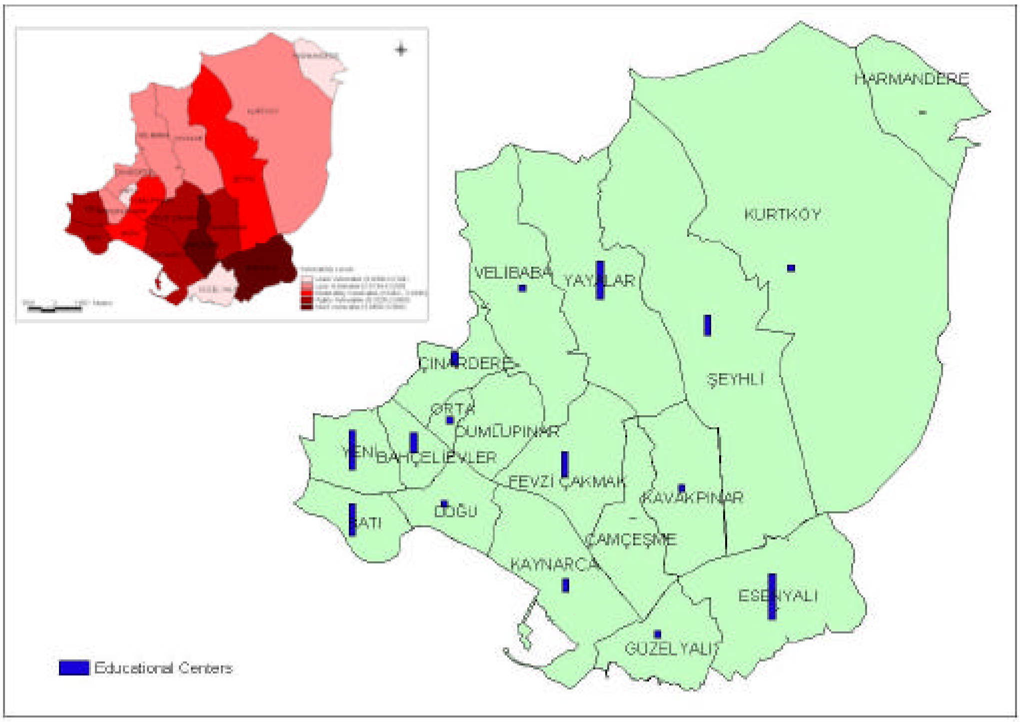

Figure 4.5 Number of Educational Centers in Pendik Neighborhoods

As seen in Figure 4.5, most of the education centers become dense in the west and south part of the district. In fact, ‘Esenyali’ neighborhood has 7 schools and the neighborhoods of ‘Yayalar’ and ‘Yeni’ have 6 schools. However, ‘Dumlupinar’, ‘Çamçesme’, and ‘Harmandere’ neighborhoods do not have any schools in their neighborhood boundaries. This result is very interesting, because an opposite relationship is seen between the neighborhood's social vulnerability level and the number of schools in that neighborhood. For example, as seen from the social vulnerability map in the north part of Figure 4.5, for 'Esenyali' neighborhood, while the social vulnerability level is seen most vulnerable, the number of schools in the neighborhood shows the best condition in the district. However, this judgment is just for the persons who are in the school age. Thus, this contrarily seen condition can be resulted by the people who are in the age of 18 and more. At this point, the 2000 census data should also be examined in the future studies, to see the difference in the generation of students at 1990.

The other analysis in building usage is done for the health centers in Pendik, and shown in Figure 4.6.

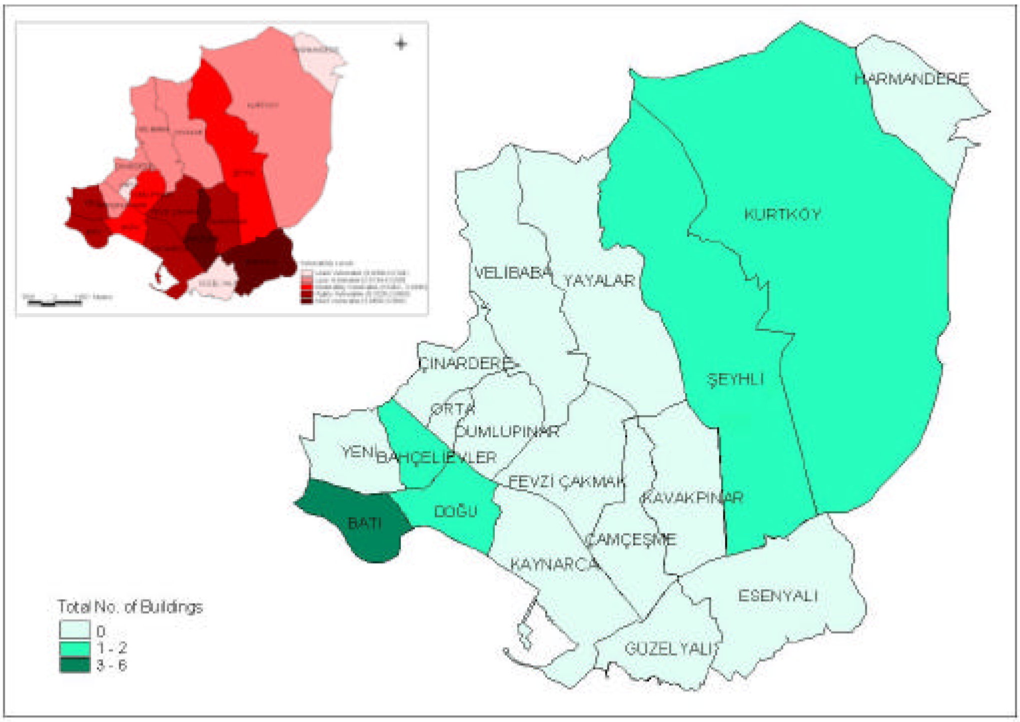

Figure 4.6 Number of Health Centers in Pendik Neighborhoods

Figure 4.6 shows an interesting result that, except the 5 neighborhoods

(Bati, Bahçelievler, Dogu, Seyhli, and Kurtköy), other parts of the district do not have any health center possibility. In fact, just the neighborhood of 'Bati' seems to have the best conditions with 6 health centers. Other than this, the neighborhoods of 'Bahçelievler' and 'Dogu' have 2 health centers, and 'Kurtköy' and 'Seyhli' neighborhoods have one each. This result is very crucial. Because, although the direct influence is not seen on the calculation of social vulnerability levels of neighborhoods, as seen from the social vulnerability map in the north part of Figure 4.6, inhabitants' health center possibilities do really effect their vulnerabilities to any possible hazard. In addition to that, it is also important for the post disaster interventions. Therefore, it can be stated that, other than the 5 neighborhoods, most parts of the district show vulnerability at this point.

The last analysis in the building usage is the examination of cultural and sport centers. The result of it is presented in Figure 4.7.

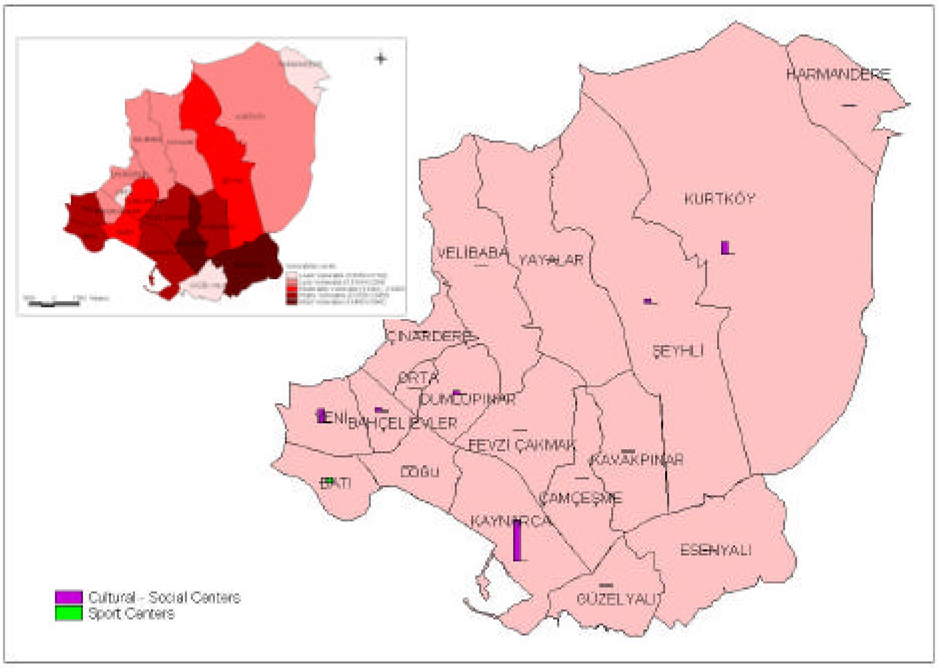

Figure 4.7 Number of Cultural-Social and Sport Centers in Pendik Neighborhoods

Figure 4.7 clearly shows that, 'Kaynarca' neighborhood is appeared to be the best in the district with the number of 10 cultural-social centers. Besides that, the neighborhoods of 'Yeni' and 'Kurtköy' follow this neighborhood with 3 centers. However, in the district level the number of cultural-social centers is very low, with just 19 centers in 6 neighborhoods. When the sport centers are in consideration, there is only one building, which is in 'Bati' neighborhood. From these results, it can be indicated that, these cultural-social and sport possibilities are very low for Pendik. In fact, when the inhabitants' social interactions are very effective to decrease the vulnerability level in any hazard, the places, where the inhabitants come together in, are very important.

The third type of GIS Analysis consists of the examination of interactions zones of transportation possibilities. For this purpose, first the transportation lines are presented in Figure 4.8.

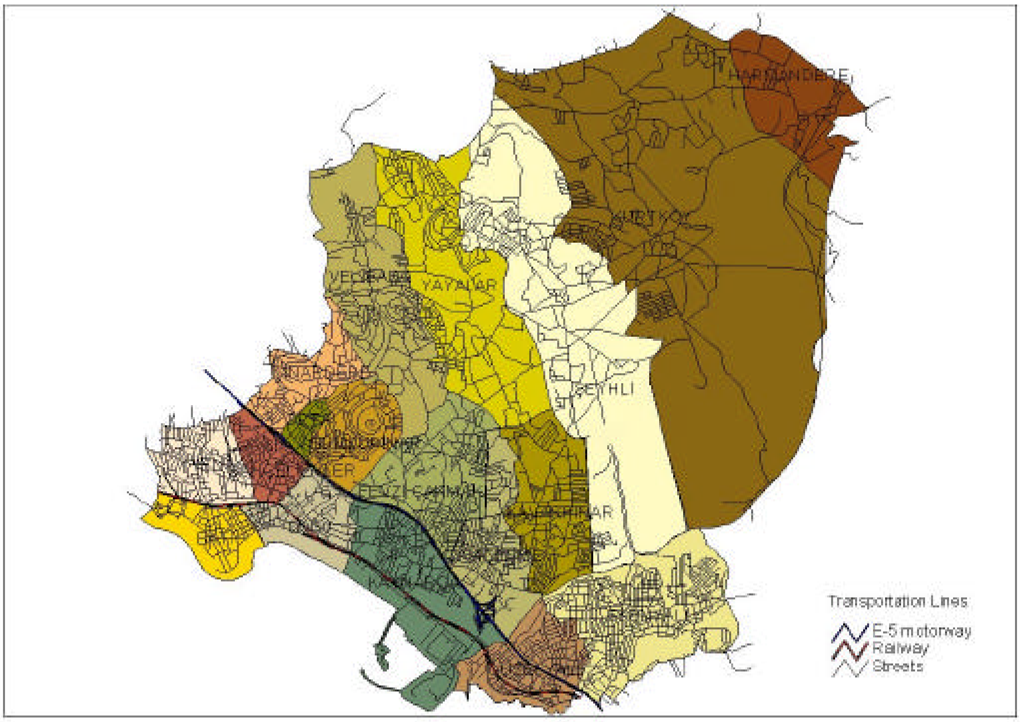

Figure 4.8 Transportation Lines at Pendik

As seen from Figure 4.8, the transportation opportunities are very high in Pendik (Section 3.1.3). Besides the motorways, there are railway, airport, and sea opportunities in the district. Especially, the two major transportation lines, E-5 motorway and railway that connect Anatolia to Istanbul, are passing through the district. Besides the opportunities of these lines for the inhabitants of Pendik, there are also restricting points which need to be focused. In fact, these main lines are effective factors to divide the areas physically. In order to understand this effect in Pendik the map in Figure 4.9, with Social Vulnerability levels of Neighborhoods and the main transportation lines, is formed.

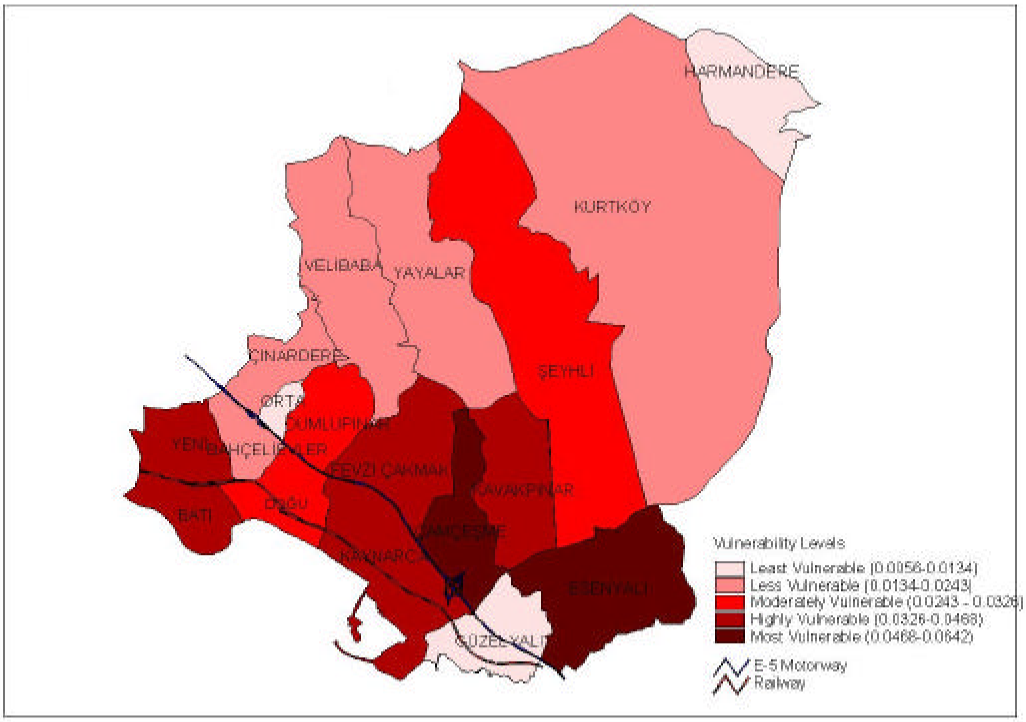

Figure 4.9 Social Vulnerability Levels of Pendik Neighborhoods at 1990 with Main Transportation Lines

The social differences of Pendik neighborhoods, in terms of inhabitants' economical status, are mentioned in Erder's (1996, 1997) Pendik study. In fact, she states that, this social change appears distinctly in the above and the below parts of the E-5 motorway. However, in our study this change is not seen properly with the levels of social vulnerability. This indicated that the concept of social vulnerability to natural hazard is different from the economical status of the population. In fact, in the social vulnerability assessment methodology, not just the economical structure of the inhabitants, but also their educational levels, family sizes, ownership status, age, and sex factors are taken into account.

In order to understand the influence areas of these two major transportations lines in the neighborhoods, one more analysis is also applied, and presented in Figure 4.10.

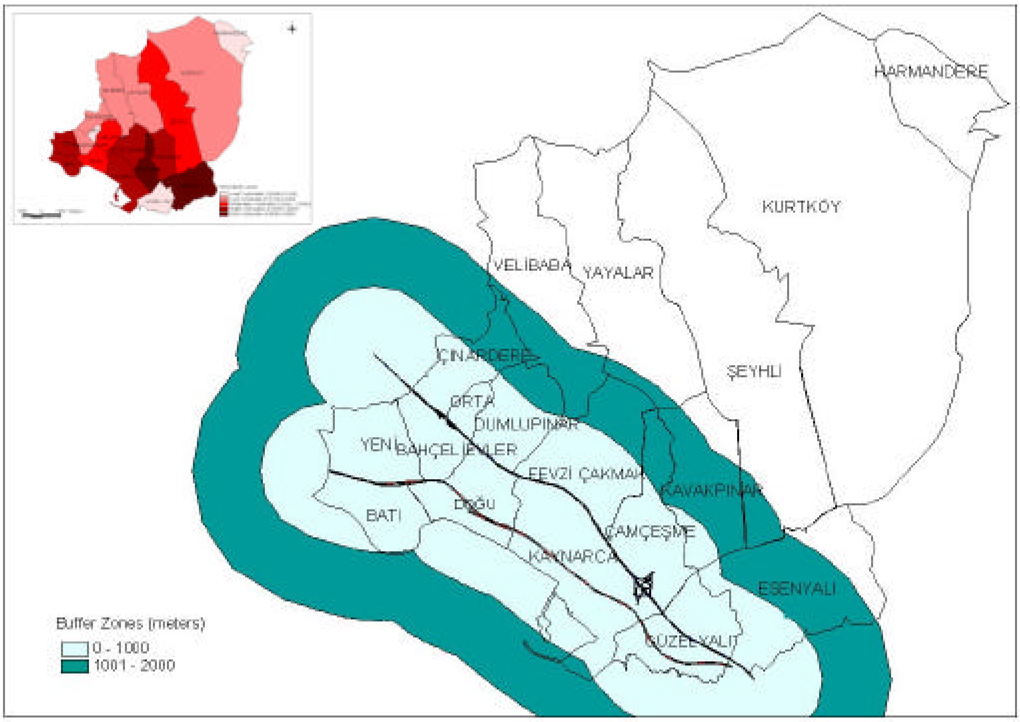

Figure 4.10 The Buffer Analysis for Railway and E-5 Motorway

In this analysis, the buffer method with the zones of ‘0-1km’ and ‘1-2km’ is applied to the railway line and E-5 motorway. As seen from Figure 4.10, the neighborhoods of ‘Orta’, ‘Çinardere’, ‘Bahçelievler’, ‘Dumlupinar’, ‘Dogu’, ‘Yeni’, ‘Bati’, ‘Fevzi Çakmak’, ‘Kaynarca’, ‘Çamçesme’, and ‘Güzelyali’ are in the first-degree interaction zone of railway and E-5 motorway. Therefore, the inhabitants of these neighborhoods have an easy-access opportunity to be in relation with people from other districts if any hazard occurred. However, the two neighborhoods of ‘Kurtköy’ and ‘Harmandere’ are totally far from these lines. Therefore, their connections with people out of the district are limited. In another perspective, the neighborhoods which are in between these lines, ‘Yeni’, ‘Bahçelievler’, and some parts of ‘Dogu’, ‘Kaynarca’, ‘Güzelyali neighborhoods, can be determined as they are closely pressed by the lines and do not have an easy access to be in relation with their surrounding neighborhoods. Nevertheless, this effect is not seen with the levels of social vulnerabilities of neighborhoods, from the social vulnerability map in the north part of Figure 4.10. The reason again can be explained with the unifying characteristics of the methodology. Since our concern in social vulnerability assessment is to determine the social vulnerability with 8 different variables, the effect of these transportation lines is not appeared clearly. However, if the economical status of neighborhoods is the consideration to examine, then this discrimination can easily be seen.

The above-mentioned GIS Analyses’ results show again the important contribution of spatial analysis in the determination of Pendik neighborhoods’ social vulnerability levels. In fact, the first analysis of 1990 populations described that, the most vulnerable neighborhoods are the ones, which have the most inhabitants, and vice versa. The second analysis of building density indicated that, there is a positive relationship among the neighborhood’s population, the existent buildings in that neighborhood, and its social vulnerability level.

The next four analyses are based on the identification of building usages and their effects on the neighborhoods. In fact, the first usage analysis determines the commercial and industrial centers in the district. The second building usage analysis on educational centers show that, there is an opposite relationship between the neighborhood's social vulnerability level and the number of schools in that neighborhood. However, this result is ignored because the previously mentioned factors are not appropriate for the comparison. The third building usage analysis resulted with a critical output that, the total number of health centers in the district are very limited. Although the direct influence is not seen on the calculation of social vulnerability levels of neighborhoods, inhabitants' health center possibilities do really affect their vulnerabilities to any possible hazard. In the last building usage analysis, the cultural-social and sport possibilities indicated very low levels in Pendik. In fact, it is appears as a crucial factor, since the inhabitants' social interactions decrease the vulnerability level if any hazard occurs.

The last three GIS Analyses were for understanding the effects of transportation lines. For this purpose the two main lines' examinations described the neighborhoods, which are benefited from and limited from, in terms of their social interactions with other neighborhoods. However, these analyses are not explained the relationship between the two transportation lines and neighborhoods' social vulnerability levels, due to the unifying characteristics of the methodology.

4.2. Different Approach's Results on Defining Study Data Variables

Up to this part, the social vulnerability assessment methodology is described with its basic steps, and the supportive analyses, especially spatial data and GIS analyses, are applied. Besides that, 10 more different evaluations are integrated to the study, to avoid subjective decisions on the assessment. However, there is still one important point, which needs to be taken into consideration. This is the expressiveness level of 1990 Census Sample Data for the Pendik neighborhoods. In fact, as mentioned by Güvenç and Isik (2002), the 1990 Census data is an important resource, which includes, for the first time in Turkey since 1935, the neighborhood level information. However, as they state, the census data does not constitute a solution on its own to the problem of deciphering social segregation. From this data, the detection of 'income-based social divisions' (Güvenç and Isik, 2002) is very hard, as the census does not include questions about income levels. Because of this reason, any examination on the income-based information becomes weak. As Güvenç and Isik (2002) state, to differentiate the high-income wage earners from the data on employment status cannot be possible, since company managers and low-income factory workers are both classified under the heading of 'wage earners' (employee). Besides this unclear feature of employment status variable, the importance of its category-inside differentiation is determined and explained by Güvenç (1998). He states that, this differentiation is at least as important as status differentiation, since there is a crucial variation in the variable.

For the above-mentioned reasons, an empirical construct, developed by Güvenç and Isik (2002), is applied to the study data. In fact, this construct, which is examined in 5 big cities of Turkey (including Istanbul) in neighborhoods level, is resulted as the decrease of indefiniteness of 'Employment Status' variable (Güvenç, 2001). This empirical construct contains a status-tenure index, which is 'well capable of measuring social differentiation along the lines of income' (Güvenç and Isik, 2002). In fact, the index is consisted of cross-tabulation of 'Employment Status' and 'Housing Tenure Types' (Güvenç and Isik, 1997; 2002; Güvenç, 1998; 2001). Moreover, the 'Housing Tenure Types' is also formed by the cross-tabulation of 'Owner of the Dwelling' and 'Own any Other Dwelling' variables. In this respect, Pendik neighborhoods' 1990 Census Sample data is reformed from the mentioned housing tenure variables, and applied to neighborhoods separately. The below cross-tabulated Table 4.1 presents the format of the mentioned process.

Table 4.1 Housing Tenure Types

Variables		Own any Other Dwelling	
		Yes	No
Owner of the Dwelling	Yes	Tenure type 1	Tenure type 2
	No	Tenure type 3	Tenure type 4

The above housing tenure types are explained by Güvenç and Isik (2002) as follows.

1. *Tenure type 1*: Households who own at least two dwelling units.

2. *Tenure type 2*: Households who own only the housing unit they occupy (i.e., owner-occupiers).

3. *Tenure type 3*: Tenant households who own at least one dwelling unit elsewhere (i.e., high-income tenants).

4. *Tenure type 4*: Tenant households who rent a dwelling (i.e., low-income tenants).

The main cross-tabulation of these housing tenure types by employment status variable is resulted as a new variable of *status-tenure* with a total of 16 categories. These sixteen categories are presented in Table 4.2, by employment status categories with letters and housing tenure type categories with numbers.

Table 4.2 Differentiation of Status-Tenure Variable

Variables		Housing Tenure Type			
		1	2	3	4
Employment Status	Employee	A1	A2	A3	A4
	Employer	B1	B2	B3	B4
	Self-employed	C1	C2	C3	C4
	Other	D1	D2	D3	D4

As seen from Table 4.2, the ‘Employment Status’ variable’s ‘Unpaid Family Worker’ and ‘Not Applicable’ sub variables are combined as ‘Other’. The reason of this combination is the feature of ‘Other’ variable’s general representation of people who do not work or earn money (which also contains the sub variables of ‘Reasons for not Working’ variable). Güvenç and Isik (2002) state the explanations of the above categories as; A1, high-income wage earners; A2, owner-occupier wage earners; A3, high-income tenant wage earners; A4, low-income tenant wage earners; B1, high-income employers; B2, owner-occupier employers; B3, high-income tenant employers; B4, low-income tenant employers; C1, high-income self-employed; C2, owner-occupier self-employed; C3, high-income tenant self-employed; C4, low-income tenant self-employed; D1, high-income *others*; D2, owner-occupier *others*; D3, high-income tenant *others*; D4, low-income tenant *others*.

In the next step of the method, the ‘Block Model’ application is formed with the help of ‘Dissimilar Indicator Matrix’, which measures differentiation levels of these 16 categories of status-tenure variable. The details of the mentioned model are out of the scope of this thesis, and will not be mentioned (for more information see Güvenç, 2001). However, it needs to be mentioned that, as a result of this model application, different statuses are clustered in 3 components, which are high-income groups, dominated by owner-occupier wage earner or other groups (can also be called middle-income groups), and dominated by low-income wage earner groups (can also be called low-income groups). This grouping is detected in the 5 big cities of Turkey (Gaziantep, Bursa, Izmir, Ankara, and Istanbul), as a general tendency for the representation of income levels (Güvenç, 2001). Table 4.3 presents this clustered structure of the status-tenure variable.

Table 4.3 Final Components of 'Status-Tenure' Variable

High-Income Groups	B1+B3
Middle-Income Groups	A1+A3+B2+B4+C1+C3+D1+D3
Low-Income Groups	A2+A4+C2+C4+D2+D4

In order to integrate this method into the study, and to remove the undescriptive condition of 'Employment Status' variable, the above-mentioned processes are applied to Pendik neighborhoods' 1990 Census Sample Data. After the necessary calculations, the distribution of new Status-Tenure Variable in terms of neighborhoods is gathered and presented in Table 4.4.

Table 4.4 Distribution of 'Status-Tenure' Variable by Pendik Neighborhoods

Neighborhoods / Status-Tenure	High-Income Groups	Middle-Income Groups	Low-Income Groups
Mahalle 1	0	13	173
Mahalle 2	3	125	405
3.Bahcelievler	1	41	317
4.Bati	10	215	490
Mahalle 5	0	31	118
6.Çamçesme	1	188	854
7.Çinardere	0	82	372
8.Dogu	0	133	406
9.Dumlupinar	0	107	543
10.Esenyali	1	120	1154
11.FevziÇakmak	1	104	690
12.Güzelyali	1	59	213
13.Harmandere	0	23	82
Mahalle 14	1	44	303
15.Kavakpinar	0	96	640
16.Kaynarca	0	145	648
17.Kurtköy	0	74	378
18.Orta	0	14	190
19.Seyhli	0	45	557
Mahalle 20	1	45	473
Mahalle 21	7	100	241
Mahalle 22	1	37	61
23.Velibaba	0	50	335
24.Yayalar	0	23	471
Mahalle 25	0	50	370
26.Yeni	3	159	748

Therefore, this 'Status-Tenure' variable forms more logical and expressive distribution of income levels in Pendik neighborhoods. In order to see the differences between the original distribution 'Employment Status' variable of 1990 Census Sample Data and new 'Status-Tenure', the maps in Figure 4.11 and Figure 4.12 are formed.

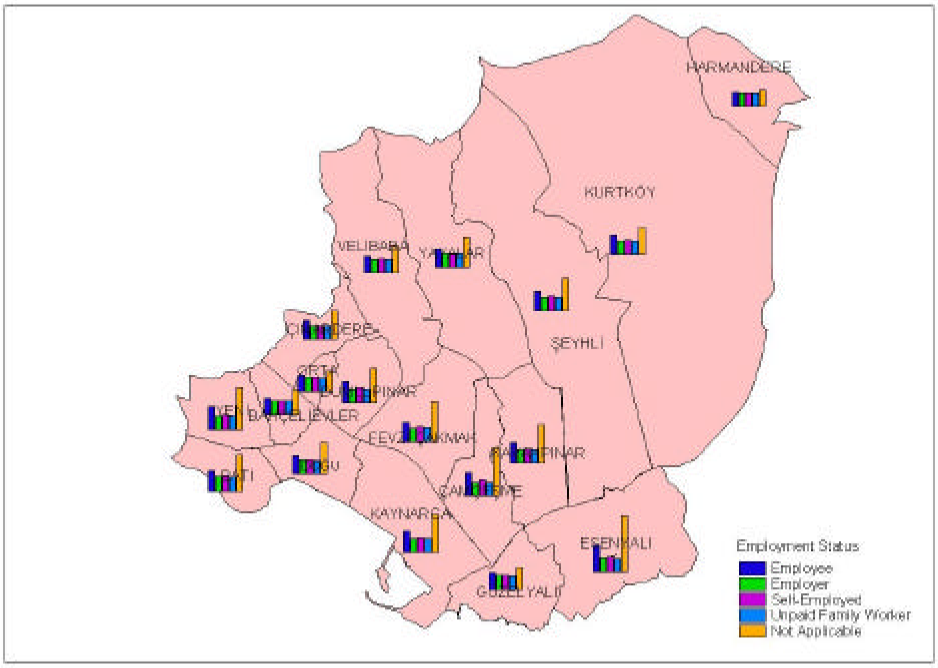

Figure 4.11 Distribution of Employment Status by Neighborhoods According to 1990 Census

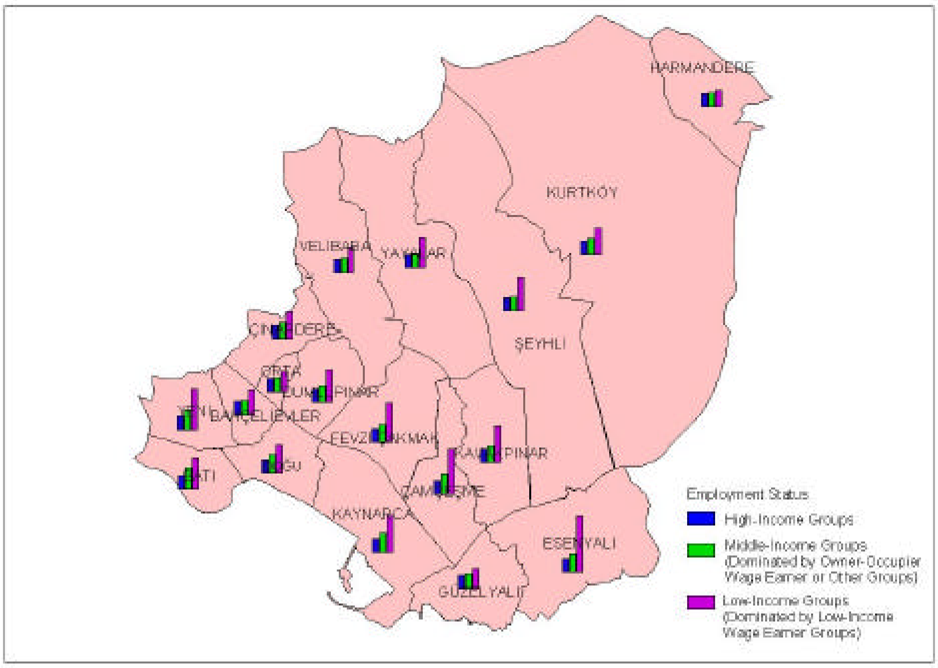

Figure 4.12 Distribution of Status-Tenure by Pendik Neighborhoods

As seen from the above maps, the distributions of ‘Employment Status’ categories are different in the original and in the new data. In fact, in the original distribution, the dominance of ‘Not Applicable’ sub variable is seen. This distinct level of difference is caused by the sub variable’s feature of containing the other sub variables of which imply the unemployment reasons (such as ‘Retired’, ‘Student’, ‘Housewife’, etc.). Besides that, the distribution of ‘Employee’ sub variable is seen increasing through the south neighborhoods. However, these sub variables’ category-inside differentiations are not clear to understand in this distribution. The above second map meets this need, and gives clearer picture of Pendik in terms of income levels. In fact, the dominance of the ‘Not Applicable’ or ‘Other’ group, which means the low-income group, can be seen more distinct with this 3 categorization. Moreover, ‘Middle-Income Groups’ distribution is decreasing through the north side of the district. However, the ‘High-Income Groups’ are hardly seen in the district. Therefore, from this new categorization, it can be easily stated that, the general income level in Pendik is low.

The main benefit, to the Social Vulnerability Assessment, of this method’s application is that the integration of these new expressive categories to the methodology. In this respect, the original ‘Employment Status’ distributions in neighborhoods are replaced with the newly reformed distributions. Since the sub variables are changed, the need of reevaluation of their Social Vulnerability Values is appeared. In fact, the decision of ‘0,1’ value for ‘High-Income Groups’, ‘0,3’ value for ‘Middle-Income Groups’, and ‘0,8’ value for ‘Low-Income Groups’ is made, and the variables’ weights are not changed. By using these distributions and sub variables’ social vulnerability values, the same computations (Section 3.2.3) are done and the results are presented in Figure 4.13.

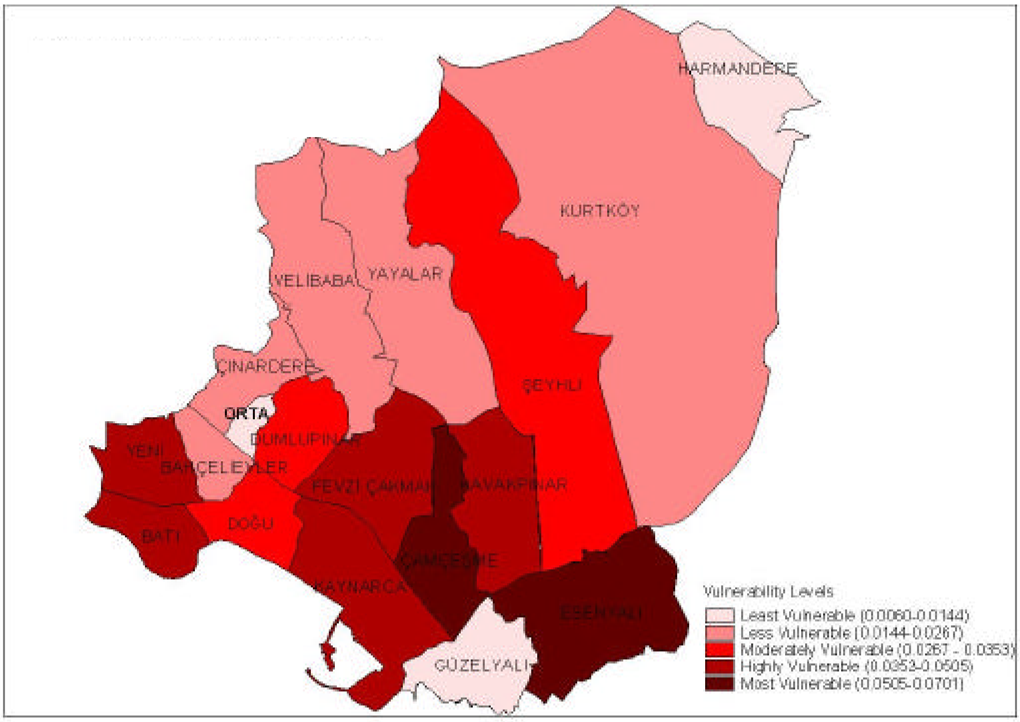

Figure 4.13 Social Vulnerability Levels of Pendik Neighborhoods by The Different Approach on Defining Study Data Variables

As seen from Figure 4.13, there is not any difference, when it is compared with the original result (Figure 3.7). In fact, the levels of social vulnerabilities in neighborhoods show the same outputs. This indicates that, there is no direct relation between economic status and social vulnerability. In fact, the concept of social vulnerability covers more indicators to natural hazard. However, still this method contributes very much for the integration of logical income-level-based variables in to the methodology.

The flowchart of the proposed methodology for social vulnerability assessment is given in Figure 4.14.

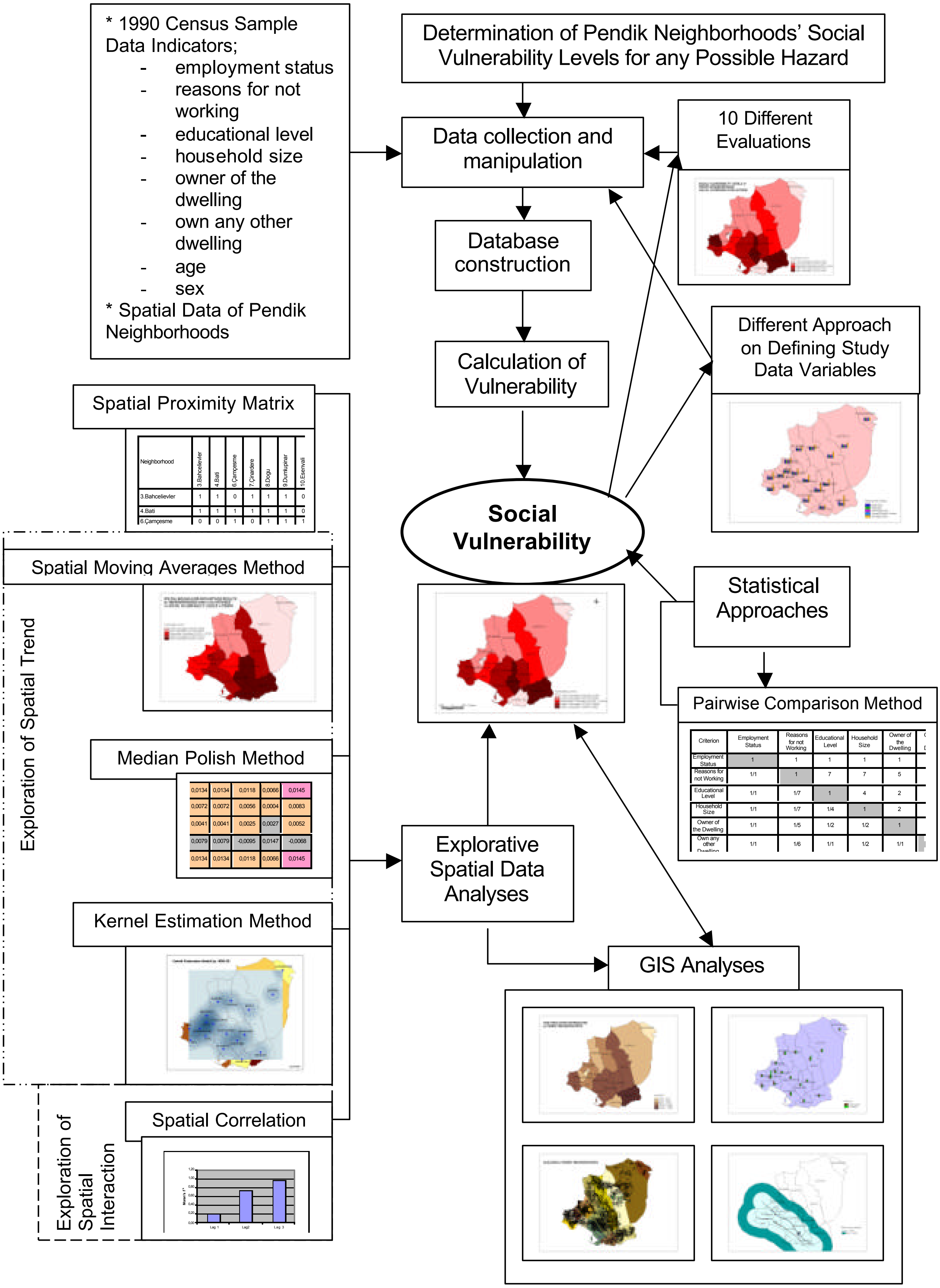

Figure 4.14 The Flowchart of the Methodology for Social Vulnerability Assessment

CHAPTER 5

CONCLUSION

Whatever the size or the type of the natural hazards is, being prepared for them does decrease their destructive effects in the communities. Especially, identification of susceptible people is very important for the pre- and post-disaster interventions. In this respect, the subject of this thesis is decided as establishing a methodology for identifying the vulnerable groups for any possible hazard, in terms of their social conditions.

In order to achieve the thesis's aims, GIS plays one of the crucial roles in designing the methodology. Therefore, the developed GIS-based Social Vulnerability Assessment brings easiness on the identification of social vulnerable groups from the complicated approaches. Moreover, the methodology gives a new contribution to the approach of analyzing the social indicators with comparable methods and spatial techniques.

In fact, the study is carried out in three phases. In the first phase, the concept of social vulnerability is explained from the various approaches. Secondly, the developed methodology's, on social vulnerability assessment, main steps are explained and examined in the study area. The discussions on the results of the methodology in Pendik case are also covered in this part. The last phase includes the supplementary analyses for the case study and their results' discussions.

In the calculation of social vulnerability; criterion standardization, weighting and combining are accomplished by means of multi criteria evaluation (MCE) methods. These MCE methods helped in the transformation of social indicators to comparable units, which is very crucial for such social studies. However, the observed applications that use these methods in the literature are generally applied with measurable indicators (such as, slope, land price, location, etc.). In fact, these evaluation methods may become imperfect for the evaluation of social vulnerability, due to the characteristic of coarse grading. In addition to that, to avoid the subjective decision on these methods in the methodology, 10 more different evaluations are integrated into the case study applications. This integration is very vital for this study, because, the determination of social indicators for the vulnerability analysis is already very hard, in fact, the assessment of social vulnerability by applying comparable methods is much more crucial. In these sensible conditions, the subjectivity on the assessment cannot be acceptable. For these purposes, in the future studies these evaluation methods should be reassessed and more sensitive evaluation approaches for social indicators should be developed.

All these social vulnerability level calculations and the integration of 10 different evaluations in Pendik resulted as; the southeast part of the district is very vulnerable for any possible hazard. In the next phase, the explorative spatial data analyses are applied and again showed that the southeast neighborhoods of the district are highly vulnerable and in strong relation to each other. Although, explorative spatial data analyses helped very much to understand the global trends, which neighborhoods having similar social vulnerability levels locate close to each other, and spatial interactions of the study data, the *median polish method* did not work for Pendik case study and cannot give any contribution to the methodology (which may work in more regular-shaped area-based studies). However, all of the analyses are necessary for the vulnerability studies, in order to determine the spatial interactions among the considered units.

In the next phase, the supplementary analyses helped to determine the physical effects of basic service locations and transportation opportunities in the study area. In fact, the results showed that, there is a positive relationship among the neighborhood's population, the existent buildings in that neighborhood, and its social vulnerability level. Besides, basic services (health, education, cultural, social, and sport) and transportation possibilities in the district showed very limited resources to serve its inhabitants for decreasing their vulnerabilities in any possible hazard. Therefore, in order to respond to these concerns, basic services should be improved in that part of the district by the authorities. Although, these mentioned basic analyses are applied in this thesis, more varied analyses should be examined in the future studies by considering a specific hazard (such as; earthquake, flood, etc.). This may also help to understand the physical structure of the considered area for a better planning for that specific hazard.

Moreover, since the methodology has flexibility for any application and hazard, local and central authorities can benefit from this methodology in their disaster management applications. In fact, by knowing the most vulnerable areas, more effective disaster preparedness plans can be undertaken, and better public awareness studies can be developed in these areas. In addition to that, for during- and post-disaster phases, implementation of these preparedness plans can be organized, due to the fact that, scarce resources can be allocated to these most vulnerable areas, considering that the disaster may affect these areas first.

Besides, in the last phase a different approach was examined, which was very helpful to decrease the complicated structure of the study data's income-level-based variables. The results showed the logical discrimination of income levels in the study area, and the same original social vulnerability levels in Pendik. It is approved by this result that, the use of only income-level indicators are not adequate for the determination of social vulnerability in any hazard; because, the concept of social vulnerability should cover other factors, such as education level, household size, property rights, etc.

Although this methodology covered some social indicators, due to its availability and overall representation of the study area, the detailed structure of these indicators should be reassessed by the sociologists, for the definition of social vulnerability. Especially, since the concept of social vulnerability is different from poverty and cannot be determined just by economical factors; in the future works the indicators, which will clarify this discrimination, should be examined and determined by the sociologists. Since the main considerations in such social studies are the people and their lives, it is important to investigate them properly.

Therefore, whatever the difficulty caused by a hazard, which mankind encounters is, the better preparedness by identifying his/her vulnerability will definitely strengthen his/her capacity to anticipate, cope with, resist and recover from the impacts of that hazard. Thus, more human lives can be saved from hazards.

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APPENDIX A

10 PERSONS' RATINGS ON SOCIAL VULNERABILITY VALUES OF SUB VARIABLES

Table A.1 10 Persons' Ratings on Social Vulnerability Values of Sub Variables

Variable	Sub Variable	Social Vulnerability Value									
		1st inhabitant	2nd inhabitant	1st local authority	2nd local authority	3rd local authority	1st academician	2nd academician	3rd academician	4th academician	5th academician
Employment Status	Employee	0,5	0,7	0,5	0,7	0,4	0,4	0,7	0,8	0,4	0,4
	Employer	0,6	0,4	0,8	0,5	0,6	0,8	0,5	0,8	0,2	0,3
	Self-employed	0,6	0,5	1	0,7	0,3	1	0,5	0,7	0,2	0,4
	Unpaid family worker	0,5	0,6	0,3	1	0,7	0,5	0,8	0,7	0,9	0,8
Reasons for Not Working	Retired	0,3	0,7	1	0,7	0,9	0,4	0,8	0,3	0,7	0,7
	Student	0,3	0,6	0,5	0,6	0,5	0,6	0,9	0,3	0,7	0,8
	Housewife	0,2	0,8	0,5	1	0,5	0,4	0,8	0,3	0,7	0,9
	Rentier	0,3	0,3	0,6	0,4	1	0,3	0,5	0,2	0,2	0,2
	Other	0,2	0,8	0,1	1	0,8	0,8	1	0,3	0,9	1
	Unemployed	0,1	0,9	0,2	0,6	0,5	0,8	0,8	0,3	0,9	1
Educational Level	Can't read/write	0,7	1	0,3	0,9	0,4	0,8	0,6	0,4	0,9	0,8
	Didn't complete Primary School	0,7	0,9	0,4	0,9	0,3	0,7	0,6	0,4	0,9	0,8
	Primary School	0,6	0,8	0,6	0,8	0,4	0,7	0,5	0,5	0,8	0,8
	Middle School	0,6	0,8	0,6	0,7	0,5	0,6	0,5	0,5	0,7	0,7
	High School	0,4	0,5	0,7	0,8	0,5	0,5	0,4	0,6	0,5	0,6
	High School Equivalent	0,4	0,5	0,7	0,7	0,4	0,4	0,4	0,6	0,5	0,6
	Higher Education Schools	0,1	0,7	0,5	0,6	0,6	0,3	0,3	0,7	0,4	0,5
	University	0,1	0,7	0,5	0,5	0,6	0,3	0,3	0,7	0,2	0,3
Household Size	1-4 persons	0,4	0,5	0,3	0,8	0,7	0,4	0,5	0,7	0,4	0,6
	5-14 persons	0,6	0,9	0,4	0,5	0,3	0,6	1	0,6	0,8	1
Owner of the Dwelling	Yes	0,4	0,4	0,5	0,8	0,7	0,3	0,9	0,5	0,4	0,4
	No	0,6	0,8	0,5	0,7	0,4	0,8	0,7	0,2	0,9	0,8
Own any Other Dwelling	Yes	0,3	0,7	0,5	0,5	0,4	0,1	0,7	0,2	0,5	0,4
	No	0,4	0,8	0,7	0,8	0,7	0,3	0,9	0,6	0,7	0,7
Age	0-6 years	0,1	0,8	1	1	0,3	0,8	1	0,4	0,9	1
	7-17 years	0,3	0,7	1	0,9	0,6	0,6	0,9	0,5	0,9	0,9
	18-24 years	0,5	0,6	0,7	0,5	0,7	0,4	0,8	0,5	0,8	0,7
	25-36 years	0,6	0,5	0,5	0,6	0,7	0,4	0,7	0,6	0,6	0,7
	37-54 years	0,7	0,7	0,5	0,8	0,7	0,5	0,7	0,7	0,7	0,7
	55-64 years	0,5	0,7	1	0,7	0,8	0,6	0,8	0,6	0,8	0,8
	65-99 years	0,3	0,8	1	0,8	0,9	0,8	1	0,6	0,9	1
Sex	Male	0,5	0,7	0,5	0,6	0,4	0,4	0,5	0,8	0,5	0,6
	Female	0,5	0,8	0,7	0,8	0,7	0,7	0,8	0,8	0,9	0,9

APPENDIX B

10 PERSONS' RATINGS ON PAIRWISE COMPARISON EVALUATION

Table B.1 1st Inhabitant's Pairwise Comparison Evaluation

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	1	8	8	2	1	3	4	1
Reasons for not Working	1/8	1	1	9	4	1	8	9
Educational Level	1/8	1/1	1	5	3	2	4	5
Household Size	1/2	1/9	1/5	1	2	2	2	2
Owner of the Dwelling	1/1	1/4	1/3	1/2	1	1	1	2
Own any other Dwelling	1/3	1/1	1/2	1/2	1/1	1	1	1
Age	1/4	1/8	1/4	1/2	1/1	1/1	1	1
Sex	1/1	1/9	1/5	1/2	1/2	1/1	1/1	1

Table B.2 2nd Inhabitant's Pairwise Comparison Evaluation

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	1	7	4	2	3	5	9	9
Reasons for not Working	1/7	1	2	9	1	1	7	9
Educational Level	1/4	1/2	1	8	3	3	6	9
Household Size	1/2	1/9	1/8	1	1	1	8	9
Owner of the Dwelling	1/3	1/1	1/3	1/1	1	1	8	9
Own any other Dwelling	1/5	1/1	1/3	1/1	1/1	1	8	9
Age	1/9	1/7	1/6	1/8	1/8	1/8	1	9
Sex	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1

Table B.3 1st Local Authority Person's Pairwise Comparison Evaluation

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	1	7	6	3	8	2	8	8
Reasons for not Working	1/7	1	1	1	5	7	4	6
Educational Level	1/6	1/1	1	1	4	8	6	8
Household Size	1/3	1/1	1/1	1	3	5	3	8
Owner of the Dwelling	1/8	1/5	1/4	1/3	1	1	2	2
Own any other Dwelling	1/2	1/7	1/8	1/5	1/1	1	2	2
Age	1/8	1/4	1/6	1/3	1/2	1/2	1	1
Sex	1/8	1/6	1/8	1/8	1/2	1/2	1/1	1

Table B.4 2nd Local Authority Person's Pairwise Comparison Evaluation

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	1	3	1	4	6	5	5	1
Reasons for not Working	1/3	1	1	1	5	3	4	4
Educational Level	1/1	1/1	1	7	8	5	9	6
Household Size	1/4	1/1	1/7	1	7	8	6	8
Owner of the Dwelling	1/6	1/5	1/8	1/7	1	1	2	2
Own any other Dwelling	1/5	1/3	1/5	1/8	1/1	1	2	2
Age	1/5	1/4	1/9	1/6	1/2	1/2	1	1
Sex	1/1	1/4	1/6	1/8	1/2	1/2	1/1	1

Table B.5 3rd Local Authority Person's Pairwise Comparison Evaluation

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	1	4	3	1	6	5	1	1
Reasons for not Working	1/4	1	1	1	5	7	4	6
Educational Level	1/3	1/1	1	1	4	8	6	8
Household Size	1/1	1/1	1/1	1	3	5	3	8
Owner of the Dwelling	1/6	1/5	1/4	1/3	1	1	2	2
Own any other Dwelling	1/5	1/7	1/8	1/5	1/1	1	2	2
Age	1/1	1/4	1/6	1/3	1/2	1/2	1	1
Sex	1/1	1/6	1/8	1/8	1/2	1/2	1/1	1

Table B.6 1st Academician's Pairwise Comparison Evaluation

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	1	5	5	1	1	1	5	6
Reasons for not Working	1/5	1	1	1	1	1	1	6
Educational Level	1/5	1/1	1	1	1	1	1	6
Household Size	1/1	1/1	1/1	1	3	2	2	1
Owner of the Dwelling	1/1	1/1	1/1	1/3	1	1	2	1
Own any other Dwelling	1/1	1/1	1/1	1/2	1/1	1	2	1
Age	1/5	1/1	1/1	1/2	1/2	1/2	1	1
Sex	1/6	1/6	1/6	1/1	1/1	1/1	1/1	1

Table B.7 2nd Academician's Pairwise Comparison Evaluation

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	1	1	7	7	1	1	8	8
Reasons for not Working	1/1	1	7	7	1	1	8	8
Educational Level	1/7	1/7	1	1	1	1	1	7
Household Size	1/7	1/7	1/1	1	1	1	7	7
Owner of the Dwelling	1/1	1/1	1/1	1/1	1	1	8	8
Own any other Dwelling	1/1	1/1	1/1	1/1	1/1	1	9	9
Age	1/8	1/8	1/1	1/7	1/8	1/9	1	1
Sex	1/8	1/8	1/7	1/7	1/8	1/9	1/1	1

Table B.8 3rd Academician's Pairwise Comparison Evaluation

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	1	5	7	4	3	4	8	5
Reasons for not Working	1/5	1	7	5	4	4	8	7
Educational Level	1/7	1/7	1	4	5	3	1	5
Household Size	1/4	1/5	1/4	1	2	4	4	2
Owner of the Dwelling	1/3	1/4	1/5	1/2	1	2	4	5
Own any other Dwelling	1/4	1/4	1/3	1/4	1/2	1	4	5
Age	1/8	1/8	1/1	1/4	1/4	1/4	1	4
Sex	1/5	1/7	1/5	1/2	1/5	1/5	1/4	1

Table B.9 4th Academician's Pairwise Comparison Evaluation

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	1	7	5	7	8	8	8	2
Reasons for not Working	1/7	1	2	2	2	2	5	2
Educational Level	1/5	1/2	1	2	2	5	5	8
Household Size	1/7	1/2	1/2	1	2	7	7	2
Owner of the Dwelling	1/8	1/2	1/2	1/2	1	7	4	3
Own any other Dwelling	1/8	1/2	1/5	1/7	1/7	1	4	1
Age	1/8	1/5	1/5	1/7	1/4	1/4	1	4
Sex	1/2	1/2	1/8	1/2	1/3	1/1	1/4	1

Table B.10 5th Academician's Pairwise Comparison Evaluation

Criterion	Employment Status	Reasons for not Working	Educational Level	Household Size	Owner of the Dwelling	Own any other Dwelling	Age	Sex
Employment Status	1	8	4	7	7	7	5	8
Reasons for not Working	1/8	1	8	6	4	7	8	7
Educational Level	1/4	1/8	1	9	9	9	6	9
Household Size	1/7	1/6	1/9	1	4	3	5	3
Owner of the Dwelling	1/7	1/4	1/9	1/4	1	6	5	5
Own any other Dwelling	1/7	1/7	1/9	1/3	1/6	1	6	8
Age	1/5	1/8	1/6	1/5	1/5	1/6	1	6
Sex	1/8	1/7	1/9	1/3	1/5	1/8	1/6	1