DEFINING URBAN FIRE RISK: EXPLORATORY ANALYSIS OF FIRE INCIDENTS WITH SOCIOECONOMIC CHARACTERISTICS FOR ALTINDAĞ AND ÇANKAYA DISTRICTS, ANKARA

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DEFINING URBAN FIRE RISK: EXPLORATORY ANALYSIS OF FIRE INCIDENTS WITH SOCIOECONOMIC CHARACTERISTICS FOR ALTINDAĞ AND ÇANKAYA DISTRICTS, ANKARA

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Fire incidents are mostly and widely seen in settlements where urbanization rate is increasing rapidly and population density is high. Development and progression are national objectives of countries. However, problems accompanied with development would be significant. Due to rapid and uncontrolled progression and urbanization, fire prevention and safety subjects are getting problematical. Fire is a spatial problem related to built environment. Various disciplines include 'fire safety' subjects, but exactly city-planning discipline comprises, by means of problem definition and solution constitution.

For improved urbanization and fire-safe built environments, alteration in urban areas should be controlled through planning process, and fire problem should be handled at urban scale. This thesis hypothesis that fire risk should be defined in urban context, and varies with a number of factors. Consequently, this thesis tries to define the 'urban fire risk' term and its factors related with urban elements. Theoretical and analytical basis are fire risk management models and fire incidence analysis. For examining urban fire risk factors relation with fire rate, assessment study is performed between socioeconomic characteristics and fire rate, based on the conceptual urban fire risk management model. The analysis is based on fires occurred in Altındağ and Çankaya Districts, Ankara in 1998. Scatter diagram and multiple regression methods are used for analysis. Main findings are that fire rate is differentiated according to several socioeconomic factors, and risk assessment analysis could be used for defining areas containing more risk within the city.

Key Words: Fire, Risk, Urban Fire Risk, Fire Rate, Socioeconomic Factors

ÖZ

KENTESEL YANGIN RİSKİ TANIMLAMASI: ANKARA, ALTINDAĞ VE ÇANKAYA İLÇELERİNDE KENTSEL YANGIN OLAYLARININ SOSYO-EKONOMİK ÖZELLİKLERE GÖRE İSTİKŞAFİ ÇÖZÜMLEMESİ

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Kentleşme oranının arttığı ve dolayısıyla nüfus yoğunluğunun yüksek olduğu yerleşmelerde yangın olayı daha sık ve yaygıdır. Gelişme ve kentsel anlamda büyüme ülkelerin ulusal hedefleri arasındadır. Ancak, bu büyüme ve gelişmenin beraberinde getireceği sorunlar da büyük olmaktadır. Hızlı ve denetimsiz büyüme ve kentleşme sonucunda, yangından korunma ve yangın güvenliği sorunarı daha da zorlaşmaktadır. Yangın, kentsel çevre ile ilgili mekansal bir problemdir. 'Yangın güvenliği' konusu bir çok disiplinde ele alınmaktadır, ancak problem tanımlama ve çözüm üretme açısından tam olarak şehir planlama disiplini ile alakalıdır.

Sağlıklı, gelişmiş ve yangın-güvenli kentsel alanlar elde etmek için kentsel alandaki değişimler planlama süreci ile kontrol edilmeli, incelenmeli ve yangın problemi kentsel ölçekte ele alınmalıdır. Bu tez, yangın riskinin kentsel ölçekte tanımlanması gerektiğini ve bir dizi faktörlerle değişkenlik gösterdiğini varsaymaktadır. Bu amaçla, çalışma 'kentsel yangın risk'ini ve kentsel unsurlarla ilişkili olan 'yangın risk faktörleri'ni tanımlamaya çalışacaktır. Bu çalışmanın temelini oluşturan teorik ve analitik konular yangın riski yönetim modelleri ve yangın oranı analizleridir. Çalışmada geliştirilen kavramsal kentsel yangın risk yönetim modeline göre, faktörlerin yangın oranı ile ilişkisini sınamak için sosyo-ekonomik özellikler ve yangın oranı arasında kentsel yangın risk değerlendirme çalışması yapılmıştır. Çalışmada serpme diyagram ve çoklu regresyon çözümleme araçları kullanılmıştır. Çözümlemede, 1998 yılında Ankara'nın Altındağ ve Çankaya ilçelerinde çıkmış olan yangın olayları kullanılmıştır. Yangın oranının bir çok sosyo-ekonomik faktöre göre değişkenlik gösteriyor olması ve risk değerlendirme analizlerinin kent içinde diğer alanlardan daha riskli bölgelerin tespitinde kullanılabilir olması çalışmanın temel bulgularıdır.

Anahtar Kelimeler: Yangın, Risk, Kentsel Yangın Riski, Yangın Oranı, Sosyo-Ekonomik Faktörler

To Sıdıka and Lale Öztürk

With yearnings...

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CHAPTER I

INTRODUCTION

Campbell and Fainstein (1996) draw a figure of the changing urban environment in the past hundred years. They state that many cities, as the center of global economy or technical innovation, loss their economic importance and activities, although their population continues to increase. Environmental pollution, traffic, ethnic discrimination, and financial crises cause many problems in urban areas. There appear gentrifications in different poles as poor neighborhoods for low-income groups and suburbs with gates and walls for high-income groups. The distinction between poor and rich become bigger while the social, economic, and environmental conditions of the urban areas are rapidly and simultaneously changing.

The rapid urbanization due to the process of accelerated urban growth reflects itself by the redistribution of population and consequently the redistribution of space in built environment. The general trend of the population redistribution is the decline in central areas and the fast growth on the periphery. Hamza and Zetter (1998) state that this spatial differentiation and polarization drive cities into a social and economic chaos. This chaotic environment and pressure increase various risks at city level at the end. They underline that "with spatial growth in some areas comes densification and centralization in others, which increases the risk associated with disasters". (Hamza, 1998:293)

As a result of the rapid urbanization and the formation of more densely populated parts in the metropolitan areas, fire incidents and the spread of fire through large areas become an important urbanization problem. US Today (1993) indicate that improvements in infrastructure, firefighting, and construction safety during the first half of the 20th century have reduced the fire risk. However, rapid urban growth, insufficient infrastructure development, and economic diminishments reappeared the fire risk in the middle of the 20th century. Rapid and uncontrolled growth during the 1960s and 1970s in the urban areas, together with the economic pressures of the 1980s and 1990s has led to an abrasion of fire protection. As Crapo (1998) indicates, dying in a fire is eight percent and getting injured in a fire is fifty percent greater today than it was 20 years ago. Moreover, the average property loss per fire is 41.5 percent greater over the same period. These figures prove how fire risk is much more significant today in the urban environment than it was before, and how it is essential and crucial to manage the fire risk in the urban environment.

> Fire can be useful, but it can also be deadly. It has always fascinated and frightened; and as the proverb states, it is a good servant and a bad master. Without fire, civilization would be radically different – it might not even exist. However, the cost of fires which get out of control is high, and an average of two to three people die in fires each day in the UK. (Stollard, 1991:1)

Climate, building stock characteristics and human factors importantly influence the fire rates. As technology improves, fire safety products and human factors become increasingly important for understanding the causes of fires and how they can be prevented. Even fire is such a hazard; the necessary importance is given neither by public nor by governmental organizations in Turkey. The fire risk calls public attention only when conflagrations or multiple fatality fires occurred.

The first article of the Natural Disaster Law No. 7269 and its later modification, Law No. 1051 define the 'fire' as 'disaster' like earthquakes, floods, or avalanches. Nevertheless, different than other disasters pointed out in the Law, fire is caused by human or technical failures dominantly, not by a natural event, unless a little percent of the natural causes of fires are included. This means the fire is not a 'surprise' or 'misfortune' of the nature to human. Fire causes and factors could be determined previously, and precaution and prevention efforts can be favorable for minimizing the effects of fire. That is why the fire is one of the most manageable disasters by precautions and safety measurements.

The technology providing human a higher quality of life considers such fire risks as a threat to human and built environment's safety. The only way to eliminate the fire risk or at least to minimize the effects is to manage the risk urban environment face towards. Fire risk management is such a subject that many disciplines are concerned with, such as chemistry, architecture, electrical or mechanical engineering. All these disciplines study on either the fire safety of materials used in structures or the fire safe design process. Nevertheless, the city planning as a discipline does not concern urban fire risk management as the base for all structural or organizational fire risk management studies. In literature, the only subject city planning discipline involved in is either the analysis of fire rates relation with the socioeconomic and built environment characteristics or the fire department deployment models. These subjects separately could only be a part of a complete model for managing the fire risk in urban context.

Urbanized areas have large populations, and they typically have higher densities of people and buildings than rural areas. These differences make the fire problem in urban areas worth of studying separately. While it is important to profile urban fires, it is also interesting to look for variations within this category. Differences in socioeconomic and built environment characteristics across neighborhoods may lead to slightly different fire risk areas and/or profiles. Thus, the intent of the research is to help the identification and clarification of relationships between characteristics of people and places and fire risk. This information can be used for a variety of purposes, including the design, targeting, and evaluation of the fire prevention programs.

This thesis concentrates on socioeconomic characteristics influencing the fire risk at urban scale. The intent is to identify socioeconomic factors that influence the complex and varied relationships between buildings, humans, and the occurrence of the structural fires and to map the fire risk based on analysis at quarter scale. Structural fire is defined as any fire originated inside a building or structure whether or not there was structural damage. It is necessary to study socioeconomic factors related to increased fire risk, because socioeconomic factors are among the best-known predictors of fire rates at the neighborhood level. Even structural factors have an effect on the incidence of fire, today it is much more important how humans use and maintain those buildings. (FEMA[1], 1997)

This study will consist of a review of the literature on fire incidence, fire rate analysis and fire risk management models. The literature will be used for defining fire risk factors in urban environment and fire risk management model. The model and factors will form the basis for addressing the place of the analysis of socioeconomic relation with urban fire risk in the case study area. The analysis is based on 682 structural fires occurred in 1998 in Altındağ and Çankaya Districts, Ankara. Using Geographic Information System (GIS), the fire risk maps based on socioeconomic characteristics of the study area are utilized.

[1] FEMA: The United States Federal Emergency Management Agency

In the next Chapter, the literature on fire risk management and studies of fire rate relation with socioeconomic and built environment characteristics are reviewed. The theoretical framework about fire risk management models constitutes a basis for constituting a broad urban fire risk management model, whereas the analytical framework, which reviews the fire rate analysis, will then be used for defining urban fire risk factors. The following Chapter describes briefly the relation of fire problem with urban environment and city planning. Urban fire risk factors and a broad urban fire risk management model are represented. Chapter Four explains the data sources and the data set preparation processes. A general fire problem profile of the area is also offered. Chapter Five presents the analysis of fire rate relation with socioeconomic variables in the case study area. The analysis includes scatter diagram and multiple regression methods. Based on analysis, fire risk map of the study area is obtained according to socioeconomic characteristics of the population. The conclusion of the study, in which a general summary, a critique and suggestions for further research are given, is represented in Chapter Six. The Appendix includes data set codes, correlation analysis outputs and maps of quarters according to their socioeconomic characteristics.

CHAPTER II

LITERATURE ON FIRE PROBLEM

There has been an extensive body of literature produced on fire problem in different disciplines. The literature, as the base for urban fire risk study in this thesis, can broadly be divided into two. The first part of the literature gives a theoretical framework for fire risk and management models at building scale, whereas the second part provides an analytical framework about the analysis of fire incidents and their relation with socioeconomic or built environment characteristics.

The first section will start by defining the fire risk and fire risk management briefly, and then cite the structural fire risk management models according to architectural approach. The second section will firstly cover subjects on fire incidence analysis, such as determining and ranking fire rates, causes, property classes, origin of fire and fire loss rates. Secondly, fire risk analyses, which are concentrated on the relations between fire incidence and socioeconomic or/and building characteristics at different scales will be explained. The theoretical framework will then be used as a basis for defining urban fire risk term and risk identification and assessment methodology within risk management model, whereas the analytical framework will be used for determining and ranking socioeconomic risk factors within urban fire risk management model in following chapters.

2.1 THEORETICAL FRAMEWORK – FIRE RISK

2.1.1 RISK AND RISK MANAGEMENT

The term 'risk' is used by various disciplines in different meanings. Glendon (1994) conceptualizes different risk approaches by a multidisciplinary context comprising three-nested section, as shown in Figure 2.1. The inner section contains risk measurement in various forms such as calculating probabilities, cost/benefit analysis and risk analysis. Inner section disciplines are mathematics, economics, and engineering. The second section, which is the subject of psychology and philosophy, is concerned with perceptions, cognitions and behavior. The outer section providing a broader context by disciplines such as sociology, geography and politics is about the social and political environment.

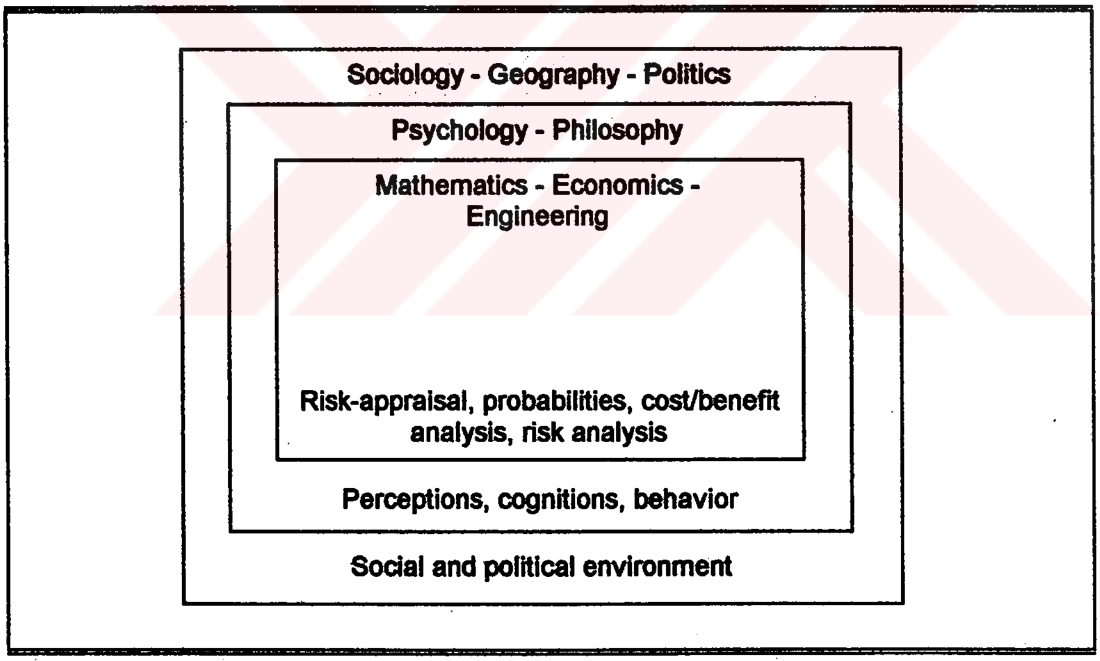

Figure 2.1: A multidisciplinary context for the term 'risk' by Glendon

Source: Glendon, A. I. (1994) "Risk Cognition", p: 88

Even there are various disciplines concerning the risk, there is no generally accepted risk definition in literature. However, there are four descriptions of risk, as listed by Vlek and Stallen[1] in 1981: (cited in Brehmer, 1994:24)

1. Risk is the probability of a loss;
2. Risk is the size of the possible loss;
3. Risk is a function, mostly the product of probability and size of loss;
4. Risk is equal to the variance of the probability distribution of all possible consequences of a risky course of action.

Risk management is a systematic approach for living with the possibility that future events may cause adverse effects. Management suggests an organized approach, which is implementing evaluated techniques to control systems, events, and people. The term 'risk management' refers to any activity that involves the evaluation or comparison of risks and the development of approaches that change the probability or consequence of a harmful action.

> The management of a company or of a society feels responsibility to consider and to have an evaluation system for all types of risk, to take precautions against them, and to have contingency plans and emergency organizations. (Bjordal, 1994:43)

Various disciplines deal with risk and operate risk management models. Different institutions consider and manage risks in different ways. For instance, risk management for banks means determination of loan acceptability, whereas for large engineering and construction projects, risk management means to identify whether the project is feasible or not, which alternative would be more beneficial, or which techniques and design procedure should be followed. Risk management models developed by agencies, organizations and individuals from various disciplines are generally

[1] Vlek, C., Stallen, J. P. (1981) "Judging Risks And Benefits In The Small And In The Large", in *Organizational Behaviour And Human Performance,* vol. 28, pp. 235-271

rooted in 'the classical risk management model' for minimizing different losses. The classical risk management approach is based on three stages:

1. Every risk should be identified, 'risk identification';
2. Consequences of risks should be analyzed, 'risk evaluation';
3. Control and reduction methods should be implemented for minimizing risk effects, 'determination and implementation of the control measures'.

Although disciplines are so diverse from each other, ranging from financial risk management models to building fire risk management models, all of them include these three basic common stages of the classical risk management model; defined above. Furthermore, risk management models can contain more steps, where the number of steps depends on how three core stages of classical model are broken down. Another common point of all these models is that the risk management is a dynamic process and should be periodically updated. The risk management is an ongoing, evolving and continuously improved process, since the model changes based on events that occur internally or externally. (Loflin, 1997b)

2.1.2 FIRE RISK

The Oxford American Dictionary defines the risk in three different ways; first is the possibility of meeting danger or suffering harm or loss; second, a person or thing insured or similarly representing a source of risk; and lastly in verb form as to expose to injury or loss. Intently, NFPA[2] 1500 defines the risk as "the measure of the probability and severity of adverse effects resulting from an exposure to some type of hazard". (FEMA, 1996:22)

[2] NFPA: The United States National Fire Protection Association

Hakan Frantzich defines the fire risk at building scale as "the quantitative measure of the condition that people are not able to escape safely before the untenable conditions have occurred on the premises". (Frantzich, 1998b:65) He defines two types of fire risk at building scale:

1. 'Individual risk' is defined as the risk to which any particular occupant is subjected at the location of fire zone; while,
2. 'Societal risk' concerns with the risk of having multiple fatalities.

Milne (1959) divides the fire risk into two different categories in scope of the fire insurance according to the property in which fire occurred.

1. 'Ordinary risk' is the fire risk seen in properties such as dwellings, schools, stores, due to their large number and common characteristics of construction and occupancy.
2. 'Special risk' is seen in special use properties which are fewer in number, and which have wide variation of occupancy construction and characteristics, like factories warehouses, department stores.

The common characteristic of all fire risk definitions is that they refer to terms 'possibility' and 'loss'. Hence, the risk can broadly be defined as the variation at the end of an action occurred. Thus, the term 'fire risk' in this thesis refers to the probability fire occurrence and undesirable consequences that might occur at the end, such as death, injury, property loss or damage. Consequently, there are two interrelated factors of fire risk:

1. The first factor is the 'probability' that fire might occur. Probability of occurrence can be described in subjective terms as rare and high, or in numerical terms as one in a million and twenty percent.
2. Second is the harmful or undesired 'consequence' that can be expressed in descriptive terms like death, injury, and destruction, or in more concrete terms such as loss of a $ 1.5 million facility.

2.1.3 FIRE RISK MANAGEMENT MODELS IN ARCHITECTURAL APPROACH

Fire occurs dominantly within the buildings, therefore the literature underlines that designing and constructing a building completely fire-safe is crucial for property protection and life safety of occupants. As previous studies underlines, common causes of fires are human failure based. For this reason it is impossible to achieve full safety within the buildings. But the fire risk in buildings can be minimized by some means of controls and implementations. Fire risk management at building scale involves both the design process and existing situation. There is no universally accepted methodology for fire risk management and fire safety design for buildings. Many studies have developed different fire risk management models based on classical risk management model for achieving fire safety in buildings. The main question in this area is how to get the optimal or maximum fire safety at building scale.

Stollard and Abrahams (1991) study the risk management process for achieving fire safety in buildings. They lay out some basic principles for fire safety. The fire risk management process, developed by Stollard and Abrahams, is composed of three steps; first step is to set the objectives for achieving an acceptable level of fire safety; second step is to identify the tactics to achieve the objectives; and last step is to determine the components used within tactics. (Figure 2.2)

Stollard and Abrahams determine life safety and property protection as fire safety objectives for the architect to achieve. In their study, five tactics are determined for fulfilling the objectives. The first tactic is prevention, ensures that fire does not start if ignition and fuel sources were under control. If ignition occurred, the second tactic, the communication become important which ensures that occupants and fire brigades were informed about the fire quickly. The third tactic is to ensure escape, so that the occupants leave the building where fire broken out and the surrounding building safely before the threat of heat and smoke. The fourth tactic, containment aims to contain the fire within the smallest area and limit its spread. The last tactic is extinguishment whose aim is to extinguish fire quickly with minimum damage. The matrix in Figure 2.3 explains the logical sequence between these tactics.

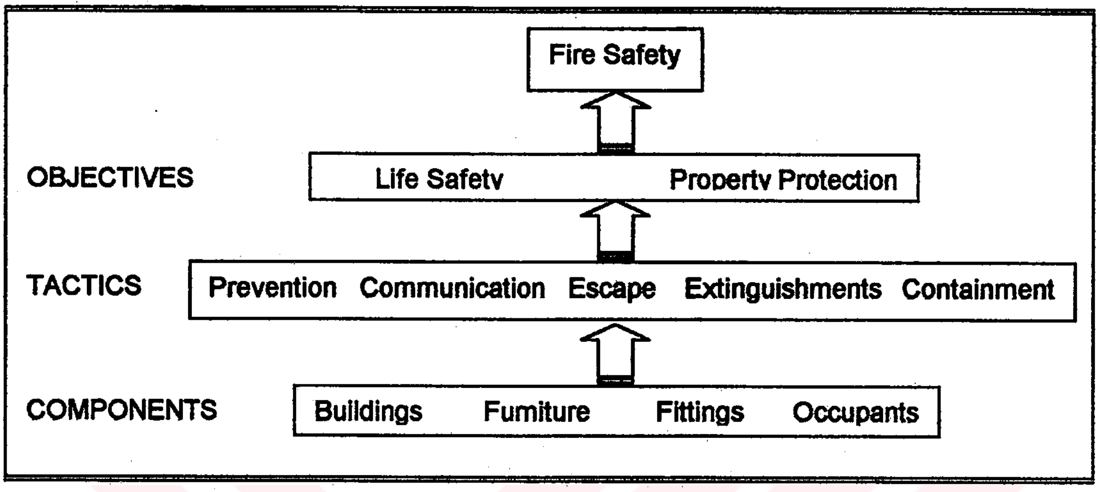

Figure 2.2: Fire safety model by Stollard and Abrahams

Source: Stollard, P., Abrahams, J. (1991) Fire From First Principles, p: 5

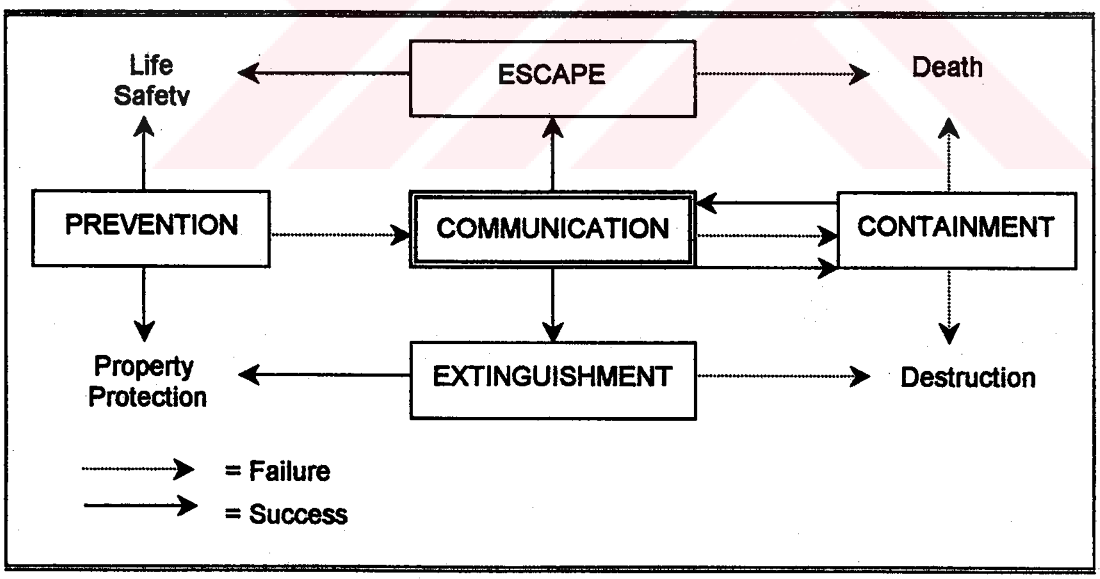

Figure 2.3: Matrix of tactics and objectives by Stollard and Abrahams

Source: Stollard, P., Abrahams, J. (1991) Fire From First Principles, p: 17

According to another study, performed by Shields and Silcock (1987), if the objectives and constraints upon the system have been clearly specified, compulsory tactics could be chosen for attaining the objectives. The fire risk management process for Shields and Silcock is composed of three steps: objectives, constraints, and tactics. The fire risk management plan for buildings formulated by Shields and Silcock is given in Figure 2.4.

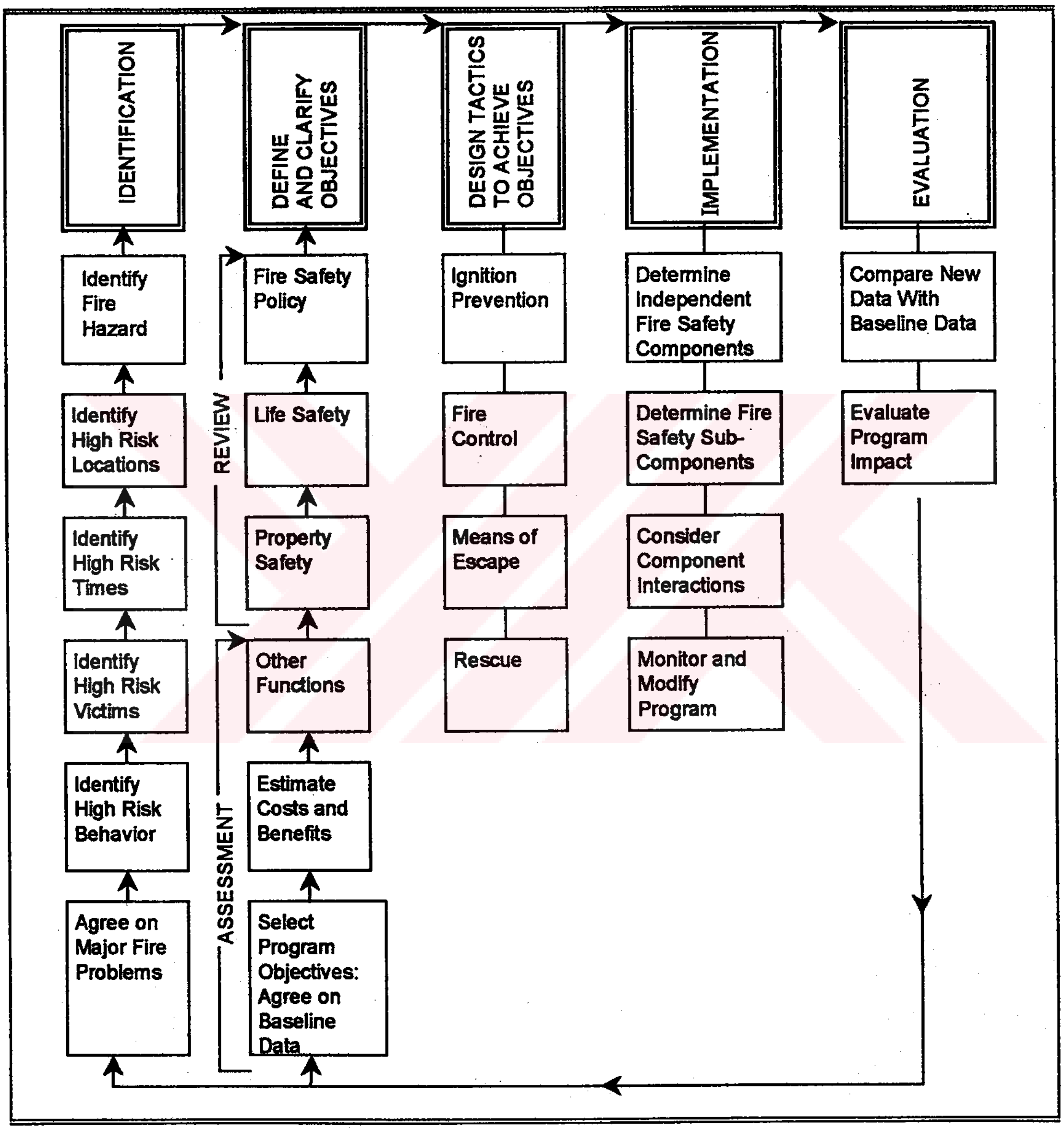

Figure 2.4: Planning process of the fire risk management model by Shields and Silcock

Source: Shields, T. J., Silcock, G. W. H. (1987) Buildings and Fire, p: 418

Recently, Hakan Frantzich (1998) presents the quantitative methods used for determining the risk levels of occupants in case of a fire and formulates a model for obtaining the design values for fire safety in his doctoral dissertation. He uses the definition and process of risk management that has been stated by IEC[3] in 1995. According to IEC, the risk management process is the complete methodology in which qualitative and quantitative analysis methods are contained. The steps of the fire risk management process determined by IEC are definition of the goals, identification of the hazard, determination of the measure of risk, evaluation of the tolerability of the risk, definition of risk reduction measures, and implementation of the result into practice including monitoring. These steps are seen in the Figure 2.5.

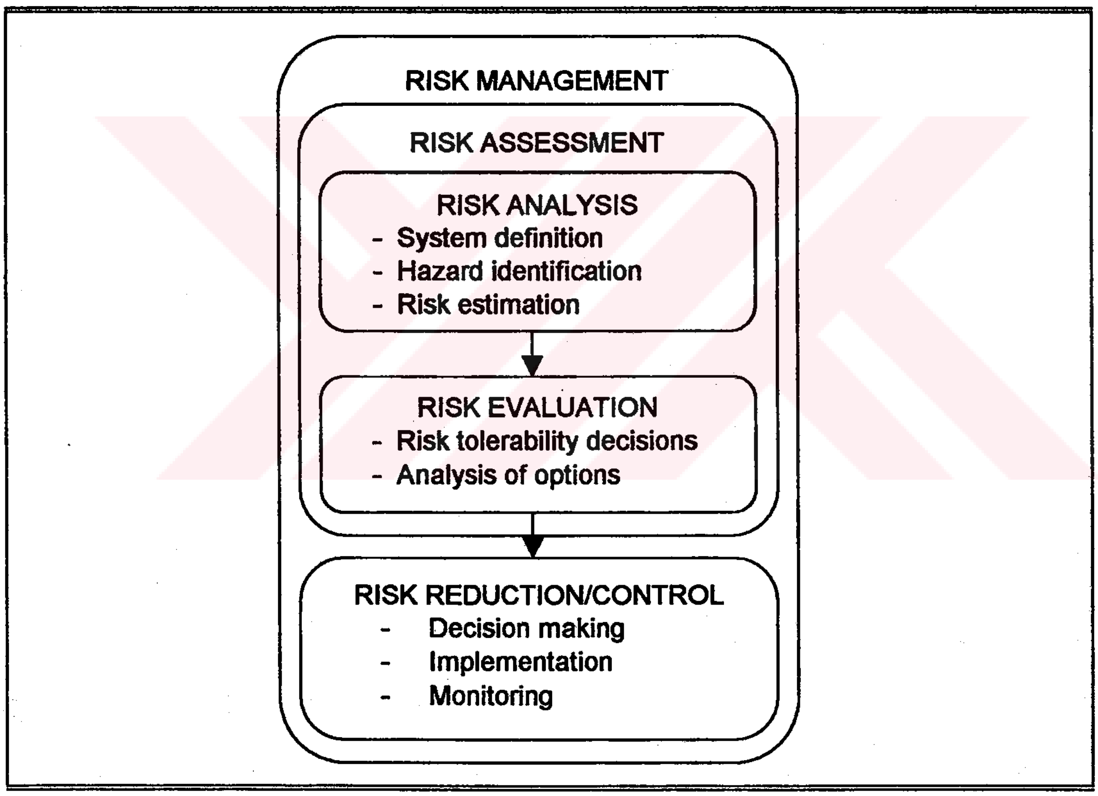

Figure 2.5: The activities in the process of risk management in Frantzich model

Source: Frantzich, H. (1998) Risk Analysis And Fire Safety Engineering, p: 316

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[3] IEC: The International Electrotechnical Commission

2.2 ANALYTICAL FRAMEWORK - FIRE ANALYSIS

The literature on fire analysis in itself can broadly be divided into two: first is the fire incidence analysis, and second is the fire risk analysis. Fire incidence analyses are more often statistical analyses of fire incident reports for determining and ranking fire rates, causes, property type and fire death rates at city, national or international scales. On the other hand, fire risk analyses are considered in different disciplines and concentrated on relations between fire incidents and socioeconomic or/and structural characteristics at different scales. The most remarkable areas in which fire risk analyses carried out are social sciences. Accordingly, the first section below will review studies on fire incidence analyses, whereas second section will summarize studies on relation of social and economical factors with fire incidents.

2.2.1 FIRE INCIDENCE ANALYSIS

There are many recent analyses about fire carried by two main United State's organizations: NFPA and FEMA. In these reports, fire causes, fire rates according to property classes and origins, and fire death rates are studied and analyzed in detail.

One of the recent important reports of FEMA (1999) characterizes the nature of fire problem in urban areas of the United States for the year 1996. According to large population size, geographical location, and NFIRS[4] participation criteria, 18 metropolitan areas with 306775 cases are selected for constituting the urban fire incident data. In this report, urban fires in 1996 are divided into three different groups, as outdoor fires, vehicle fires, and structural fires. The study underlines that although outdoor fires are large in number, estimated dollar loss of fires are much more in structural fires, which

[4] NFIRS: The United States National Fire Incident Reporting System

accounts for at least three-fourths of all urban fire deaths, injuries, and estimated dollar loss. In the report, fire causes are listed as incendiary or suspicious, children playing, careless smoking, heating, cooking, electrical distribution, appliances, open flames, other heat, other equipment, natural, and exposure. Fire causes are differently ranked according to the fire groups. For example, for outdoor and vehicle fires the major cause is found as incendiary or suspicious, whereas in structural fires the major cause is cooking. This report also differentiates structural fires as residential and non-residential, and finds that the most common cause of fires is incendiary or suspicious in non-residential, whereas cooking in residential structures.

In the same report, mortality data between years 1991 and 1995 are also analyzed for calculating an overall fire death rate. For the period 1991-1995, it is determined that the Midwest has the highest urban fire death rate with 16,5 deaths per million population, followed by the Northwest with the rate of 14,3, and then by the South with the rate of 13,8. The lowest fire death rate is in West whose fire death rate is 10,0%. This statistical analysis shows that the fire death rates tend to be lower in regions with the warmest and driest climates and higher in regions with worst climate and older housing stock. Therefore, the report states that climate and building stock characteristics are related with fire rates.

Ahrens (1999) prepares a report for NFPA and analyzes fires occurred in 1997 in the United States. For the year 1997, 1,8 million fires occur, 4050 civilians lose their lives, and 23750 civilians injure. Direct property damage is estimated at $8.5 billion dollars. It is found that 31% of the reported fires are structural fires, and 87% of civilian fire deaths and 86% of civilian fire injuries occur in structural fires. 74% of structural fires take place in residential buildings including homes, hotels, motels, rooming houses, and dormitories. Four out of every five fire deaths are in residential structure fires. During 1997, 22% of fires are vehicle fires, where 47% of total reported fires are considered outside or other.

After reviewing fires in U.S., Ahrens examines fire causes according to the occupancy of the structure. Structures are broadly grouped into two as residential and non-residential structures, and then subgroups are formed. The most detailed examination is carried on home structure fires, including dwellings, houses, apartments, flats, and condominiums; but not rooming houses, hotels, motels, and dormitories during the five years period from 1992 to 1996. Besides, Ahrens analyzes residential structures in detail according to the times when fire occurred. During the study period, the peak period for home structure fires is between 18:00 and 20:00. This period is the time when household members arrive home. The peak period for home structure fire deaths is very early in the morning, between 02:00 and 04:00, when most people sleep. Home structure fires and home fire deaths peak in winter months, which reflected the influence of heating equipment fires. The report states that the seasonal differences in causes of home structure fires and home fire deaths show that heating equipment caused 27% of the home structure fires and 22% of home fire deaths during winter months, but only 11% of fires and 9% of fire deaths in the months between March and November.

Another report of FEMA (1998b) analyzes residential fire statistics in U.S at the state level after giving a national fire problem review between the years 1986 and 1995. Within the national perspective, It is found that fires increased 18 percent during ten years period. The report indicates that fire rates and fire death rates differ from region to region, and state to state according to the climate, poverty, education, demographics, and other factors. Another important finding of the report is that even most of the fires occur in outside, the majority of civilian deaths and injuries occur in residential structure fires. Overall, the arson is determined as the main cause of fires and dollar loss, careless smoking as the main cause of fire deaths, and cooking as the main cause of fire injuries. From statistical analysis, the elderly and very young are found to be the highest risk groups in case of a fire.

In literature, there are also studies, which are specialized on fire death rates. Most important studies about the fire death rates are FEMA reports, one analyzing the fire death rates at international scale, and second analyzing the multiple fatality fire rates in the United States.

The first report of FEMA (1997b) studies the fire magnitude and the nature of the US fire death problem. Report states that even the fire death rate falls from 36,3% fire deaths per million population in 1979 to 19,5% in 1992, the United States is one of the highest per capita fire death rates among the countries considered in comparison. Thereupon, the second part of the report tries to answer the question 'why other countries' fire death rates are lower than the United States. According to the report, the answer is the level of resources devoted to fire suppression versus fire prevention. It is stated that other countries have been giving priority to prevent fires rather than to put them out once they occur. The report indicates that the European countries with lower relative fire death rates have suggested that prevention is more effective than suppression in saving lives.

In the second report of FEMA (1999b) specialized on the multiple fire death rates, the causes of multiple-fatality fires, the differences and similarities with single-fatality fires are studied. It is stated that each year in the US, one in six of residential fires is a multiple-fatality fire, means a fire in which more than one civilian lost his life. In this study, residential structures are the primary focus because of the fact that the majority of fire deaths among civilians occur in the home between 1994 and 1996. (FEMA, 1999b)

The report compares multiple and single-fatality residential fires according to 10 aspects; cause of fire, area of fire origin, heat source, form of material ignited, time of day, performance or presence of smoke alarms, age of victim, gender of victim, victim's condition before injury, and victim's activity at time of injury. The analysis also identifies similarities between multiple- and single-fatality fires, which were type of residential structure, level of fire origin, type of material ignited, month of year, and nature of victim injuries. Main findings of the analyses are that the main three causes of multiple-fatality fires between 1994 and 1996 are heating with 19 percent, arson with 17 percent, and children playing with fire-starting materials with 15 percent; both single- and multiple-fatality fires exhibit a similar pattern in the time of day in which they occur, between midnight and 6:00 a.m.; the age profiles of multiple-fatality fire victims versus single-fatality fire victims differed from each other as followed the very young were the largest age group represented in multiple-fatality fires; conversely, the very old were the largest age group represented in single-fatality fires; and both multiple- and single-fatality fires mainly occurred during winter months.

2.2.2 FIRE RISK ANALYSIS IN SOCIOECONOMIC APPROACH

This approach describes the fire incidence on social and/or economic perspective, and directly focuses on the fire problem at neighborhood or city scale. The main question is the differentiation of fire problem and incidences between geographic areas at different scales.

Socioeconomic analyses of fire incidents are generally structured by evaluating the fire rate statistics relations with socioeconomic and built environment variables that are hypothesized to be related with fire incidents. Prior researches have shown that socioeconomic and built environment characteristics could be used as indicators of the magnitude and nature of fire problem in different neighborhoods and cities. In literature, it is dated that most of the studies about the socioeconomic characteristics and fire rates were performed and published in the late 1970s and early 1980s. Till that time, limited amount of new researches were carried out, mostly unpublished doctoral dissertations and master's theses.

For this part of literature review, only three main studies[4] could be summarized in detail: one by Jennings in 1996, and two by FEMA in 1997 and in 1998. Besides, the literature chapters reviewed in three studies are also looked over and summarized in Table 2.1 and Table 2.2 by examining the research strategies, the data analyzed, and the indicators found to be related to fire incidents.

Table 2.1: Major demographic and socioeconomic studies on fire incident

YEAR	STUDY	DATA SET AND STUDY AREA
1976	Clarke and Ottoson	All U.S.
1977	Schaenman, Hall, Schainblatt, Swartz, Karter	Census tracts in four cities and one county
1977	Munson	633 residential fire incidences of Charlotte, North Carolina
1977	Waters	Fire call data for London, Ohio
1978	Karter and Donner	Census tracts of five cities
1979	Chandler	Census tracts of Greater London
1980	Donnell	61 census tracts of an area in Syracuse, New York
1981	Gunther	Census tracts of Toledo, Ohio
1982	Chandler, Chapman, and Hallington	Census tracts of London, Birmingham, and Newcastle
1983	Munson and Oates	54 large U.S. cities, 36 NJ cities, and Census tracts of Charlotte, NC
1985	Gilliam	Census tracts of Highland Park, Michigan
1987	Murrey, Pitts, Smith, and Kenneth	Census tracts of all U.S. at the state level
1989	Fahy and Miller	50 U.S. cities
1991	Goetz	Census tracts
1996	Jennings	Census tracts, Tax Assessor's data, Fire records of Memphis, Tennessee
1997	Statistics Unit, New South Wales Fire Brigade	Postal codes of Sydney, Australia
1997	FEMA	Census tracts of all over U.S.
1998	FEMA	Census tracts of 27 major U.S. cities

[4] Due to some deficiencies, only three studies could be achieved. The basic deficiency was that the earlier published studies could be found and obtained neither in libraries nor in internet. Secondly, most of the studies performed in the last years were unpublished doctoral dissertations and master's theses in foreign universities.

Table 2.2: Dependent and independent variables used in the socioeconomic and demographic studies

YEAR	STUDY	DEPENDENT VARIABLE	Age of Structure	Rent/property value	Percent structure substandard	Avg. num. of persons per room	Percent units occupied	Percent units owner occupied	Education	Property or population density	Percent of children or elder	Percent of non-white	Family stability	Income	Poverty rate	Unemployment	Other
			VARIABLES USED														
1976	Clarke and Ottoson	Fire death rates															[A]
1977	Schaenman, Hall, Schainblatt, Swartz, and Karter	Intra-city fire rates	⊖			[⊖]	⊖	[⊖]	[⊖]		[⊖]	[⊖]	[⊖]	[⊖]	[⊖]		
1977	Munson	Fire rates in residential dwellings								[⊖]				[⊖]	[⊖]		
1977	Waters	Intra-city fire rates	[⊖]	⊖						⊖				⊖			
1978	Karter and Donner	Intra-city fire rates for residential buildings				[⊖]	[⊖]	[⊖]					[⊖]		[⊖]		
1979	Chandler	Intra-city residential fire rates			[⊖]			[⊖]		[⊖]	[⊖]	[⊖]					
1980	Donnell	Intra-city fire rates in urban renewal area		[⊖]			[⊖]		[⊖]			[⊖]	[⊖]	[⊖]	[⊖]		
1981	Gunther	1. Intra-city residential fire rates 2. Fire rates for each cause of fire										⊖		[⊖]			
1982	Chandler, Chapman, and Hallington	Inter-city fire rates						[⊖]			⊖	⊖		[⊖]		[⊖]	
1983	Munson and Oates	Intra and inter-city residential fire rates			⊖	⊖		[⊖]			⊖	⊖		[⊖]	⊖		[B]
1985	Gilliam	Fire cause rates		⊖		⊖	⊖	⊖	⊖		⊖				⊖		
1987	Murrey, Pitts, Smith, and Kenneth	Fire rates								[⊖]	[⊖]	[⊖]	[⊖]	⊖		⊖	[C]
1989	Fahy and Miller	Inter-city fire death rates													[⊖]		
1991	Goetz	Intra-city arson rates		[⊖]			[⊖]					[⊖]		[⊖]			
1996	Jennings	Intra-city residential fire rates					[⊖]				[⊖]		[⊖]		[⊖]		
1997	Statistics Unit, New South Wales Fire Brigade	Number of total fires, house fires, structure fires, arson fires, and bush and grass fires	[⊖]					[⊖]	[⊖]			[⊖]		[⊖]		[⊖]	
1997	FEMA	Fire rates			⊖	⊖	⊖		⊖		⊖		⊖	⊖			D
1998	FEMA	Inter-city urban residential fire rates and fire cause rates	[⊖]	⊖	⊖			[⊖]	⊖		[⊖]		⊖	[⊖]	⊖	[⊖]	[B]

The type of loss, type of occupancy, time of day, ignition source, item ignited, and the direct cause of the loss like smoke

Temperature

Crime rates, percent urbanized

Careless smoking, social pathology, housing tenure

⊖ : Variable used

[⊖] : Significant variable

Jennings (1996) studies the relation of fire rates with socioeconomic and built environment characteristics in residential structures in Memphis, Tennessee. He builds his analytical framework on Lösch's approach: location, activity, and population. In this framework, 'population' refers to fire rates expressed in terms of population or dwelling units, 'activity' refers to fire codes written for addressing specific processes, and 'location' refers to building and zoning codes restricting hazardous activities. He tries to determine why some areas, populations or activities experience more fires. He uses three different data sets; fire department records, Tax Assessor's data, and census tract data. His model includes three fire classes; Class 3 fires are exterior fires caused by lightning, exposure; Class 1 and 2 are interior fires caused by mechanical or human act, but in Class 2 fires human action is non-proximate to the ignition, whereas in Class 1 fires it is proximate. The conceptual model for fire ignition developed by Jennings is shown in Figure 2.7.

In his study, Jennings firstly conceptualized the fire ignition model broadly. After analyzing the Memphis fire data, he determines the socioeconomic variables for correlation and multiple regression analysis based on the fire ignition model. The final data he achieved represents the interaction between four socioeconomic factors, which were characteristics of building stock, characteristics of the household system, household demographics, and household economic factors. Jennings uses multiple regression analysis on fire rate data for various census tracts of Memphis. He determines four variables for each factor highly correlated with residential fire rates, which are the percentage of vacant dwelling units, in concept of building stock; the percentage of households headed by female single parents, in concept of household system; the percentage of population less than age of 17 or older than age of 65, in concept of demographics; and the median household income, in concept of economics. Multiple regression analysis also reveals that each of these variables in this model is significant.

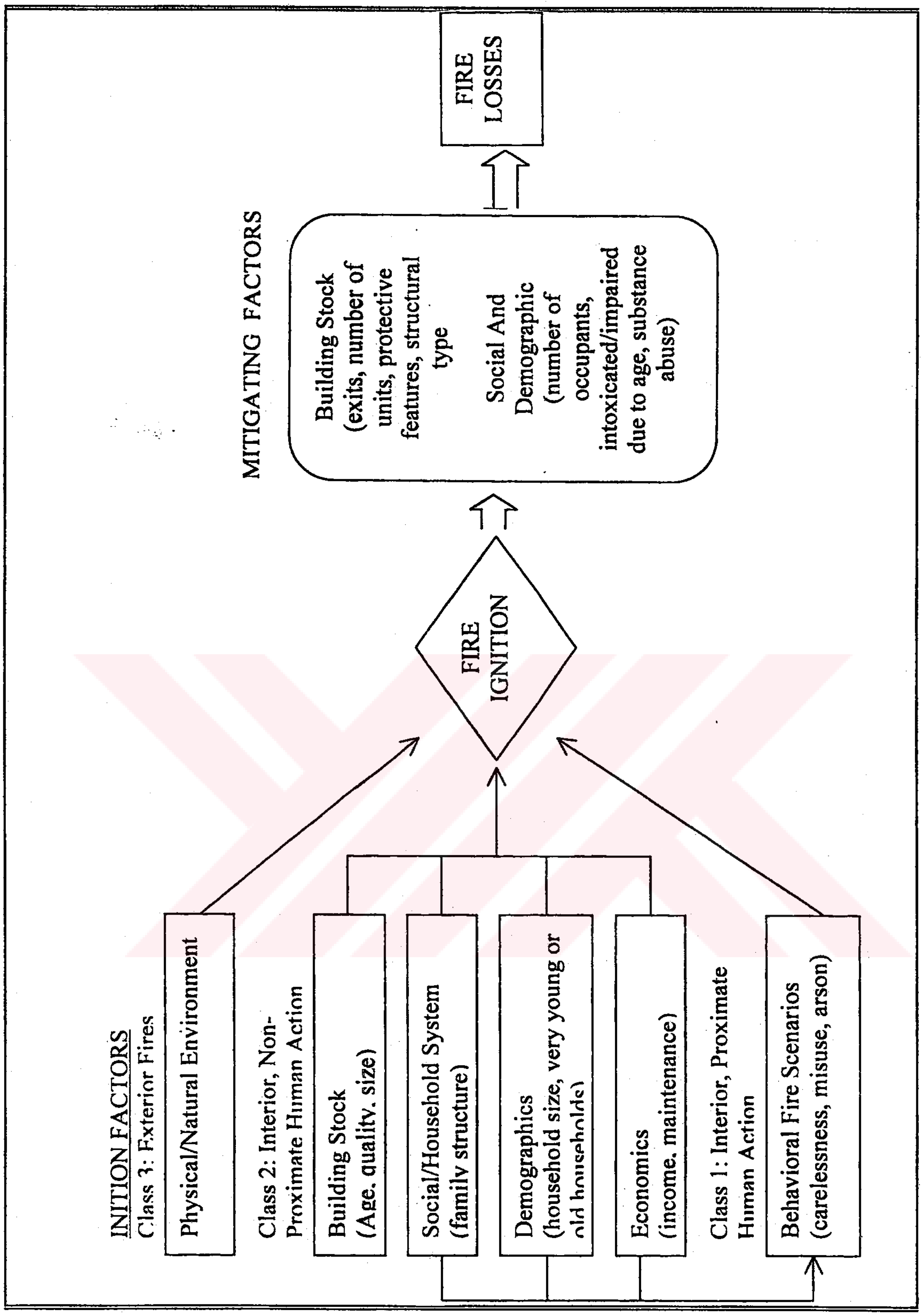

Figure 2.6: Conceptual model for fire ignition by Jennings

Source: Jennings, C. R. (1996) Urban residential Fires, p: 122

One of the latest studies about the socioeconomic fire risk analysis is the report prepared by FEMA (1997). In this study, income is selected as the main socioeconomic variable, because of the assumption that most of the socioeconomic factors are related to income. The questions tried to be answered in this report are how low income groups are experienced higher fire risk than people with high income, and how some factors increase fire risk in urban areas. This report generally focuses on urban areas since it is claimed that urban and rural socioeconomic factors are so different than each other while examining the fire incidents.

A top-down approach is used for determining socioeconomic factors at three levels. These levels are the level of the neighborhood, the level of the household including the housing unit and household members characteristics, and the level of individual. The socioeconomic factors at the level of neighborhood are vacant and abandoned buildings, neighborhood decline, and arson. Factors explained at the level of household are housing quality, including smoke detectors; housing affordability; and household structure, including single parent households and the presence of children, presence of elderly persons, and overcrowded households. Lastly, factors at the level of individual are determined as careless smoking, low level of education, housing tenure, and social pathology as socioeconomic variables related with fire incident rate.

Another report of FEMA (1998) about socioeconomic fire risk analysis is published as a complimentary of the first report, 'Socioeconomic factors and the incidence of fire' in 1997. This report mainly tries to identify the relationship between residential fire rates and city characteristics, especially climate, demography, and socioeconomic factors. The report mainly focuses on residential fires due to two reasons. First, many civilian fire deaths and injuries are occurred in residential structures, second, over the percent of 55 of residential fires are directly attributable to human activity between the years 1993 and 1995.

The study analyzes fire data from 27 major U.S. cities reported to the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS). Fires between the years 1993 and 1995 are classified according to causes determined by NFPA as arson, children playing, careless smoking, cooking, heating, electrical distribution, appliances, and open flames. For each city, city fire rates are calculated by dividing the aggregate number of residential fires in each category by city population. For analyses, another data set is created by the data obtained from 1994 City and County Data Book CD-ROM. This data contains the climate, demographic, and socioeconomic indicators, such as total population, annual precipitation, race, income, poverty, family structure, and age of housing for each city. Then, this data set is combined with the fire rate data set, and the final data is studied for testing whether there is a relationship between city characteristics and fire rates by using correlation coefficients and multiple regression analysis.

Major finding of the analysis is that particular city characteristics are strongly related at least one of the fire causes. These factors are age distribution of population, unemployment rates, median income, poverty levels, housing unit characteristics, housing tenure, housing cost, education, and household structure. Two important socioeconomic factors, presence of female-headed households and education, are not found strongly related to residential fires. Other findings are that five of eight causes; arson, children playing, careless smoking, heating, and electrical distribution are found to be strongly to at least one city characteristics; and lastly, cooking fires are not found strongly related to city characteristics. (Table 2.3)

Different then these general socioeconomic analyses of fire incidents, there are also other studies carried by FEMA in specific socioeconomic characteristics of the population. These studies are generally focused on the high-risk groups such as disabled people, elderly people, and people use alcohol.

Table 2.3: Expected and actual results, and correlates for city characteristics and fire rates in residential structures by FEMA

Source: FEMA (1998) An NFIRS Analysis, p: 14

Fire Rate	Expected	Research Findings	Significant City Characteristics	Percent Of Difference
Overall	High	High	1. Annual precipitation (+) 2. Percent of pre-1940 housing units (+) 3. Percent of population under age 5 (+)	64%
Arson	High	High	1. Median income (-) 2. Percent rental housing (+)	70%
Children playing	High	High	1. Percent change in population (-) 2. Percent of population under age 5 (+)	60%
Careless smoking	High	Moderate	1. Percent pre-1940 housing units (+)	40%
Cooking	High	Low	None	-
Heating	Moderate	Moderate	1. Annual precipitation (+) 2. Percent rental housing (-)	49%
Electrical distribution	High	High	1. Annual precipitation (+)	62%
Appliance	High	Low	None	-
Open flame	High	Low	1. Percent pre-1940 housing units (+)	27%

One of the FEMA reports (1999c) studies high-risk groups is about the patterns and trends in alcohol use and fire casualties. The report firstly summarizes the existing data on the involvement of alcohol in fire deaths, and the impact of socioeconomic and demographic variables on alcohol use and fire casualties; and then analyzes two case studies from Ontario and Minnesota for the question of alcohol use and fire. At the end, the need for public awareness and education is expressed. In the report, it is claimed that several researches from medical and fire protection organizations have found that about half of all adult fire fatalities, and over 40 percent of all residential fire deaths were alcohol-impaired. That is why the report remarked the people who use and abuse alcohol as a growing high-risk fire group. The case study results also verify this remark.

2.3 CONCLUDING REMARKS

Fire problem and fire risk are such subjects that various disciplines are concerned with, such as chemistry, civil engineering, mechanical engineering, medicine, electrical engineering, architecture, or sociology. Disciplines, which include subjects about the fire risk in built environment, study either the fire safety of materials used in structure or the fire-safe design process of structures. In literature, structural fire risk management subject is so much studied in detail; and many models, including computer-based ones are developed. On the other hand, disciplines, which comprise the subjects of socioeconomic characteristics of the population, study only the relations between the socioeconomic characteristics and the fire rates, but do not connect these data with the urban patterns, for such as determining the risky neighborhoods or areas within the city. Different than these two diverse study areas, there are other areas deal with fire risk, even out of this research's afford. First study area is concerning the risk to which a fire department exposes both in organization and in operation. Even this study area is not so related with the city planning process, it is important for a better service providing within the city. Second is about the fire service deployment models. This study area is a subject of city planning discipline, but the missing point is that it is based on assumptions without considering which area, part or the population group in the city is much more risky than others according to the socioeconomic and built environment characteristics.

Within the city, population and building stock are distributed according to density gradient, and this arrangement forms the basis for studying the distribution of other urban phenomena. Several studies in literature indicate that the fire risk in two buildings with same qualities is not same because of the user factor of buildings. Also, it is stated that the fire risk in building environment is not same for everyone, since climate, building stock and socioeconomic characteristics importantly influence fire rates. The exact combination of factors influencing fire risk are not known, but considerably progress was made in identifying individual variables that are strongly associated with fire risk. (FEMA, 1997) (Jennings, 1996)

As Glendon's conceptualization of different risk approaches, risk on social and political environment, studied by sociology, geography and politics, covers all other risk approaches including risk perception, risk behavior, risk analysis, risk assessment, and management in other disciplines. Geography constitutes a basis for urban approach, therefore urban fire risk must be defined in the outer section of all other fire risks, including structural, sociological, or operational risks for achieving fire safe societies, as well as structures and cities.

Literature is incapable about urban fire risk subject, both about definition and determination. Although there are some studies mentions fire risk at urban scale, such as Frantzich's 'societal risk' definition besides building risk or Jenning's model of fire initiation and fire loss, there seen a lack of well-defined and complete fire risk definition and model at urban scale. In the next chapter, theoretical and analytical frameworks will be used for developing a conceptual model for studying urban fire risk problem and fire risk distribution within urban environment.

CHAPTER III

URBAN FIRE RISK - THE NEED FOR A MODEL

Further the destructive effects on lives and properties in single structures, fires, especially the big ones named as conflagrations, cause losses in terms of loss of production, profits, employment and labor force, societal disturbances, and environmental damage overall the urban environment. In order to reduce the negative consequences of fire to human and built environment; individuals, organizations and governments have responsibility to manage and control the fire risk.

Managing and controlling the fire risk in the urban environment necessitate a comprehensive management strategy. As stated and exampled in theoretical framework, the management strategy should cover identification, assessment and control stages. For specifying necessary control measures and effective policies, causes of fires and various contributions of social, economic and environmental realms have to be understood. A theory and a management model would be useful for determining prevention and precaution policies, and also for allocating resources between alternative policies for fire suppression or fire prevention. Therefore, this part of the thesis aims to develop a broader risk management model for urban fire problem, based on previous researches. This study will only concern structural fires in urban areas, whereas vehicle, outdoor, and forest fires are beyond the scope of thesis effort.

In this chapter, firstly fire problem relation with urban environment and city planning will be explained, then urban fire risk will be defined based on the theoretical framework. Analytical framework will be used for determining the urban fire risk elements and factors, explained in the second and third sections of the chapter. In the fourth section, urban fire risk management model will be broadly structured based on the theoretical framework of fire risk management models according to architectural approach. The model structured will be used in following chapters as a base for examining urban fire risk relation with socioeconomic characteristics of the population.

3.1 URBAN ENVIRONMENT AND FIRE PROBLEM

Built environment contains humans and their attendance to social and economic activities. Humans determine the distribution of economic and social activities within the urban area. Ecological approach can be used for researching urban phenomena and problems effectively due to admitting complexity and interdependence of human systems and organizations, and containing a wide range of information for studying a phenomenon or problem. Hawley[1] defines the elements of ecological system as population, environment, technology, organization, and socio-psychological factors. (cited in Jennings, 1996:21) Consequently "...fires are an ideal subject for the ecological approach because of their complexity and the interaction of social, environmental, and economic factors in their causes". (Jennings, 1996:21)

Besides the ecological approach, importance of human and built environment factors on fire problem at urban scale can be based on the classical model of spatial inquiry, designed by Lösch (1954). According to Lösch, the three elements of urban system which determine the division of labor are location, activity and population and the six relationships between them, as seen in

[1] Hawley, A. M. (1986) *Human Ecology: A Theoretical Essay*, University of Chicago, Chicago

Figure 3.1. These elements interactively determine the city shape and functions within the urban geography, and together affect urban phenomena and problems.

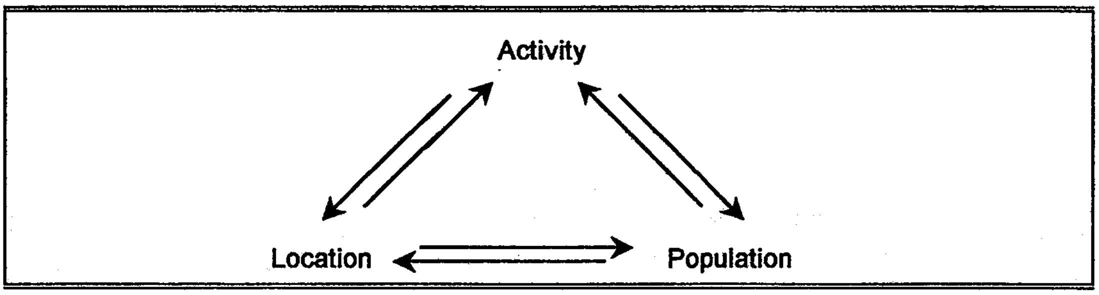

Figure 3.1: Elements of spatial analysis by Lösch

Source: Lösch, A. (1954) The Economics Of Location, p: 224

All these elements of the ecological theory and Lösch's model can also be accepted as elements of fire problem. Since, fire problem is not only a problem of a single structure or occupants living in it, but also an urban problem. Consequently, fire problem elements in urban context could be expressed in terms of occupants, as 'population'; built environment, as 'location'; and fire service, as 'activity'; also the relation between these terms need to be conducted according to Lösch's classical model for determining the problem areas. (Figure 3.2)

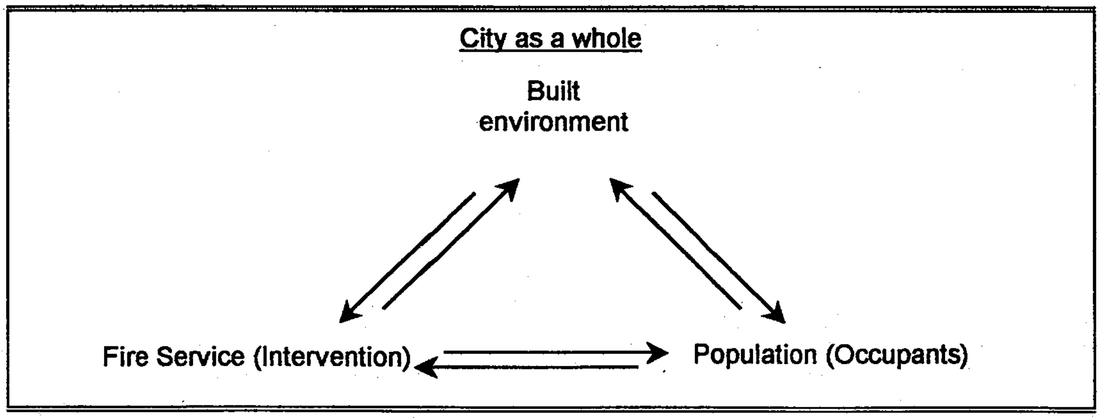

Figure 3.2: Elements of fire problem in the urban context

While determining the fire problem in urban context, population is crucial since main causes of fires are human failure based. Population relation with building stock is influential, since buildings are the places where fire occurs. Also, building stock relation with fire service is notable, since fire department is the urban service that intervene fires when they occur. The city as a whole contains the fire department, the building stock, and the population live in the city when Lösch's model, ecological approach, and fire phenomena are combined. So while studying fire problem in urban environment, a wide range of information about socioeconomic and built environment characteristics, and also organizational inputs should be considered and analyzed together.

3.2 CITY PLANNING AND FIRE PROBLEM

The population and their attendance to economic and social activity take place in urban environment, and this determines the distribution of activities within the built environment. This arrangement forms the basis for studying the distribution of other urban phenomena, so the fire problem, as explained above. Thus, fire safety and risk control methods require knowledge of socioeconomic and built environment characteristics. (Jennings, 1996)

The city planning discipline is the decision-making process for accommodation of economic, social and cultural activities within the urban environment. Fainstein and Fainstein define planning "as the future oriented, public decision making directed towards attaining specific goals". (Fainstein, 1996:265) City plans are implemented for attaining a healthier and systematic urbanization, for protecting and improving the urban environment, and for creating a safe and livable environment for the population. The 'safe and livable environment' purpose involves measures related with fire protection, precaution, and loss minimization for the community. Therefore, city plans has to contain mitigation and management plan for reducing the fire problem in urban environment.

For a fire safe urban environment, potential risks threaten the population and the built environment necessitate to be assessed; afterwards, need to be reduced by control measurements. The fire risk management process has to start at the city level as a base for all other fire risk management processes in built environment. As Alata (1988) remarks in the fire symposium, fire safety only at building scale by the enforcement of laws and regulations would not be functional and analytic unless considering the environmental and socioeconomic factors. Alata suggests that the fire risk management process affects other planning activities and it has to be started by the city plans for intervening the problem at the top. After taking necessary precautions at the city scale, these precaution and prevention measurements could be implemented differently to each building, city part, or entire city according to its unique structural, socioeconomic, environmental, and organizational characteristics.

3.3 URBAN FIRE RISK

As Bjordal (1994) defines, the 'risk' is the function of probability and consequences for unwanted events; especially the ones involve harmful and destructive results to human, environment or materials. Therefore, the 'fire risk' in this thesis is referred to the probability of fire occurrence besides coming across to damages to property or life by a fire. When 'urban' term is considered, measuring only the probability of a fire ignition in a single building or the damage to a single occupant would not be meaningful, since the term 'urban' refers to a system in which whole population, activity, and structures take part together. Thus, the 'urban fire risk' can be defined as the risk affecting whole society beyond the risk threaten the occupants in a single building; furthermore, as the fire risk affected by socioeconomic and built environment characteristics which are determining the urban phenomena.

3.3.1 URBAN FIRE RISK ELEMENTS

Being understood from the risk definition, fire risk could be expressed as the product of two factors: the probability of fire ignition and the probable damage as the consequence of a fire. (Ramachandran, 1994) Fire ignition factor is related with the ignition problem, whereas the probable damage factor is related with a systematic relationship between the determination of fire, the spread of fire, and the response to fire problems.

The main fire problem either at building or at city scale is the fire ignition problem. Fire ignition is defined as the start of a fire. Previous studies determine different fire causes. If fire causes determined in previous studies are gathered, there obtain three basic classes of fires. Class 1 fires are those arise due to a fire originated outside the structure, such as lightning, exposure to fire or heat from adjacent or nearby material, and fires not occurred in structures, as car accident fires. Class 2 and Class 3 fires are those occurred at structures due to either directly or indirectly human failure. Within Class 2 fires, human is secondary factor, while technical failure is dominant such as failures on building systems or installations. Conversely, within Class 3 fires, human factor is dominant, while technical factors have secondary importance, such as careless smoking, arson, and children playing with ignition sources. (Jennings, 1996) (Table 3.1)

Table 3.1: Fire classes and the dominant causes start the fire

Fire Type	Fire Cause		
	Natural Failure	Technical Failure	Human Failure
Class 1	✓		
Class 2		✓	
Class 3			✓

Once the fire started, there appear different problems affecting the probable damage at the end, such as determination of fire, spread of fire, and response to fire. Therefore, there are mainly four risk elements when we consider the built environment and fire science:

1. First is the 'fire ignition risk', related with the factors affecting the start of a fire;
2. Second is the 'fire detection risk', related with the determination of the fire and reporting to the fire department by occupants;
3. Third is the 'fire spread risk', related with factors affecting fire growth; and,
4. The last one is the 'fire response risk', related with intervention and fire fighting operations.

3.3.2 URBAN FIRE RISK FACTORS

In literature, various factors have been determined as effective on fire risk, which mainly concentrated on casual, structural, departmental, social or economical fields separately. Since urban fire risk is the risk threatens the society as a whole, and since urban context covers all these separate fields, as population, location and activity, they have to be considered and analyzed together for attaining a fire safe environment and for studying fire risk at urban scale. Considering the factors determined by different disciplines previously, 'urban fire risk factors', which are hypothesized as related with urban area in this thesis, can be categorized under five main headings:

1. Natural factors
2. Environmental factors
3. Structural factors
4. Individual factors
5. Operational factors

When urban fire problem constituents are considered, environmental and structural factors refer to the 'location' component as built environment, individual factors refer to the 'population' of the city, and operational factors refer to the 'activity' as fire service. Different than these factors directly related with city, natural factors such as visibility or cold weather, have to be considered while assessing and managing the fire risk at urban scale, even they could not be interfered directly by planning decisions. Factors, given in Table 3.2 in detail, affect different fire risk elements, as shown in the Table 3.3. Moreover, these factors affect each other in case of a fire and all must be considered together for fire risk management process in the urban context. Finally, based on the fire classes according to causes, urban fire risk factors and the fire risk elements, the conceptual urban fire risk problem could be schematized as shown in Figure 3.3.

Table 3.2: Urban fire risk factors

URBAN FIRE RISK FACTORS			
Natural Factors	Visibility		
	Temperature		
	Weather conditions		
Environmental Factors	Street conditions		
	Traffic conditions		
	Topography		
	Urban barriers		
	Hydrant and water system		
Structural Factors	Condition		The age of the building
			Vacancy and abandonment
	Construction		Height/Area of the building
			Building typology
			Distance between buildings
			Building density
			Construction material
Individual Factors	Occupant	Economical	Income
			Poverty
			Unemployment
			Ownership
		Social	Education
			Age structure
			Family type
			Household size
			Migration
		Population density	
	Occupancy	Occupancy type	
		Occupancy density	
Operational Factors	Fire department conditions		
	Requirements to operate		
	The distance of fire department		
	Response of fire brigade		
	Duration of extinguishment operation		
	Exposure hazard		
	Simultaneous fires		

Table 3.3: Urban fire factors- risk elements relation

URBAN FIRE RISK FACTORS		URBAN FIRE RISK ELEMENTS			
		Fire Ignition Risk	Fire Detection Risk	Fire Spread Risk	Fire Response Risk
Natural Factors	Visibility		✓		
	Temperature	✓	✓		✓
	Weather	✓	✓	✓	✓
Environmental Factors	Street				✓
	Traffic				✓
	Topography				✓
	Urban barriers				✓
	Hydrant/Water				✓
Structural Factors	Bldg. age	✓		✓	
	Vacant/Abandoned	✓	✓		
	Height/Area		✓	✓	✓
	Bldg. typology			✓	✓
	Bldg. distances			✓	
	Bldg. density			✓	
	Bldg. material	✓		✓	
Individual Factors	Income	✓	✓		
	Poverty	✓	✓		
	Unemployment	✓	✓		
	Ownership	✓	✓		
	Education	✓	✓		
	Age structure	✓	✓		
	Crowdedness	✓	✓		
	Family type	✓			
	Household size	✓			
	Migration	✓			
	Pop. density	✓			
	Occupancy type	✓	✓		
	Occupancy density	✓		✓	
Operational Factors	Fire dept.				✓
	Requirements				✓
	The distance			✓	✓
	Response			✓	✓
	Duration			✓	
	Exposure hazard			✓	✓
	Simultaneous fires			✓	✓

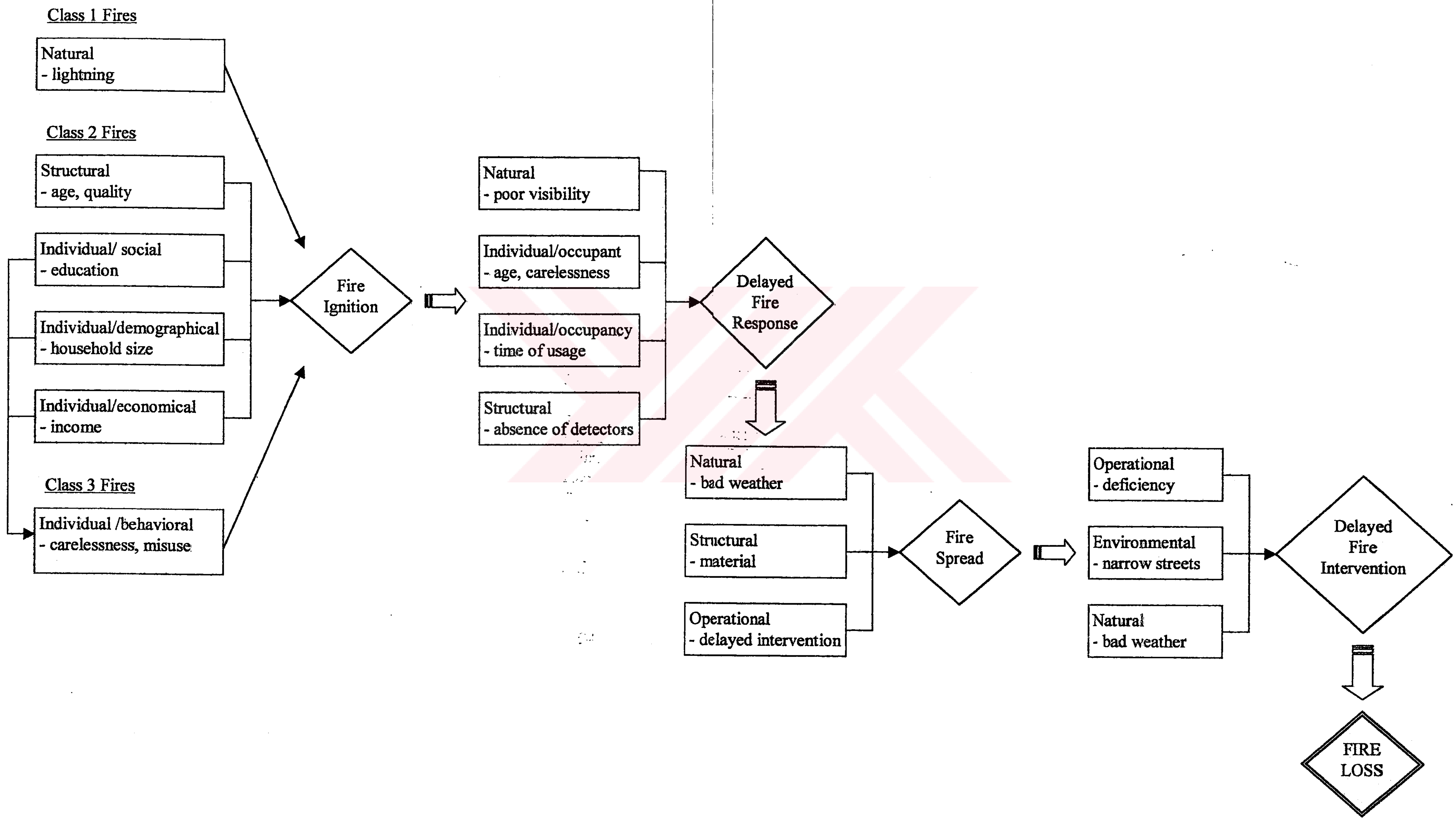

Figure 3.3: Urban fire problem

3.3.2.1 NATURAL FACTORS

Natural factors arise due to climate conditions of the area, and can be classified as visibility, temperature, and weather conditions. It is not possible to intervene and change the natural factors in an area by political or planning decisions, but these factors have to be considered within fire problem.

Smoke, snow, rain, sleet, fog impair the visibility. The poorer the visibility, the more it affects the determination of fire, but mainly the firefighting operation. Poor visibility may delay discovery of the fire and the response of fire department, thereby effect the fire response risk.

Temperature is another factor. As temperature of the outside air increases, it has positive effects on other factors. For instance better street conditions without snows, ice, or open windows makes the discovery of fire more easier, so the response will be much more quicker. Consequently, low temperature, such as frozen hydrants, ice-covered roads, and closed windows that delay the discovery and harden the firefighting operations, has negative effects. Low temperature also increases fire incidents, since more heating devices are used. Increased fire incidents, in turn, affect the operation, because there could happen simultaneous fires.

Weather conditions such as snow, rain, and wind, affect primarily the fire response risk, and secondly the fire ignition risk. Snow and rain can reduce the visibility during discovery and response. Worse street conditions as result of snow and rain slow the response and affect the fire spread risk. Nevertheless rain has a positive effect on reducing the fire spread by wetting probable exposed sides of other buildings. Lightning is an important weather factor for fire ignition risk. Another weather condition, wind velocity, affects the fire spread and fire response risks. Ground winds or winds more than 30 mph are one of the main reasons of conflagrations.

3.3.2.2 ENVIRONMENTAL FACTORS

Environmental factors mainly arise from planning decisions. They are not directly related with fire ignition problem, but affective in fire response risk. They are also affective in the fire spread risk in case of a delay or ineffective detection or intervention. Environmental factors can be categorized as street and traffic conditions, topography, urban barriers, and hydrant and water system.

Streets that are one-way, dead-end, so narrow, or double-sided parked, and street corners that are not arranged properly for turnings constitute problems both for the response of the firefighting units to the area and for the firefighting activities. Traffic jam also causes fire service delays and increases the fire response risk in urban areas.

Topography refers to the physical features of an area such as hills, valleys, rivers, streams, and lakes. Response of the fire service may delay because of one or more topographic features. Especially under unfavorable weather conditions, topography adversely affects the fire response risk; subsequently, the fire spread risk.

Urban barriers include hedges and garden-walls; trees and street lamps around the lots; pedestrian areas where car-entrances restricted by bollards; and billboards. All these barriers restricted the firefighting activities, and increase the fire response risk, and so, the fire spread risk.

The other factor affects the fire response risk is the hydrant and water system of the area. Insufficient water supply and not properly placed or covered hydrants would limit the firefighting activities in case of a fire.

3.3.2.3 STRUCTURAL FACTORS

To understand the variations of fire rates in different neighborhoods, it is useful to understand how neighborhood quality is related with fire rates. Generally speaking, the well being of a residential neighborhood is tied to the structural quality. Structural factors are those arising from the condition, form and material of buildings in an urban area. Factors related with the structure can be categorized as the age of the building, vacancy and abandonment, height and the area of the building, typology, building density, distances between buildings, and construction of the building.

Age of the building is an important indicator for the structural condition and installation situation of the building. The older the building is, the more risk it carries due to low maintenance probability of installation systems. Vacant and abandoned houses increase the fire ignition risk due to the probability of illegal possession of these buildings by homeless people and due to the lack of good and necessary upkeeps. Vacancy and abandoned also affect the fire detection risk because of non-use.

Height and area of the building affect the fire intervention risk, and therefore the fire spread risk. In a case where other conditions being equal, a one-story building has lower fire spread and fire intervention risks than a five-story building. On the other hand, large-area structures like supermarkets have negative consequences both in determination of the fire and the response to the fire area. Also, escape can be a problem in large-area or high-rise buildings, so the risk to occupants increases. Moreover the height and the area of the building, the building typology is also important in fire detection, spread and response risks in an urban area. Building typology indicates building's entrance type, height, and order in lot. Effectiveness of fire fighting activities is also depends on the building typology.

The distance between buildings also has to be considered, since fire exposure to nearby buildings is related with the distance. As Egan (1978) cited in his study, NFPA determined some schedules and formulated the necessary distance between two buildings by assuming the window opening proportions are same. The formula determined by NFPA is,

$$d = FN + 5$$

where d refers to the distance between two building, F refers to the building height or width, and N[2] refers to a constant determined according to fire spread severity and rate between open and closed parts of structure.

Building density in an urban area affects the fire incidence and fire spread risks. As the density increases, both the fire occurrence probability and the loss due to fire increase. This is because of the fact that in areas where density is high either buildings are high-rise, or buildings are so close each other so that the distance between them is insufficient.

Materials used in the construction affect the fire spread risk. "Fire resistiveness in buildings depends on the manner in which floors, walls, partitions, ceilings, columns, and girders are constructed". (Walsh, 1977:35) The fire spread rate according to construction material of two nearby buildings is shown in Table 3.4.

Table 3.4: Fire spread risk according to construction material by Egan

Source: Egan, M. D. (1978) Concepts In Building Fire Safety, p: 54

Fire spread risk	Construction material	Interior material
High	Timber	Timber
Medium	Timber	Timber covered with plaster
	Non-flammable	Timber
	Fire-resistant	Timber
Low	Non-flammable	Timber covered with plaster
	Fire-resistant	Timber covered with plaster

[2] For N values refer to Egan, M. D. (1978) *Concepts In Building Fire Safety*, p: 56

3.3.2.4 INDIVIDUAL FACTORS

Previous studies show that there is a relation between fire incident and population characteristics. Individual factors, including occupancy and occupant characteristics affect mainly the fire ignition and the fire detection risks. Occupancy factors includes building usage and behavioral factors of occupants, whereas occupant factors are related with social and economical characteristics of people within the urban area, such as income, poverty, education, household size.

Occupant factors, or socioeconomic factors, mainly reflect the socioeconomic characteristics of households and individuals. They are the best-known predictors of the fire rate at city level, especially for residential fire rates. The statement behind this assent is that even structural factors of buildings have an effect on fire incidents, it is much more important how occupants use and maintain those buildings. Occupant factors basically affect the fire ignition and the fire detection risks. Income is determined as the main factor affecting fire ignition risk at urban scale in previous studies. Inadequate income reflects population, who is living in bad housing conditions, limited resources for prevention and protection measurements, and negligence of building and installation systems. Limited income also reflects risky usages or behaviors, such as improper heating or cooking devices. For reflecting the relation between the age structure of the population and fire rate, the percent of young and elder population is used in previous studies, because they are representing risky behaviors for starting fire, such as playing with matches for children, and also because they are over-represented among the fire victims. Education level is also used as risk factor due to reflecting the sensitivity and consciousness of the individual about fire problem. Besides, it is noted that the increase in population density and household size also increases fire incidents. Household type, or family structure is also determined as related with fire risk. Households living alone, or single parent families introduce risky behaviors.

Occupancy factor reflects the content of the structure according to the occupants, and affects fire ignition and detection risks within the structure. In literature, it is stated that different occupancy types have different fire rates and contain different fire risks due to content and occupant behavior inside. Occupancy type is generally classified such as residential, commercial, public, and so on. Content, determined along with occupancy type is generally named as fire load of the structure. (Table 3.5)

Table 3.5: Occupancy type and fire loads by Stollard and Abrahams

Source: Stollard, P., Abrahams, J. (1991) Fire From First Principles, p: 77

OCCUPANCY TYPE	FIRE LOAD
Houses	Low
Flats and apartments	Medium
Residential institutions (hospital, prison, etc.)	High
Hotels and boarding-houses	Medium
Offices, commercial, schools	Medium
Shops	Medium
Assembly and recreation (theatres, cinemas, etc.)	High
Industrial	
a. High ignition risk (oil, furniture, plastics)	Very High
b. Medium ignition risk (garages, printing, textile)	High
c. Low ignition risk (metal working, electrical, cement)	Medium
Storage	
a. High fuel risk	Very High
b. Medium fuel risk	High
c. Low fuel risk	Medium
Car-parks	Low

Occupancy type also reflects the behavior of people in case of a fire, especially while escaping. There are 5 main factors when the behavior of occupants is considered. The first is the 'sleeping risk'. The fire risk of the building in which occupants are sleeping is more dangerous than the fire in a daily-use building. Since the occupants are sleeping, fire would be detected late, and so it would get bigger. Also, when it is detected, the occupants would be sleepy and would give reaction slowly. The second factor is the number of the occupants in a building. For obtaining an efficient escape, the number of the occupants has to be known. The number is related with the use of the building. Stollard and Abrahams generalizes the occupant numbers in different occupancy types, as it is seen in the Table 3.6.

Table 3.6: Occupancy type and occupant numbers

Source: Stollard, P., Abrahams, J. (1991) Fire From First Principles, p: 57

Occupancy	Occupant
Houses	5 x bed spaces
Flats and apartments	5 x bed spaces
Residential institutions (hospital, prison, etc.)	3 x bed spaces
Hotels and boarding-houses	2 x bed spaces
Offices, commercial, schools	OLF[3]: 6
Shops	OLF: 2
Assembly and recreation (theatres, cinemas, etc.)	
a. High ignition risk (oil, furniture, plastics)	OLF: 0.5
b. Medium ignition risk (garages, printing, textile)	OLF: 0.7
c. Low ignition risk (metal working, electrical, cement)	OLF: 1
Industrial	OLF: 5
Storage	OLF: 15
Car-parks	2 x parking places

Mobility is the third factor of occupancy. It reflects the escape speed of the occupants in case of an emergency. Especially disabled, elderly, children would not be so fast as a normal person. The forth factor is familiarity, which means that if the occupant knows the building well, the escape would be much more easier. The last factor is response to the fire alarm, including the differences between reactions of occupants to the fire alarm. The problems due to the human behavior differentiation in case of an emergency and escape situation are shown in the Table 3.7.

[3] OLF: Occupancy Load Factor: The area to be considered in square meters is divided by the occupancy load factor for getting a rough guide to the maximum numbers to be expected. The total for a large building would be calculated by adding all OLFs for each individual area. No account is normally taken for the circulation areas.

Table 3.7: Human behaviors according to occupancy type

Source: Stollard, P., Abrahams, J. (1991) Fire From First Principles, p: 61

OCCUPANCY TYPE	Sleeping	Number	Mobility	Familiarity	Response
Houses	X	-	-	-	X
Flats and apartments	X	-	-	-	X
Residential institutions	X	X	X	-	-
Hotels and boarding-houses	X	-	-	X	X
Offices, commercial, schools	-	X	-	-	-
Shops	-	-	-	X	-
Assembly and recreation	-	-	-	X	X
Industrial	-	-	-	-	X
a. High ignition risk	-	-	-	-	-
b. Medium ignition risk	-	-	-	-	-
c. Low ignition risk	-	-	-	-	X
Storage	-	-	-	-	-
a. High fuel risk	-	-	-	-	-
b. Medium fuel risk	-	-	-	-	-
c. Low fuel risk	-	-	-	-	-
Car-parks	-	-	-	-	-

3.3.2.5 OPERATIONAL FACTORS

Figure 3.4 gives the fire department intervention schema and the time series in general. As seen from the figure, firefighting operation starts with the report of fire to the department, and lasts till the extinguishment completed. Departmental factors contain the extinguishment efforts of the fire fighting service in case of a fire; thus, these factors affect the fire spread and fire response risks. The most important element here is the fire department. As the fire department conditions get better, it can give effective and efficient fire fighting services. Requirements for fire fighting operation, which include water supply, apparatus, equipment, personnel, and special extinguishing agents is another factor affecting the service effectiveness and efficiency. The distance of the fire department to the fire area is so important for reducing the damage to life and property. (Walsh, 1977)

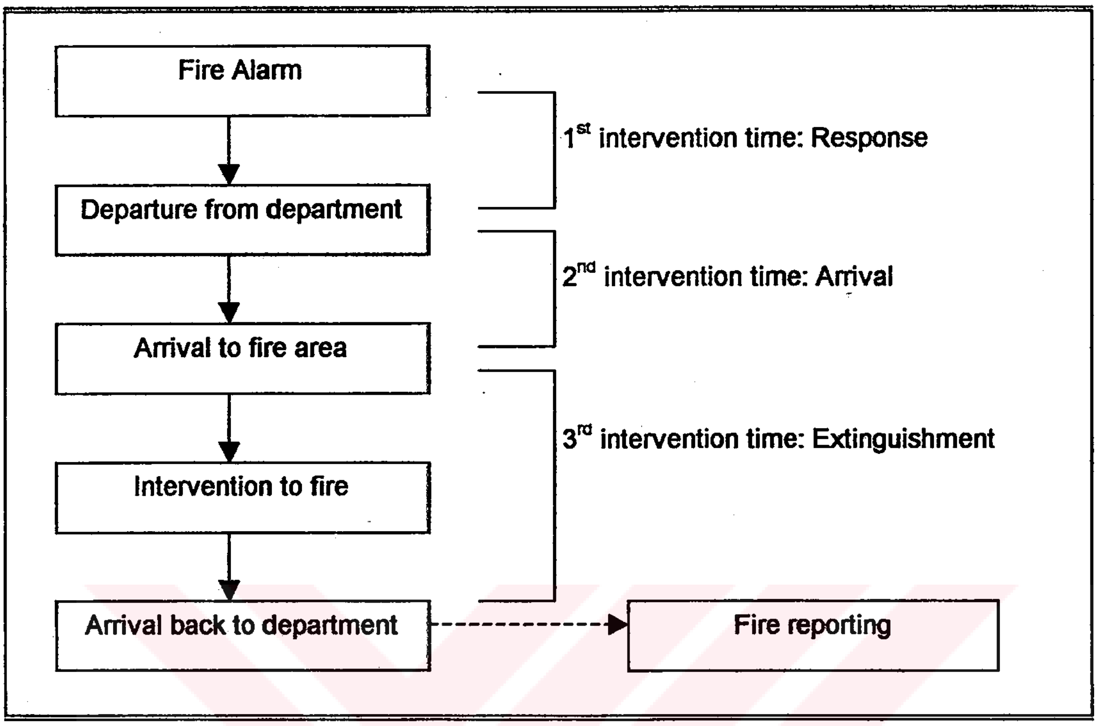

Figure 3.4: Fire department intervention and time schema
Source: Meşhur, M. C. (1997) Fire Brigade As An Urban Service, p: 42

Time of fire including the month, day and hour when fire occurred can be used for measuring the effect of different factors on fire incidents. Time of fire as month reflects the seasonal effects, such as snow or rain; hence, these elements are highly related with weather conditions. Day and hour factors give information about periods more risky according to occupancy characteristics of the structure. For example, most work places are closed at weekends; therefore, fire discovery and alarm can be a problem in such occupancies at weekends. Similarly, night fires can be more risky in residential structures, due to the occupancy factors such as sleeping factor. Duration of the operation, different than other time factors, means the period between the time fire service arrival and the time when fire is completely extinguished. Time factors related with the fire occurrence as month, hour, or day affect the fire incidence and fire spread risk, whereas the duration of operation affects only the fire spread risk. Other than these time factors, response period of the fire brigade is also important due to its effect on fire response risk.

In addition to departmental and time factors, exposure hazard and simultaneous fires affect operations, so the fire response risk. The possible spread of fire through the interior areas of the structure or through the exterior structures is called as 'exposure' of fire. The quicker the arrival of the fire brigade to scene is, the less probably fire expose to other areas or structures. If fire is controlled before he exposure of fire to other areas or buildings, loss of life and property will be reduced. 'Simultaneous fires' refers to several alarms at the same time. Simultaneous fires, even one more alarm, could delay the intervention of fire brigades; consequently, the fire spread and intervention risks increase. (Walsh, 1977)

3.4 URBAN FIRE RISK MANAGEMENT MODEL

Risk management is a decision making process in which the risk is evaluated and control measures are determined based on risk assessment. As reviewed in theoretical framework, several models are developed for managing the risk in different disciplines and they all have common steps based on the classical model. More broadly, Staples and Kimerle (1987) define the classical risk management process as 'the cycle of problem solving'. (Figure 3.5)

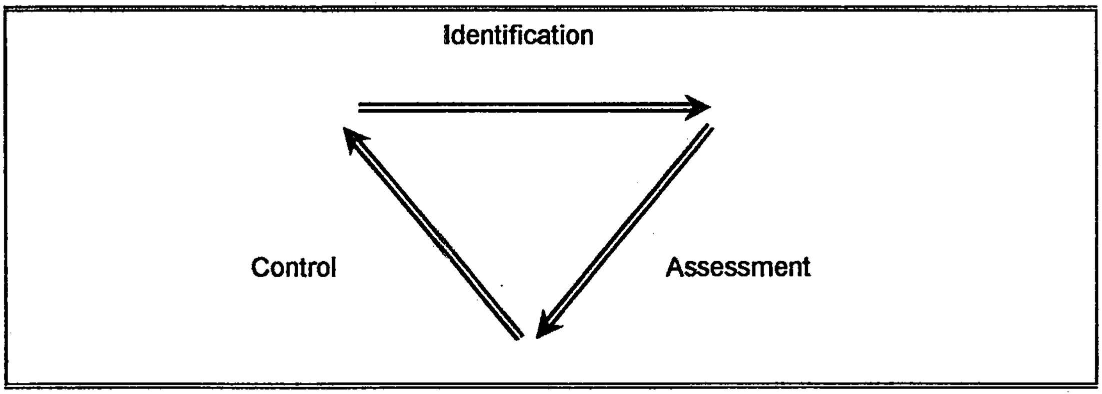

Figure 3.5: The cycle of problem solving by Staples and Kimerle

Source: Staples, C. A., Kimerle, R. A. (1987) The Cleanup Of Chemical Waste Sites, p: 63

Researches indicate that risk could be reduced if the nature of threat is known, 'identification'; if the risk potential based on signs and symptoms are determined, 'assessment'; and if the risk management practice is incorporate into the plans, 'control'. The model of the urban fire risk management, therefore, can be formed as seen in the Figure 3.6, based on the classical risk management schema.

Before following implementation process of steps, objectives have to be determined at the outset for applying a model. The urban fire risk management plan should include various objectives, such as:

1. Attaining a fire safe environment for the population by city plans;
2. Introducing a base fire safety schema for the structures built within the city;
3. Developing options such as regulations and remedial solutions;
4. Inducing community participation for development of proper solutions and implementation of the plan;
5. Considering the social, political, economic and scientific impacts in the process of selecting proper solutions.

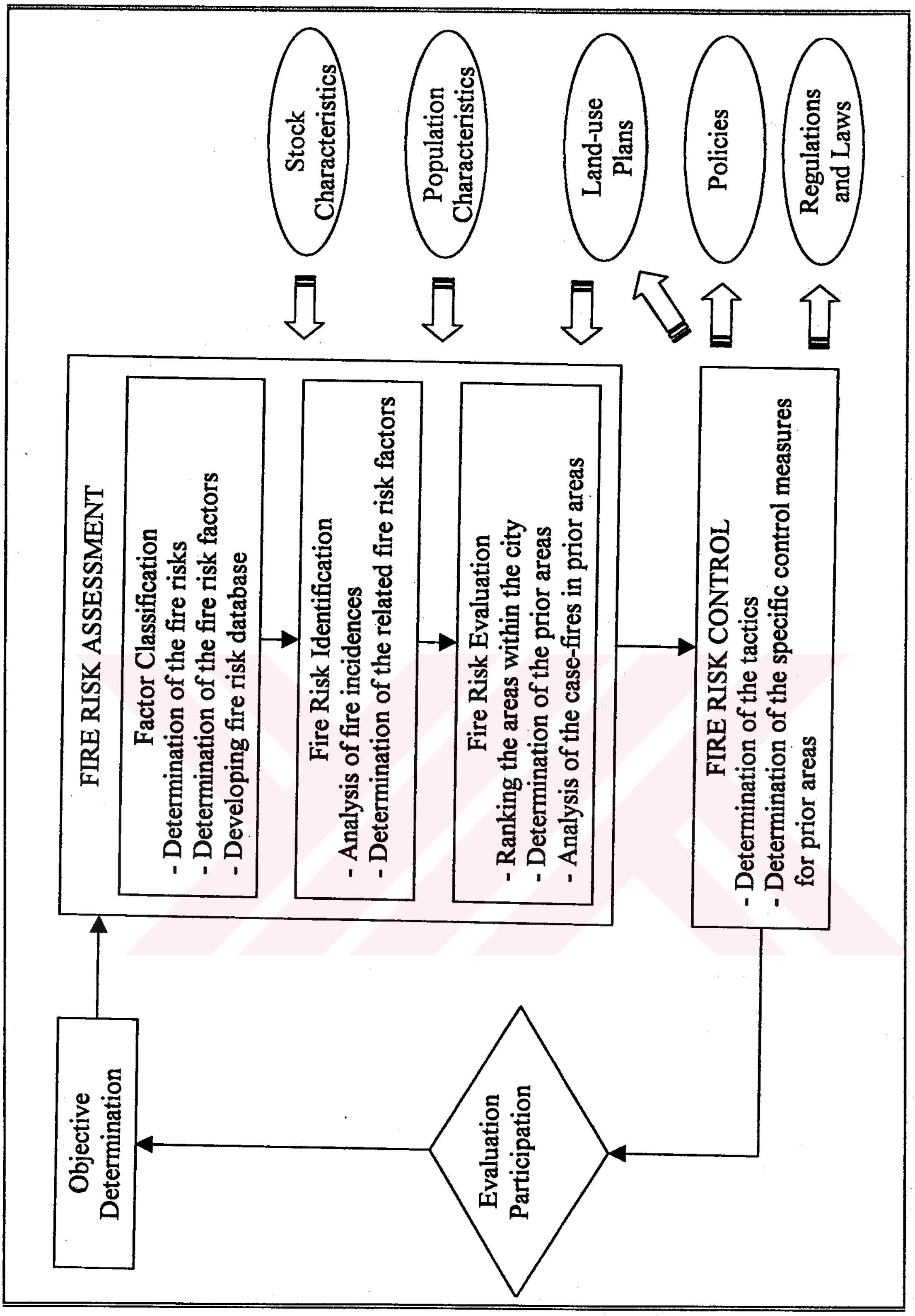

Figure 3.6: Urban fire risk management model

3.4.1 FIRE RISK IDENTIFICATION

The management process starts with the fire risk identification stage whose purpose is to define the data set with 'the factor classification' and 'the fire risk database formation steps. The third step, 'the fire incident analysis' identifies the fire problem within the urban environment by analyzing past fire incidents. This stage is important by means of fire risk factor classification and the database arrangement.

The factor classification step is important for database preparation and fire risk factors determination, since "accurate and well-defined empirical statistical databases are prerequisites both for risk management in general and for progress in most of the problem areas". (Doderlein, 1994:5) Databases form the basis for risk management studies, however they are generally inadequate in data definition, collection, handling, and accuracy. That is because data requirements are not defined on the bases of the specific risk management uses. Therefore, there is a need for arranging and matching various raw data for specific use by the fire risk database formation step. In these two steps, the urban fire risk elements and fire risk factors are overviewed. After objective and subjective data are gathered, checklist that contains the identified fire risk factors is prepared.

Fire incident analysis step includes gathering of information about past fire incidents and describing the fire risk profile, as a vehicle for summarizing the fire problem in the urban environment. As the result of this stage, an overall fire problem in the urban area is obtained.

3.4.2 FIRE RISK ASSESSMENT

After fire risk factors are determined and fire problem is identified in urban environment, the second stage, fire risk assessment starts. The fire risk assessment stage is so important, since control measures for reducing the risk are based on the determination attained in this stage. Heino and Kakko (1998) state that the information gained from risk assessment at urban scale could be used for decision support during an emergency, as well as for the prevention and preparedness decisions. Moreover, St. Louis and Wilder (1999) appraise the fire risk assessment stage so critical in identifying weaknesses. They claim that related organizations would be prepared for such a fire incident and all of the rescues would be accomplished, only if previous risk assessments would identify the possibility of such a situation. Fire risk assessment stage includes two steps: the first step is the fire risk determination, and second is the fire risk evaluation.

After database is conducted and fire risk factors are determined, the relation of fire risk factors with fire rates and fire loss are examined for determining the mostly related factors in the urban environment by the fire risk determination step. The main purpose of this step is to determine related factors affecting the fire risk in urban environment. After related fire risk factors are determined, they are ranked according to how effective they are on fire risk. The success of the risk management system depends on the reliability of risk determination stage. A poorly conducted risk determination study at which some of risk factors are skipped can bring more risks. Therefore, all related factors have to be considered simultaneously.

Following the determination of fire risk factors, the fire risk evaluation step starts. The aim of this stage is to determine the most risky areas or neighborhoods within the city by considering most related fire risk factors. As a result of the analysis, a ranking map is obtained at quarter, neighborhood, or district scales. The most risky areas, which are determined by ranking map, are examined in detail for understanding which fire risk factors are dominant.

3.4.3 FIRE RISK CONTROL

During this stage, two facts about the fire risk management determined by previous studies have to be considered. The first fact is that every building and every city contains fire risk because of the human factor they involve, since most fires are human failure based. The second fact is that the fire risk of every building and every urban area is not same, since many factors such as climate, city plans, socioeconomic characteristics and structural factors influence fire rates. Due to the first fact, it is impossible to eliminate the fire risk. Therefore, fire risk has to be managed for reducing damages and losses. According to the second fact, it is not meaningful to apply same control methods to every building or city for managing the fire risk.

In this stage, necessary control measures for fire risk are selected. There are mainly three measures for controlling the risk in the literature: avoidance, transfer and reduction. Avoidance means to eliminate the risk completely, but due to the first fact explained above, it is not so meaningful to use this measure as a fire risk management strategy. The second measure is to transfer the risk to a third party. This measure is generally implemented in insurance companies, as transferring the risk of a person or organization to the insurance company. This kind of a control measurement can be applicable for financial risk management models, but in case of risk where human life is exposed, it is not possible to transfer the risk to a third party. This is also against the city-planning notion, which aims to attain a safe and livable environment for the population. The last control measure, reduction is the most meaningful and realistic measure in urban fire risk management model. Reduction is the control measure aiming to minimize the fire loss by precautions for preventing the fire ignition or, if fire arise, for controlling and extinguishing the fire by immediate intervene, if fire arises.

The fire risk both in urban environment and in structures can be reduced by means of active or by passive measures. Active measures are either those implemented to the structures in design and construction phases, such as fire hose cabinets, sprinklers, detections, alarms or those related with the fire intervention and extinguishment, such as fire departments. On the other hand, the passive measures are either put into operation in design or construction stages of the structure, such as proper installation, fire-resistant material usage, escape route designs, or designed in the city plans, such as sufficient water supply, hydrant systems, big openings and green areas for reducing conflagrations. Other than these active and passive measures, there are also other reduction measures, related with the precautions for preventing the fire ignition. The first measure concerning the population is education for becoming conscious about the fire risk they are exposed to in their daily lives. Another control measure is committed to fire departments for giving a better service to the community by organizational and operational fire risk management plans. Above all these control measures, the administrative measures have to be set by codes, laws, and standards.

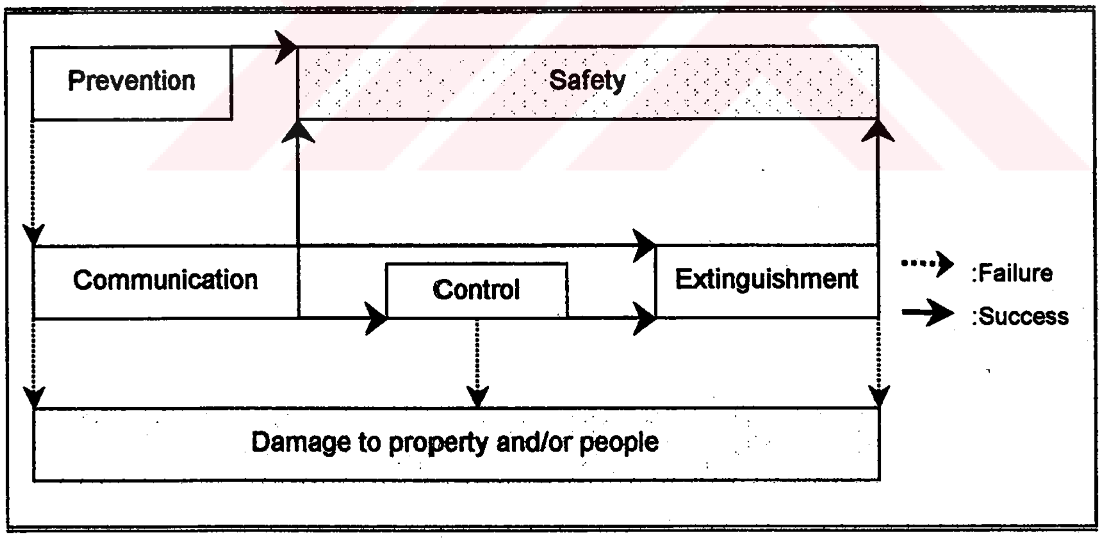

Figure 3.7: Fire risk control tactics matrix

In structural fire safety and risk management literature, there are mainly five tactics for reducing the fire risk that were prevention, communication, control, escape, and extinguishment. The matrix of fire reduction tactics, modified to urban fire risk management model, is represented in Figure 3.7.

While determining tactics, the relation of tactics with fire risk factors should also be set, since the components of main fire risk factors affect fire management tactics differently. (Table 3.8) Besides, each tactic has an affect on fire risk elements as prevention related with fire ignition risk, communication related with fire detection risk, control and extinguishment related both with fire spread and fire response risks. (Table 3.9)

Table 3.8: Fire risk factors and risk control tactics relationship matrix

CONTROL TACTICS	FIRE RISK FACTORS				
	Natural	Environmental	Structural	Individual	Operational
Prevention	✓	✓	✓	✓	
Communication			✓	✓	✓
Control		✓	✓		✓
Extinguishment		✓			✓

Table 3.9: Fire risk elements and risk control tactics relationship matrix

CONTROL TACTICS	FIRE RISK ELEMENTS			
	Fire Ignition Risk	Fire Response Risk	Fire Spread Risk	Fire Intervention Risk
Prevention	✓			
Communication		✓		✓
Control			✓	✓
Extinguishment			✓	✓

These tactics are applied in urban environment via implementations, which are organized by integrated regulations. Regulations should have a three-branched integrated policy in which the first regulating the building codes and standards, the second about the land-use, emergency and contingency plans, and lastly the third branch concerning the fire department organization and operation standards. Since the risk management is an on-going process, it is needed to evolve and develop the regulations and implementations in certain times by considering the changing urban phenomena and conditions. Within the whole process, especially while developing and operating regulations, community participation is crucial, since the basic implementer and the controller of plans and operations would the public, occupants.

3.5 NOTES ON MODEL

As cleared while constructing theoretical and analytical frameworks about fire problem, fire incidents are highly influenced by socioeconomic and built environment characteristics. But also it is noted that there is no well-defined and complete model for defining and determining fire risk at urban scale. Firstly, the conceptual model represented in this chapter comprises all fire risk factors, which have been studied separately within different disciplines previously Moreover, it clarifies the fire incidence analysis and allows identification of relationships between fire incidents and urban elements, defined as population, activity and location. By urban fire risk identification and assessment implementations, fire risk differentiation between urban parts or neighborhoods would be applicable, so the selection of control measurements and methods according to risk distribution within different urban parts or neighborhoods.

This kind of a conceptual model firstly necessitates an adequate data set capable for carrying assessment process according to all fire risk factors. Afterwards, a complete empirical study on political, organizational, and regulative side of the fire phenomena is needed for implementing the fire risk control stage of the model.

In following chapters, urban fire risk identification and assessment stages of the model will be implemented for testing and determining the relation between fire incidence and socioeconomic characteristics within the case study area. Fire incidence analysis and fire rate relation with individual factors will be performed. Based on analysis, fire risk zoning maps in related with socioeconomic characteristics will be presented.

CHAPTER IV

FIRE RISK IDENTIFICATION - URBAN STRUCTURAL FIRES

Urban fire risk identification stage will be tried to put into practice in this chapter. Before operating the fire risk assessment process, this chapter will constitute a descriptive background for the implementation of the model by describing the data set and determining fire risk factors. Thereafter, this chapter will sketch the fire problem in Altındağ and Çankaya districts in 1998 with reference to fire incident reports.

The first section of this chapter will clarify different data sources and detail the procedure for gathering and processing these data sets, which will be used for analysis later. Variables, obtain in the 'fire risk factor classification' step will then be used for determining related fire risk factors within the study area in the next chapter where assessment stage will be put into practice. The second section will present the fire problem in the study area through analyzing fires reported by the Ankara Fire Department in 1998. Fire incidence reports contain significant variables for obtaining a general profile of fires. The urban fire profile analysis will be carried under three subheadings after giving general information about fires. Chapter will be finished by underlying some significant findings on fire incident analysis at quarter scale.

4.1 FACTOR CLASSIFICATION – DATA SET

Two data sources are utilized for assessing urban fire risk relation with socioeconomic characteristics of the population in the selected study area, Altındağ and Çankaya districts of Ankara[1]. The first data is fire incident reports, and second is the Census of Population. Fire incidence data is based on Ankara Fire Department records for the calendar year 1998, whereas for socioeconomic profile of the study area, the 5% sample data from 1990 Census of Population for Ankara is used.

The first data set, fire incident reports, contains information on the location, date, time, cause, loss and circumstances related to all fires occurred in the city. Ankara Fire Department keeps detailed reports for every fire call to the department, even good intent or false calls. These reports are recorded on a standard form determined by the Ministry of Internal Affairs. (Appendix A) Non-standardize form of filling out these records requires standardization for carrying out analysis. The coding system is prepared according both to variables and codes stated in previous studies in literature and to NPFA 1900 codes. (Appendix B)

Second data set, the Census data includes information on social and economic composition of the population living within the urban area. The Census of Population dated in 1990 is used in this thesis. For achieving in-depth analysis, five percent systematic representative sample of Census data related to the study area is handled.

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[1] The main data source of analysis is fire incident reports obtained from the Ankara Fire Department. Since fire incidence reports are used as evidence in courts, it was not allowed to photocopy, but only allowed to computerized reports in the headquarter of Fire Department by special permission from the Mayor of the Greater Metropolitan Municipality of Ankara. Coding written-format records into computer was very time intensive; for this reason, only fire incidences in two main districts of Ankara, Altındağ and Çankaya, could be obtained in a limited time. Therefore, as a motivation and deficiency of fire data set, two districts within the boundaries of the Greater Municipality of Ankara, Altındağ and Çankaya districts were selected as case study area for this thesis.

4.1.1 FIRE DATA SET – PREPARATION AND CODING

For the year 1998, Ankara Fire Department intervened 2914 fire incidents within the metropolitan area in total. These fire calls can be categorized under three main headings according to where they occurred: structural fires, vehicle fires, and outdoor fires including brush, garbage, stubble fires. Omitting vehicle and outdoor fires, the study is based on only structural fires in Altındağ and Çankaya districts, accounted for 867 fires in total.

The geocoding and merging variable is determined as quarter codes, since analysis will be carried out in quarter tracts. Because Ankara Fire Department records the mailing address of the structure in which fire occurred instead of the quarter code, it is required to geocode the fire reports. All addresses recorded by the Fire Department are converted into quarter codes[2]. However, 40 fire incidents out of 867 structure fires are omitted from the data set because of missing address information. Thus, the number of fires decreases to 827. Furthermore, these structural fires contains turning backs in halfway, false calls and good intent calls besides interventions, due to the fact that every call to department is recorded[3]. (Table 4.1) In this study, only structural fires intervened by fire brigades will be taken into account, and turning backs in halfway, good intent and false calls will be eliminated, as a consequence of missing entries in data set. Therefore, the final fire data set contains 682 structural fire incidents, occurred in Altındağ and Çankaya districts during the year 1998.

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[2] But as underlined before, although fire reports are unique, there is no standardized coding format for filling these forms. Thus, while the address of building experienced fire has been registered, there could be mistakes, such as wrong entry of the street number, or the quarter name. For eliminating possible mistakes, addresses in each report were controlled from the detailed street and quarter map-book prepared by *'Ankara Şoförler Odası'* (Chamber of Taxi Drivers of Ankara). As the result of this attempt, nearly all quarter codes of addresses were determined.

[3] Turning back in halfway means that fire has occurred in the structure, but put out by intervention of occupants, so fire brigade has returned to the department without intervention. In case of good intent and false calls, fire brigades have gone to the structure addressed as fire origin, but have not came across with a fire situation.

Table 4.1: Frequency distribution of Ankara Fire Department intervention status to structural fires - Altındağ and Çankaya Districts, 1998

Intervention Type	Frequency	Percent	Valid Percent	Cumulative Percent
Intervention	710	81,89	81,89	81,89
Turning back in halfway	88	10,15	10,15	92,04
False calls	20	2,31	2,31	94,35
Good intent calls	49	5,65	5,65	100,00
Total	867	100,00	100,00	

Table 4.2: Structural Fire Incident Data Set – Altındağ and Çankaya Districts, 1998

Fire incident data set Total case number: 682 structural fires	
Variable abbreviation	Variable definition
district	District code where fire occurred
quarter	Quarter code where fire occurred
firecode	Unique code of fire recorded by Ankara Fire Department
month	Month when fire occurred
day	Day fire occurred
hour	Time of the day when fire occurred
time_res	Time in how many minutes the fire brigade arrived to scene
time_dur	Time in how many minutes fire has been suspended
time_all	All time of fire (time_res+time_dur)
int_type	Intervention type of the fire brigade to the fire
const_mt	Construction material of the structure where fire occurred
use	Occupancy type of the structure in which fire occurred
orgn	Origin where fire occurred
own	Ownership status to the structure in which fire occurred
insum	Insurance status of the structure in which fire occurred
fire_ty	Fire type
fire_st	Fire situation when fire brigade arrived to the scene
extng_st	Extinguishment type fire brigade applied to the fire
cause	Cause of the fire
factr	Factor of the fire
loss_prop	Damage to the property as a consequence of the fire
Inj_all	Total number of person injured
dth_all	Total number of person died in case of fire
fire_brg	Fire brigade which intervened the fire

Fire incident reports contain significant variables for obtaining a general profile of structural fires. As a result of coding and standardizing incident reports, loss variables indicating the damage to property and life; time variables including both the time variables of fire occurrence and period variables of response and duration of fire; property variable indicating the origin where fire occurred, the property class, and ownership; and root variables comprising of causes and factors of fires are obtained. (Table 4.2)

4.1.2 CENSUS TRACT DATA – PREPERATION AND RECODING

The 1990 Census questionnaire consists of four parts; address information, characteristic of the property in which household lives, information related to household, and information about the characteristic of each household member. The sample Census data contains of each individual recorded within the dwelling of the selected 5% sample household, either household member, or non-household member. For the study area, there are 57365 individual entries. By using the variable '*özel*' (special), which is a code for differentiating household and non-household members, individuals recorded as non-household member, which accounted for 4393 entries, are omitted from the sample. Thus, only the individuals of the households are sorted. Consequently, there are 52972 individual entries and 13510 household entries in the final Census data set for the study area[4].

Household size (number of individuals in the household) is stated as an indicator of fire risk in previous studies about socioeconomic analysis of fire incidences. Nevertheless, in Census questionnaire, household size is not directly recorded. Thus, household size is calculated by using other related

[4] Out of 52972 entries, there were 1993 individual entries whose quarter codes did not entered because of security reasons. Since using quarter codes will perform geocoding and merging data set, it was necessitated to arrange missing quarter codes. Instead of omitting these entries, they were assigned to quarters according to each quarter's representation population rate. For obtaining a correct assignment, this distribution was carried for each district separately.

variables, after eliminating non-household members. Household size is found by subtracting recorded guest number from total population recorded within the household dwelling on census day, and then adding recorded absent number of household members at the census day.

Similar to household size, another important socioeconomic characteristic predicted as related with fire incidence rate in the literature is income of the household. Income of household has not been recorded in monetary terms while census has been carried out. So, income profile determined by another research (Güvenç, 2001a) is used as a base in this study. Güvenç prepares the income status map of Ankara by using ownership, owing another dwelling, and employment status variables from 1990 Census data for determining the distribution of income status within quarters of Ankara. The income status distribution components are determined by formulating segregation matrixes. (Güvenç, 1998) (Güvenç, 2001b) Based on Güvenç's study, recoding is performed and three income status groups are obtained. Income status determination is carried out only for household heads, which were at home in census day. (Appendix C)

Other arrangement on Census data is executed on three different variables related with work status of individuals for determining unemployment rate. Individuals aged at 11 and below are defined as non-applicable variables. Individuals, recorded as not working, but seeking for job are recoded as unemployed. A new variable defining the work status of individual is obtained, which indicates whether the individual is working, or not working, or unemployed. (Appendix C)

For analyzing the effect of age structure and schooling factor on fire rate, these variables are grouped according to previous studies. At the end of data preparation and recoding, two socioeconomic data sets of study area were obtained. (Table 4.3, Table 4.4) The first data set contains individual entries of members of each household, whereas household entries are represented in the second data set. Variable codes are given in Appendix C.

Table 4.3: Census Data Set, for individual entries – Altındağ and Çankaya Districts, 1998

Individual Census Data Set Total case number: 50978 individuals	
Variable abbreviation	Variable definition
district	District code of individual recorded
quarter	Quarter code of individual recorded
hhcode	Unique household code of individual recorded in
indcode	Unique individual code
age	Age of the individual
resprv	Permanent resident of the individual
resprv5	Permanent resident of the individual 5 years ago
lit	Literacy status of the individual
sch	Last school individual graduated
work	Working status of the individual

Table 4.4: Census Data Set, for Household entries– Altındağ and Çankaya Districts, 1998

Individual Census Data Set Total case number: 13510 households	
Variable abbreviation	Variable definition
district	District code
quarter	Quarter code
hhcode	Unique household code
hhsize	Household size
income	Income status of household head
hhtype	Household type
owner	Household's ownership status to the dwelling they live in

4.1.3 FINAL DATA SET PREPARATION AND MERGING

In this thesis, SPSS[5] and Excel[6] software programs are used for preparation and analysis of socioeconomic and fire incidence variables, whereas Geographical Information System (GIS) is used for placing common geographic coordinates on each variable of data sets. For applying GIS, MapInfo[7] software program is used. After fire incident reports are coded in Excel program and obtained a computerized database format, it is transferred to SPSS statistical analysis program for carrying out analysis.

For constituting basis to spatial analysis, it is needed to overlap these three data sets into a common geography. Matching district and quarter codes recorded both in the Census data and in fire incident reports attains integration of three data sets.

For integration of individual and household census data sets, unique household and individual codes are used, and average or percentage values of variables are assigned in quarter scale. Subsequently, final census data set indicating socioeconomic characteristics of quarters was attained. Resembling to socioeconomic data set preparation in quarter scale, fire data set in quarter scale is attained by assigning average or percentage values of variables. Final quarter data sets of fire and census data are merged by quarter codes as key variable in SPSS. (Table 4.5)

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[5] SPSS for Windows Release 9.0.0 Copyright © SPSS Inc.
[6] Microsoft ® Excel 2000, Copyright © Microsoft Corporation
[7] MapInfo Professional Version 4.0, Copyright © MapInfo Corporation

Table 4.5: Final socioeconomic factors data set – Altındağ and Çankaya Districts, 1998

Final Data Set Total case number: 199 quarters	
Variable abbreviation	Variable definition
Explanatory variables	
district	District code of individual recorded
quarter	Quarter code of individual recorded
allpop	Total population of the quarter
density	Population density of the quarter
hhtype_1	Per. of households as couples without children
hhtype_2	Per. of households as couples with children
hhtype_3	Per. of households as lone parent with children
hhtype_4	Per. of households as extended families
hhtype_5	Per. of households as solitaries
hhtype_6	Per. of households as no couple groups
income_1	Per. of Low-income households
income_2	Per. of middle-income households
income_3	Per. of high-income households
work_1	Percentage of working population
work_2	Per. of non-working population
work_3	Per. of unemployed population
age_1	Per. of population aged at 7 or below
age_2	Per. of pop. Aged between 8 and 15
age_3	Per. of population aged between 16 and 59
age_4	Per. of population nagged at 60 or above
res_1	Per. of pop. whose residence is not Ankara
res_6	Per. of pop. whose residence is Ankara
res5_1	Per. of pop. whose residence was not Ankara 5 years ago
res5_6	Per. of pop. whose residence was Ankara 5 years ago
lit_4	Per. of population who can read and write
lit_5	Per. of population who cannot read and write
own_1	Per. of owner-occupied households
own_2	Per. of not owner-occupied households
Dependent variable	
firerate	Fire Rate - Number of fire per 1000 population

Geocoding final quarter data set needs some editing in Excel and MapInfo programs. While merging final quarter data sets of fire and socioeconomic characteristics, it is recognized that there were 6 quarters from census data set, which had no individual data entry, as well as some quarters accounted for 43 out of 205 quarters has not experienced any fires in 1998. Those 46 quarters in total are omitted from the final data set. The final data set including fire and socioeconomic characteristics of quarters are combined with numerical quarter map of Ankara by MapInfo software. The district and quarter boundary map, obtained from GIS Laboratory of City and Regional Planning Department dated in 1996 was arranged and used for this study.

4.2 URBAN FIRE PROBLEM DEFINITION - FIRES IN STUDY AREA

4.2.1 STUDY AREA

Even Ankara was just a small village-sized city until the Liberation War, after 1920s by the declaration as capital city of new republic, there observed a rapid population growth and rapid urban shape differentiation. While it was a city less important with 25000 people in 1920, today it becomes the second biggest city of Turkey with a population more than 4 million people. Ankara is governed by the Greater Metropolitan Municipality, including 8 main metropolitan districts, two of which are Altındağ and Çankaya. (Figure 4.1)

Altındağ and Çankaya districts are the oldest districts of Ankara. These two districts are differentiated from each other according to their historical development, urban patterns, and socioeconomic characteristics. Both districts have a comparatively more urban population and less rural population than other metropolitan districts. Population densities in both districts are also higher than other districts. (Table 4.6)

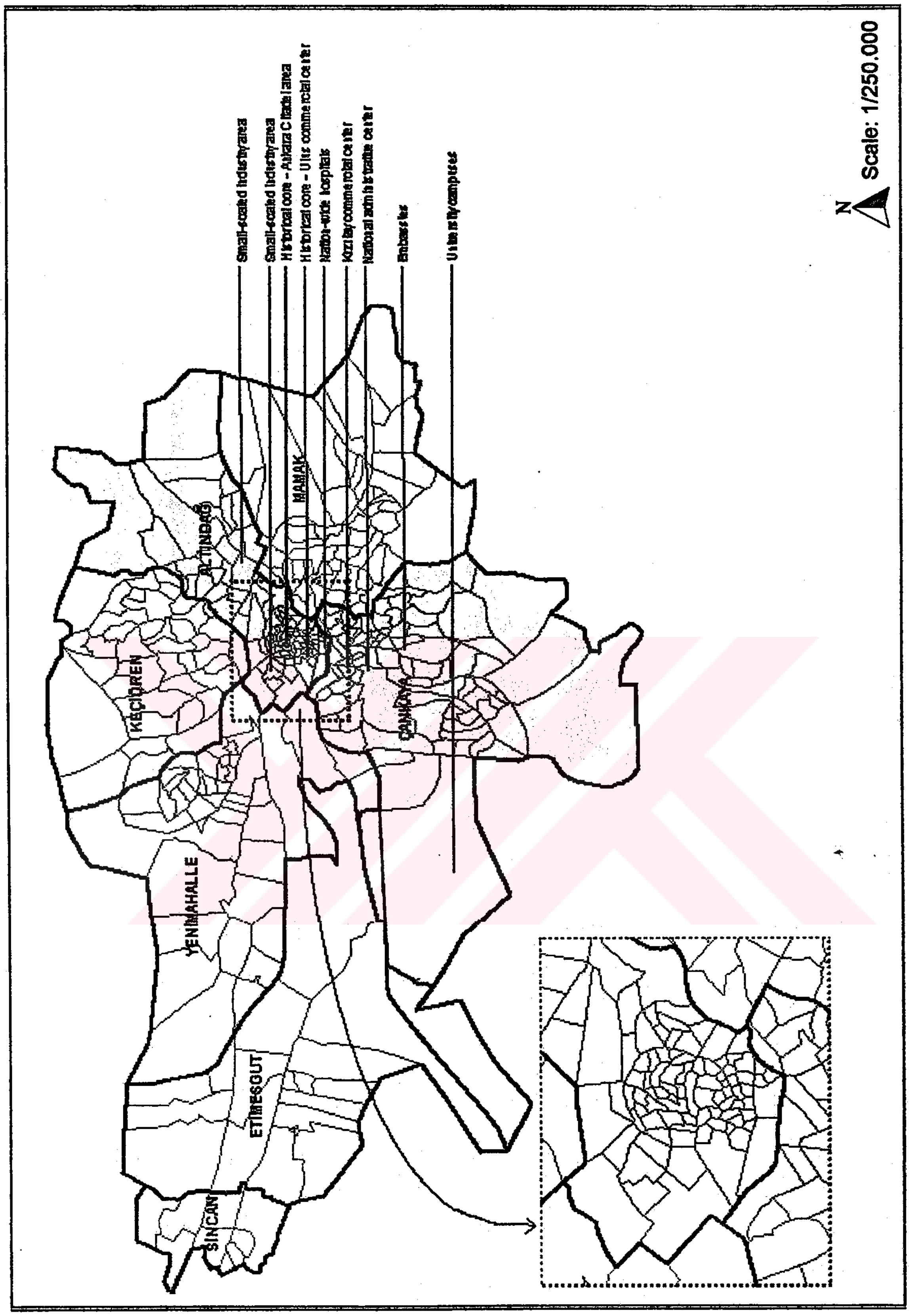

Figure 4.1: The city of Ankara and study area within the districts

Table 4.6: Population distribution and densities of districts in Ankara, 1990

Source: SIS (1193) Census Of Population – Ankara, p: 24

District	Population			Area (km^2)	Urban Population Rate	Population Density
	Total	Urban	Rural			
Altındağ	422'668	417616	5052	170	0,988	2486
Çankaya	714'330	712304	2026	307	0,997	2327
Etimesgut	70'800	69960	840	101	0,988	701
Keçiören	536'168	523891	12277	199	0,977	2694
Mamak	410'359	400733	9626	254	0,977	1616
Sincan	101'118	91016	10102	364	0,900	278
Yenimahalle	351'436	343951	7485	419	0,979	839
Gölbaşı	43'522	25123	18399	1111	0,577	39
Ankara-Metropolitan	2'650'401	2584594	65807	2925	0,975	906
Ankara - Province	3'236'626	2836719	399907	25706	0,876	126

Altındağ is the oldest district of Ankara. Different than Çankaya and other districts, Altındağ has many historical timber structures used both as residential and non-residential today. The district includes the Ulus historical center and the Ankara Citadel within its boundary. The Ulus center serves as a commercial center to lower and middle income groups of the city, whereas the historical core located in and nearby the Citadel transformed a transition zone serving to lower income and marginal groups. Except the historical core, the district is mainly shaped by the first buildings of capital at 1930s and squatter houses constructed after 1950s. 'Siteler' specialized on furniture manufacturing and located on Samsun road, 'Büyük Sanayi' (Big Industry), 'Demir Sanayi' (Iron Industry) and 'Ata Sanayi' (Ata Industry) specialized on small manufacturing and repairing are important small-scaled industrial complexes serving whole city in Altındağ district. The district also includes important hospitals at national scale, such as Hacettepe, İbni Sina, Numune. Even the district has nation-wide importance with its history and urban services; it is also an area reflecting uncontrolled urbanization, with a percent of 50% squatter house area within the boundaries. (Figure 4.2)

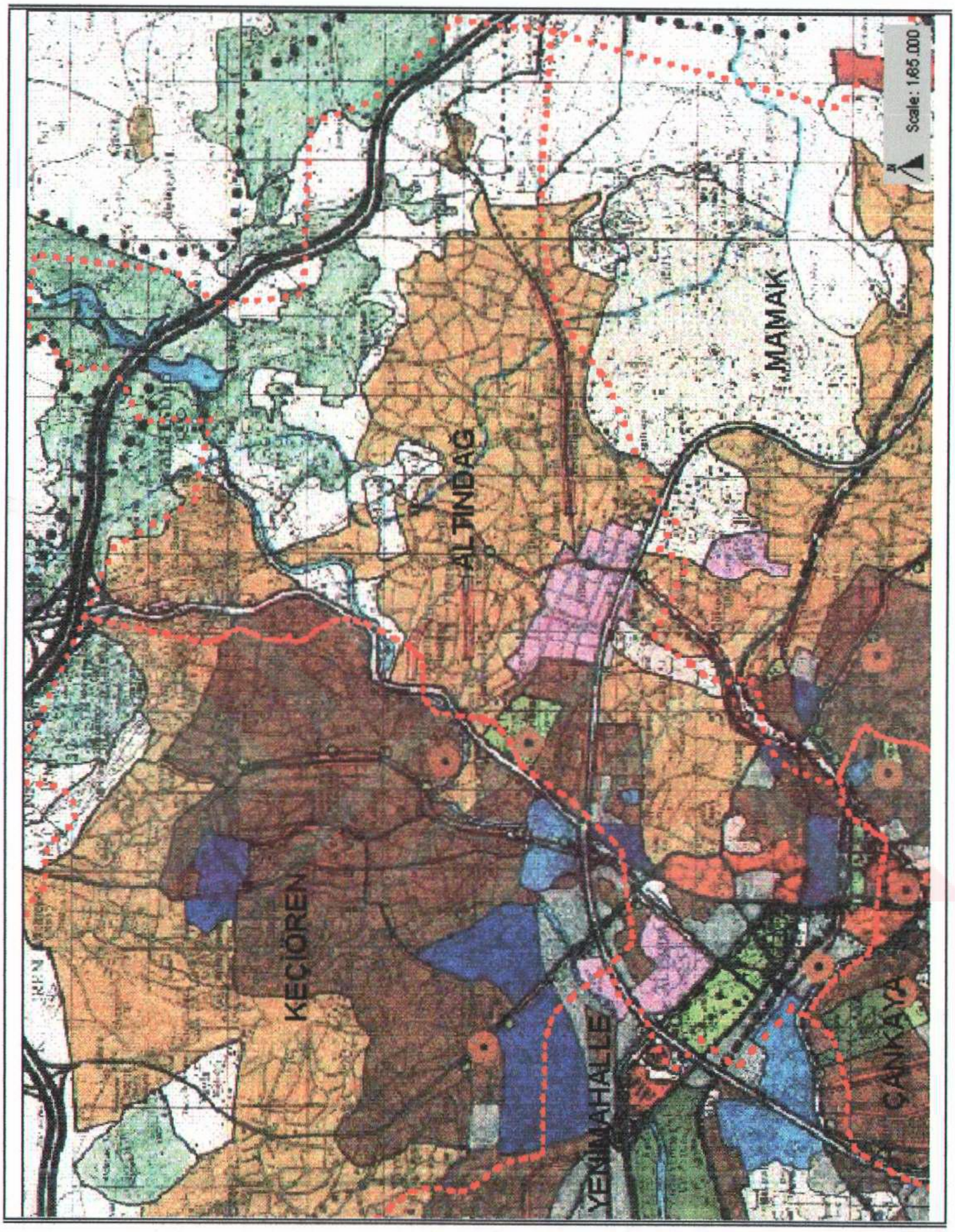

Figure 4.2: Altındağ district land-use plan

On the other hand, urban settlement within the Çankaya district started by the first years of republic in 1920s. Çankaya includes the main central business district, Kızılay serving to middle and upper income classes. It is the main administrative center of Turkey with the National Assembly, ministry buildings, and embassies. It is also an educational center in nation-wide with university campuses including. Even there were remarkable squatter house development within the boundaries of the district in 1950s and 1960s, with amnesty laws and speculative increase in land prices in the district caused a rapid transformation within quarters shaped by squatter houses. Today, the district mainly formed by middle and high income groups. (Figure 4.3)

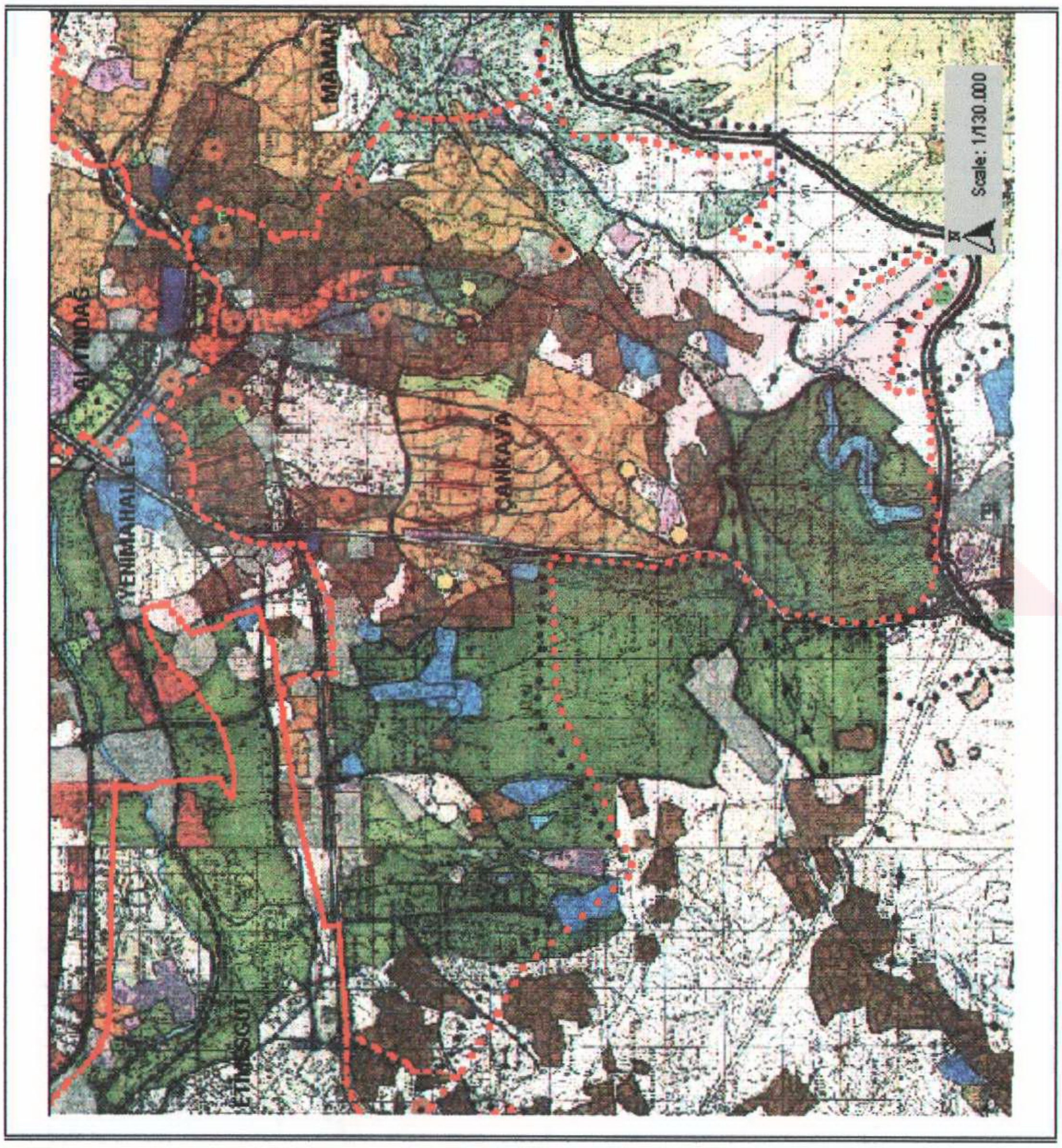

Figure 4.3: Çankaya district land-use plan

4.2.2 URBAN STRUCTURAL FIRE PROFILE

As mentioned in the description of the process of data preparation, there are 682 structural fire incidents in study area, after omitting false calls, unfounded calls, turning backs, and the incidences whose districts could not be determined from recorded addresses. Out of 682, 323 fires occurred in Altındağ district, whereas 359 fires in Çankaya district.

Fire can cause irreversible damages both to property and human life, and loss due to fire[8] is the basic indicator, which pictures the disaster side of flame. Overall, 4 fires caused 4 civilian fatalities whereas 18 fires caused 25 civilian and firefighter injuries in study area in 1998. (Table 4.7) Damage to people is mostly seen in Altındağ district with 16 injuries and 3 deaths as result of 15 fires. The remaining 7 fires caused 1 death and 9 injuries are seen in Çankaya district.

Table 4.7: Frequency distribution of fires caused civilian and firefighter fatalities and injuries - Altındağ and Çankaya Districts, 1998

Damage To People		Frequency		Percent		Total	
		Altındağ	Çankaya	Altındağ	Çankaya	Freq.	Per.
Fatality	No damage	320	358	99,07	99,72	678	99,4
	1 person	3	1	0,93	0,28	4	0,6
	Total	323	359	100,00	100,00	682	100,0
Injury	No damage	311	353	96,28	98,33	664	97,4
	1 person	8	4	2,48	1,11	12	1,8
	2 persons	4	1	1,24	0,28	5	0,7
	3 persons	0	1	0	0,28	1	0,1
	Total	323	359	100,00	100,00	682	100,0

[8] As consequence of fires occurred, damage to people were recorded in terms of how many civilian and/or fire fighter has been injured or died, but as a limitation, direct damage to property has not been recorded in monetary terms. On the contrary, damage to property was recorded as items by writing down the name of material or property damaged. Hence, damage to property was classified according to the area fire spread throughout by estimating the spread with the items damaged in fire; with reference to NFPA 901 "Extend of Flame Damage" codes. (NFPA, 1976:190) (Hall, 1999)

Furthermore, most of fire incidents in study area cause slightly considerable loss to property in 1998. The frequency distribution of loss estimation table shows that 66,5 percent of all fires did not extend far away from the fire origin, whereas almost one-tenth of overall fire incidents extended to all structure or other structures around where fire started. (Table 4.8) Altındağ district had considerably more property damage than Çankaya. (Figure 4.4)

Table 4.8: Frequency distribution of loss estimation of structural fires, 1998

Loss Estimation	Frequency	Percent	Valid Percent	Cum.Percent
No loss	135	19,8	19,9	19,9
Ignition material	168	24,6	24,8	44,8
Partly spread within the place	147	21,6	21,7	66,5
Wholly spread within the place	127	18,6	18,8	85,2
Partly spread outside the place	28	4,1	4,1	89,4
Wholly spread outside the place	49	7,2	7,2	96,6
Mostly spread within the structure	12	1,8	1,8	98,4
Conflagration	11	1,6	1,6	100,0
Total	677	99,3	100,0	
Missing	5	0,7		
Grand total	682	100,0		

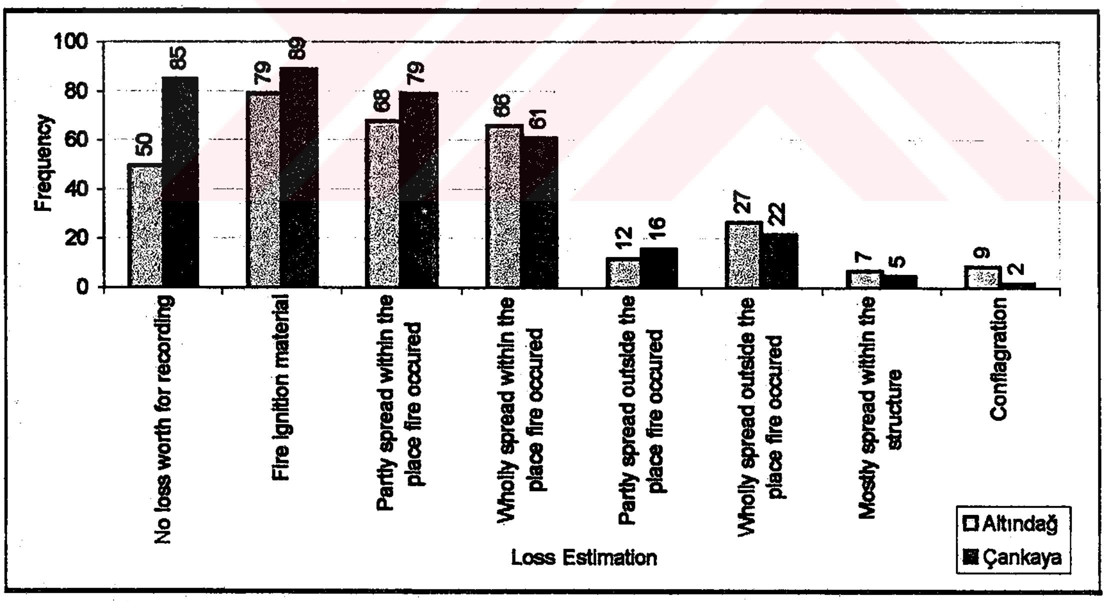

Figure 4.4: Percentage distribution of loss estimation - Altındağ and Çankaya Districts, 1998

4.2.2.1 TIME PROFILE OF FIRES

Variables related with time would give us a general opinion whether fires vary according to the month of year, day of week or hour of day in which they have broken out. Also, other time variables related with the time at which fire brigade arrived to the area and duration of both operation and fire would provide information how effectively fire brigade intervened to fires.

In literature, it is stated that there is a difference between the distribution of fires according to months of year, and cold month fires would be excess in number than hot weather fires. First two rows within the month distribution, February and March are months when average temperature is low. Also in July and August when average temperature reaches peak, fire incidents increase, as expected. (Figure 4.5) The seasonal change in fire frequency also reflects that summer fires are relatively fewer than cold weather fires. Fires occurred in winter month have the majority, with a percent of 29,03%. (Figure 4.6)

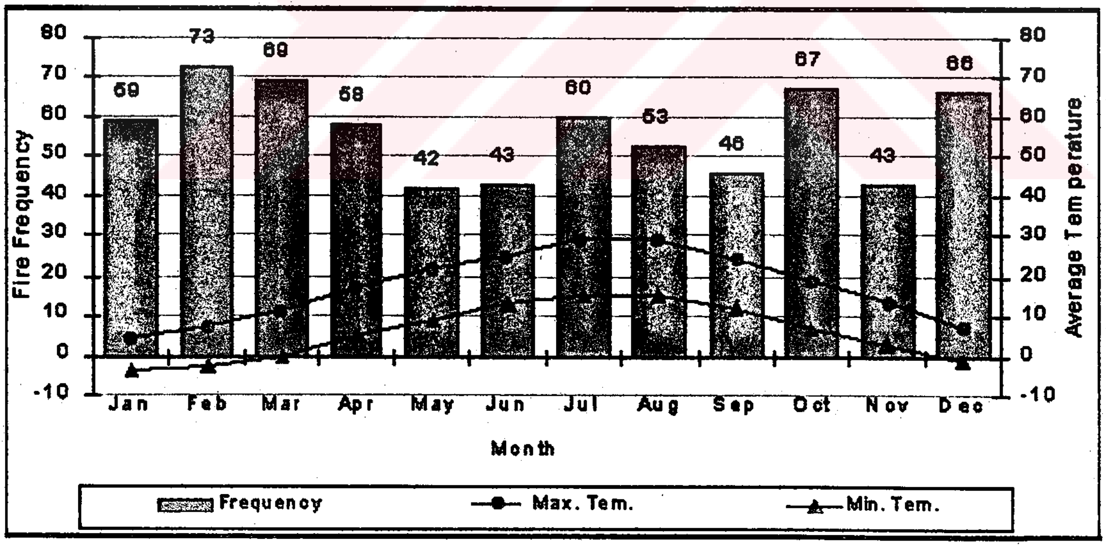

Figure 4.5: Frequency distribution of months in which fire occurred with average temperature, 1998

Source: Weather in Ankara, http://www.meteor.gov.tr/webler/turizm/havaillermaster.htm

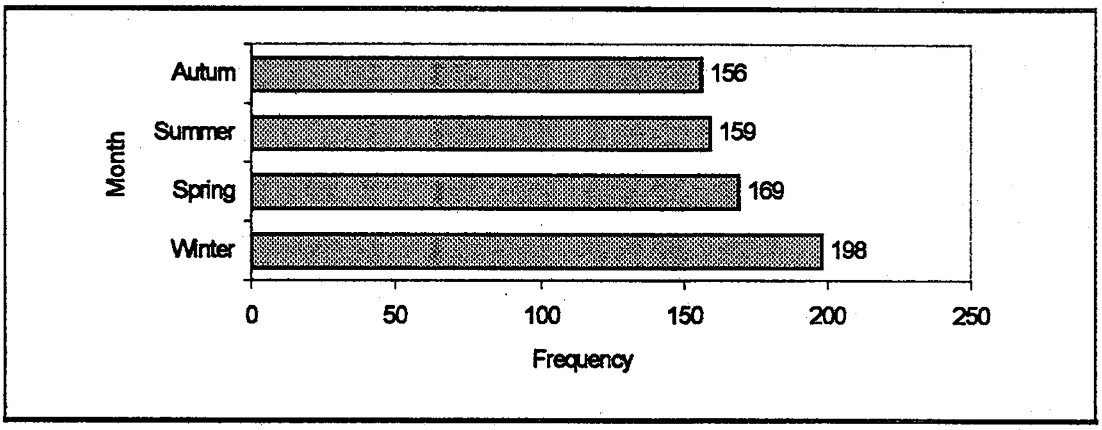

Figure 4.6: Frequency distribution of seasons in which fire occurred, 1998

Whereas opposite to studies in the literature stated that weekend fires have majority, fires occurred in the study area do not vary according to days of week. Fire rate distribution according to the days of the week are so close to each other, in which Thuesday is in the first row of distribution with 109 fires in total. Fires occurred in Sunday has the second majority with 106 fires in total, whereas the dip point is Friday with 85 fires. (Table 4.9) Also there is no significant difference between weekend and in-week fires. The average number of fires occurred in in-week days is 96, whereas for weekend days average is 106 fires.

Table 4.9: Frequency distribution of the days of the week in which fire occurred, 1998

Day	Frequency	Percent	Valid Percent	Cumulative Percent
Monday	96	14,08	14,08	14,08
Tuesday	93	13,64	13,64	27,71
Wednesday	97	14,22	14,22	41,94
Thursday	109	15,98	15,98	57,92
Friday	85	12,46	12,46	70,38
Saturday	96	14,08	14,08	84,46
Sunday	106	15,54	15,54	100,00
Total	682	100,00	100,00	

On the other hand, as parallel to previous studies, there seen a smooth S-shaped curve distribution by the hour of the day in which fire occurred. (Figure 4.7) Within the dispersion, the peak hour is between 13:00-13:59 according to 1-hour interval distribution. The average hour when fire occurred is 14:14, whereas the median, the most frequent hour is 15:07.

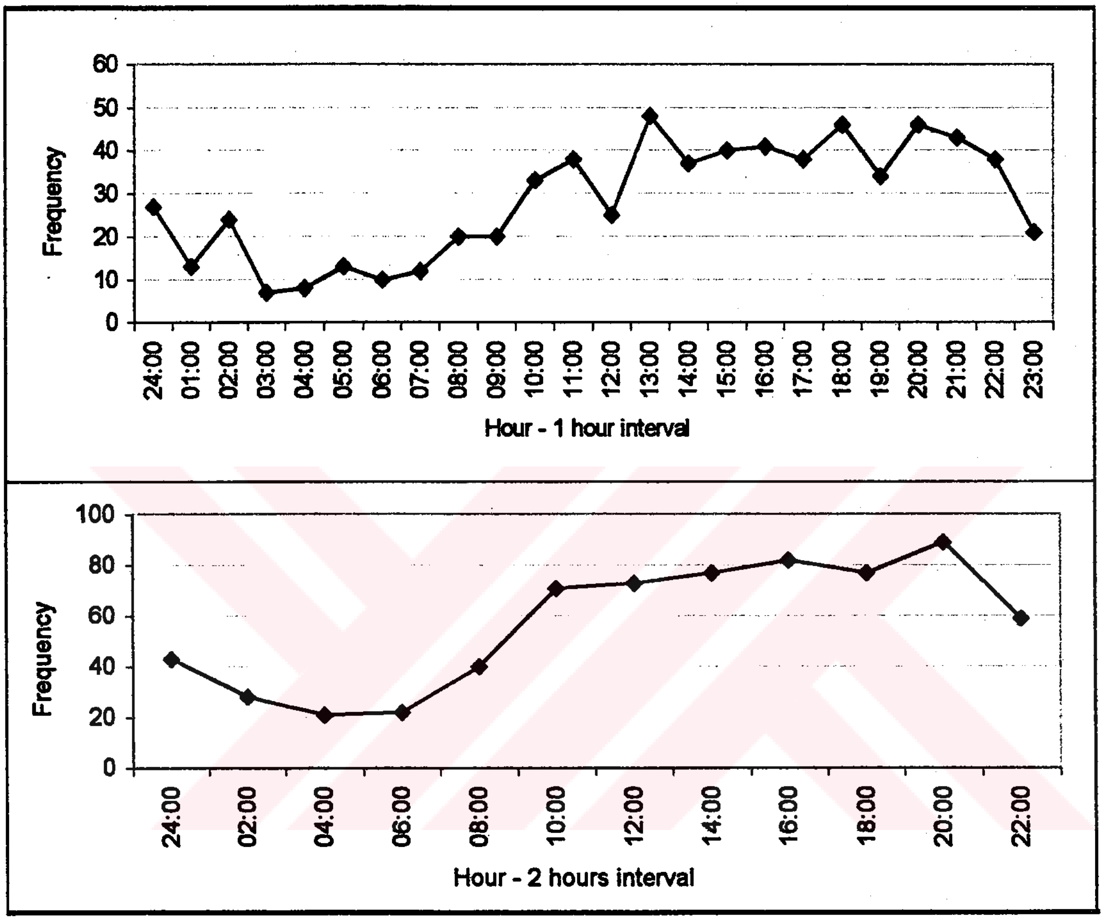

Figure 4.7: Frequency distributions of hours when fire occurred according to 1and 2-hours intervals, 1998

When slope change within the frequency distribution of the hour according to 1-hour interval, it is observed that at night times, especially after midnight, the slope of the curve is increasing, while the slope decreases from morning till noon. The most remarkable increase in slope is determined between 12:00

and 13:00. Slope changes are illustrated in Figure 4.8 in which frequency distribution represents based on 1-hour interval.

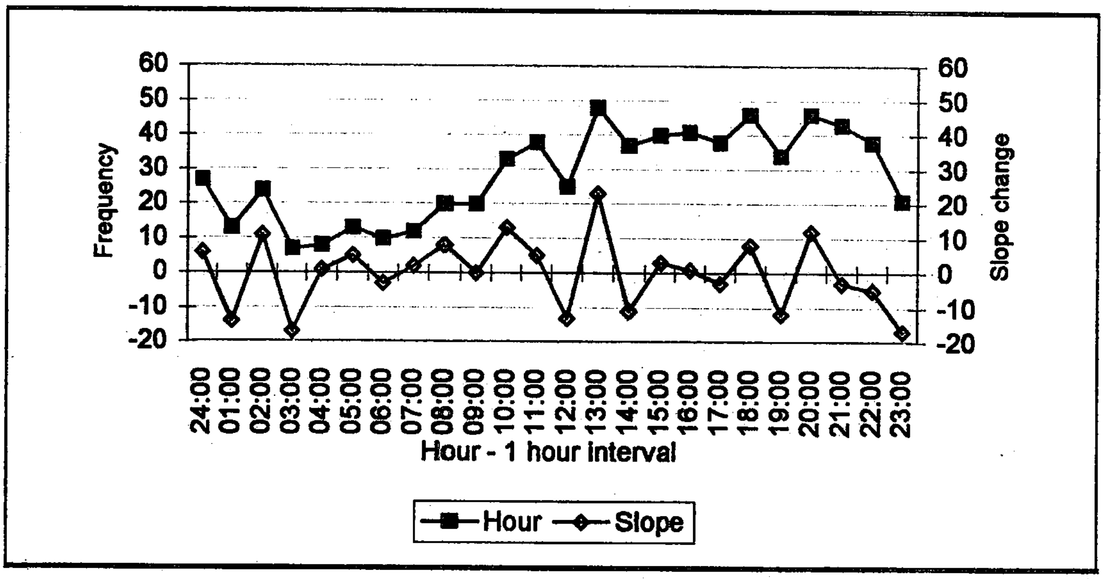

Figure 4.8: Frequency distribution of hours when fire occurred with slope changes, 1998

Other time profile variables are response time of fire brigade to scene and duration of operation, defined as the period from the time fire brigade arrive till the time fire is extinguished totally. Response time is an indicator showing how rapid fire brigade arrived to the scene, whereas duration of operation is an indicator both for picturing how effectively fire brigade operated the extinguishment and for showing how big the fire was.

When time-temperature curve in closed areas is considered, first 30 minutes of a fire is important for intervention, since approximately within 30 minutes, fire grows rapidly and flashover is seen. (Figure 4.9) After 30 minutes, at point C fire would surround the confined space. If there are barriers preventing air circulation, such as doors and windows, fire could pass over barriers, and go beyond the origin of ignition. Otherwise, fire would pass into decay phase, and self-suppression is seen till all combustible materials burn or till the oxygen within confined space is totally consumed.

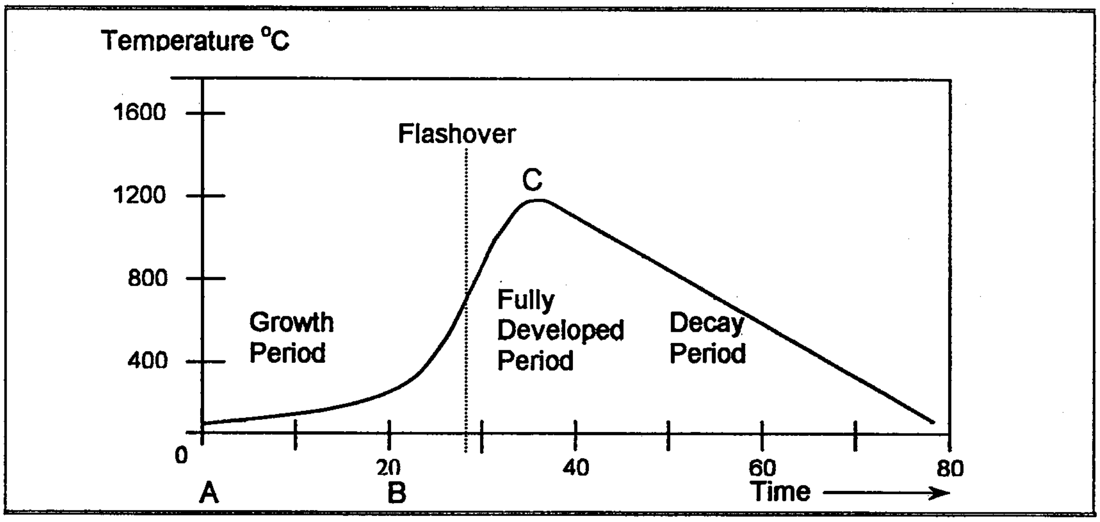

Figure 4.9: Time-temperature curve of fire in confined spaces
Source: Shields, T. J.; Silcock, G. W. H. (1987) Buildings and Fire, p: 86

According to Yalazı (1998), if fire brigade arrived at the fire scene and extinguished the fire within the first 30 minutes, possible damage to property and human would be minimized. He also assumes that the fire could be detected and reported to fire department in first 5-10 minutes, so that the fire brigade would have 20 minutes for arrival and intervention. Therefore, first 5 minutes after reporting of fire is a proper period for arriving to the scene, and 15 minutes after arriving to scene is an applicable period for intervention.

Overall, it is found that fire brigades have arrived to the fire area with an average time of 6,35 minutes in the study area. The most frequently observed response time is 5 minutes. Fire brigades have responded to more than half of all fires within the first 5 minutes after fire reported to the fire department in study area, as seen in table below which shows the response time ranges. Table 4.10 and Figure 4.11 related with response times demonstrate that fire brigades are not expectedly successful in arriving to the scene according to assumed response time. Response to fires in Çankaya district lasted more than responses in Altındağ, which reflects that traffic conditions and inadequate fire brigade within Çankaya district. (Figure 4.10)

Table 4.10: Frequency distribution of response times of fire brigades to scene (minutes) - Altındağ and Çankaya Districts, 1998

Response Time	Frequency		Percent		Total	
	Altındağ	Çankaya	Altındağ	Çankaya	Freq.	Per.
≤ 2 min.	57	26	17,98	7,30	83	12,33
3-5 min.	153	138	48,26	38,76	291	43,24
6-10 min.	86	118	27,13	33,15	204	30,31
11-15 min.	19	52	5,99	14,61	71	10,55
16 ≤ min.	2	22	0,63	6,18	24	3,57
Total	317	356	100,00	100,00	673	100,00

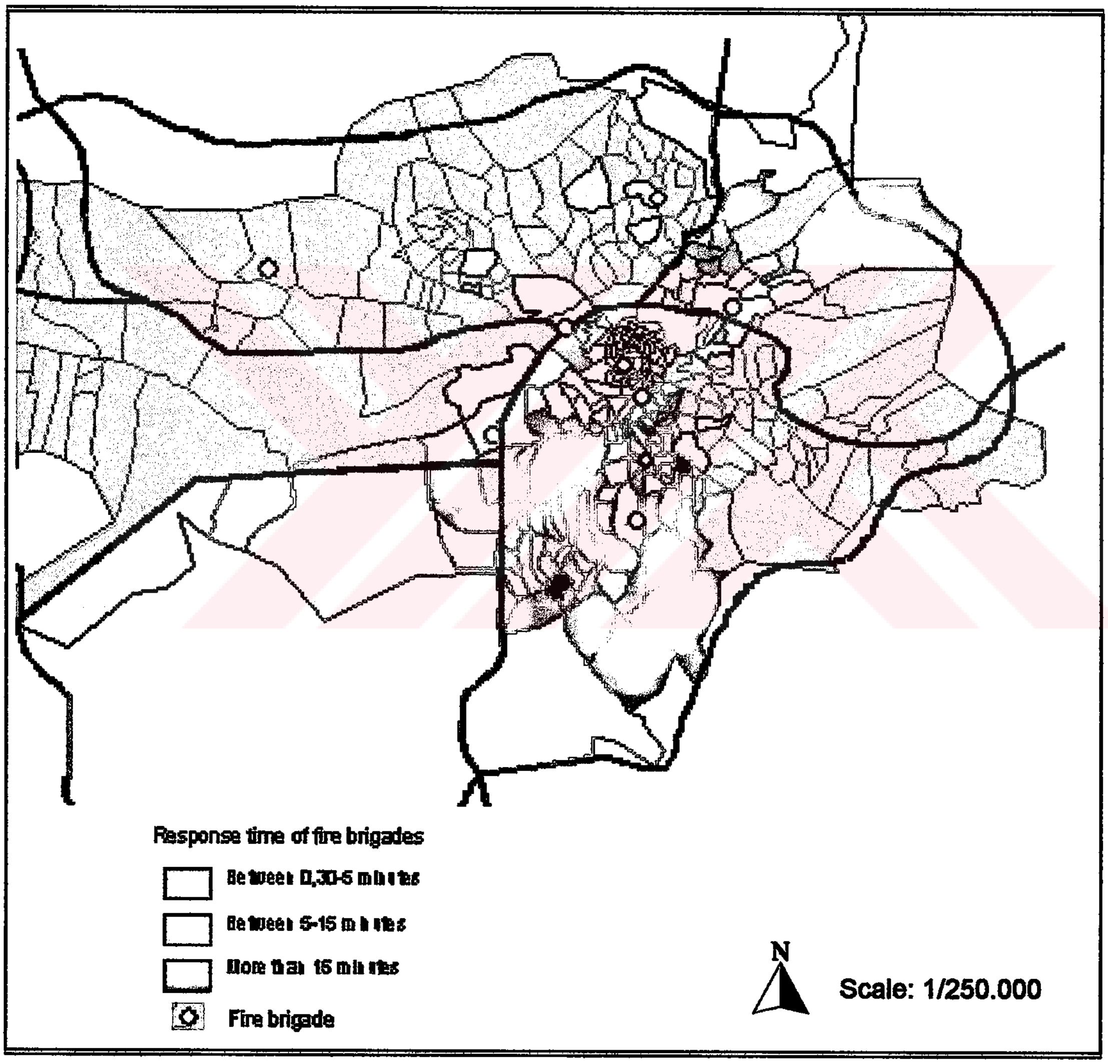

Figure 4.10: Location of fire departments and average response time of fire brigade to fires within quarters

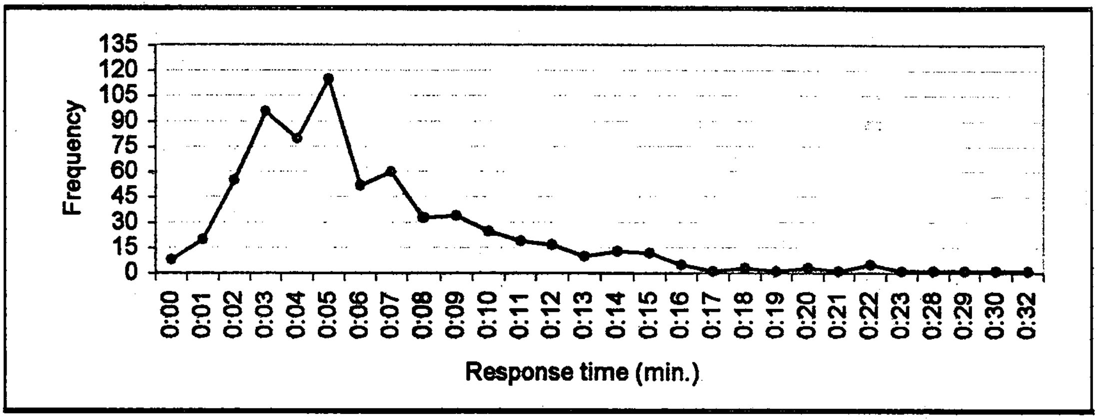

Figure 4.11: Frequency distribution of response times of fire brigades to scene (minutes), 1998

When duration of fire is analyzed, it is observed that fires occurred in study area in 1998 continued for an average of 38,87 minutes till they have been put out. The most frequently observed duration time is 19 minutes. More than one third of all fires have been extinguished within the first 20 minutes after fire brigade has arrived to the scene. However, fires extinguished within the first 10 minutes have only a percent of 10,41%, which shows that fire brigades are not so capable while intervening fires. On the other hand, more than half of fires, accounted for 376 in total, have been put out in 30 minutes before flashover and spread. (Table 4.11, Figure 4.12)

Table 4.11: Frequency distribution of duration time of fire brigade operation (minutes) - Altındağ and Çankaya Districts, 1998

Duration of Operation	Frequency		Percent		Total	
	Altındağ	Çankaya	Altındağ	Çankaya	Freq.	Per.
≤ 10 min.	54	18	17,25	5,06	72	10,76
11-20 min.	80	90	25,56	25,28	170	25,41
21-30 min.	47	88	15,02	24,72	135	20,18
31-40 min.	33	60	10,54	16,85	93	13,90
41-50 min.	30	35	9,58	9,83	65	9,72
≥ 51 min.	69	65	22,04	18,26	134	20,03
Total	313	356	100,00	100,00	669	100,00

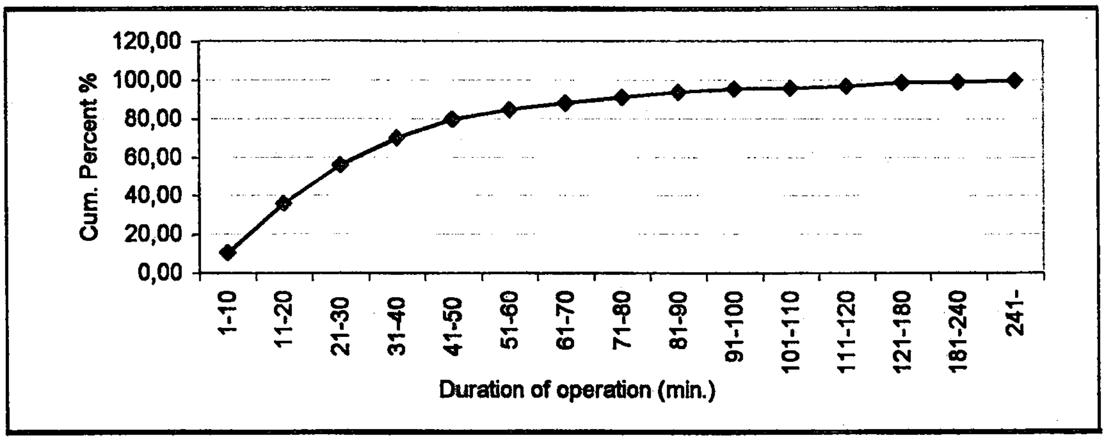

Figure 4.12: Cumulative percentage distribution of duration of fire brigade operation (minutes), 1998

By adding response time and duration of operation, total time of fire could be obtained. This period would be an indicator for determining the relation between lost and fire duration. The average time for duration of fire is 45,71 minutes, whereas the peak time is 26 minutes with 21 fires in total. When average duration time of fires is confronted with time-temperature curve assumptions, there obtained that most of fires completed fully developed phase and entered into decay phase. However, 40,71% percent of all fires lasts less than half an hour, which means that 276 fires in total are extinguished just after or before flashover has arose, or before completing the fully developed phase. (Table 4.12, Figure 4.13)

Table 4.12: Frequency distribution of all time of fires (minutes) - Altındağ and Çankaya Districts, 1998

Duration of Fire	Frequency		Percent		Total	
	Altındağ	Çankaya	Altındağ	Çankaya	Freq.	Per.
≤ 10 min.	15	6	4,70	1,67	21	3,10
11-20 min.	72	36	22,57	10,03	108	15,93
21-30 min.	59	88	18,50	24,51	147	21,68
31-40 min.	58	74	18,18	20,61	132	19,47
41-50 min.	30	53	9,40	14,76	83	12,24
≥ 51 min.	85	102	26,65	28,41	187	27,58
Total	319	359	100,00	100,00	678	100,00

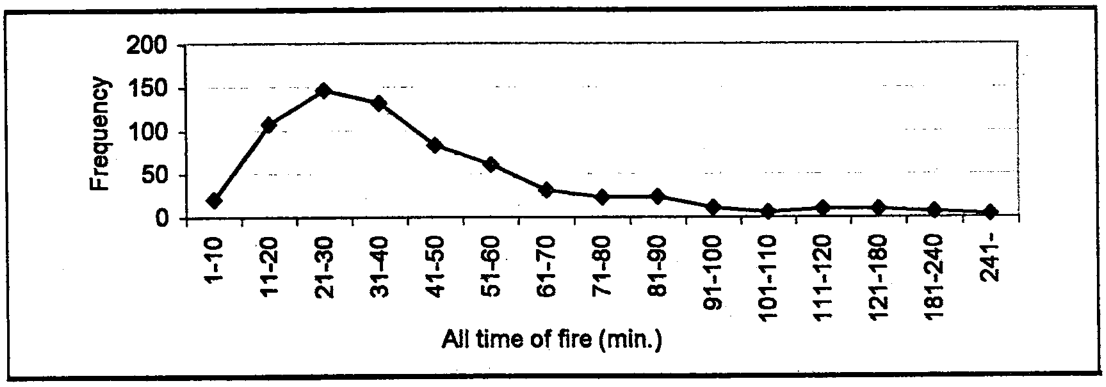

Figure 4.13: Frequency distribution of all time of fire (minutes), 1998

4.2.2.2 PROPERTY PROFILE OF FIRES

Similar to time profile of fires, variables about the place and the usage of the structure in which fire occurred would provide a general schema about the risky usages and places within structures. Furthermore, insurance and ownership distribution could be used for determining how ready and conscious the occupants of the property are about a possible fire incident.

For the year 1998, 350 fires account for 52,79% occurred in residential properties, whereas 288 of 663 structure fires occurred in non-residential property classes in study area. Vacant class structures, not in-use either residential or non-residential, has small share with 25 fires. (Table 4.13)

Table 4.13: Frequency distribution of general property classes of structural fires - Altındağ and Çankaya Districts, 1998

Property Class	Frequency		Percent		Total	
	Altındağ	Çankaya	Altındağ	Çankaya	Freq.	Per.
Residential	165	185	51,72	53,78	350	52,79
Non-residential	144	144	45,14	41,86	288	43,44
Vacant	10	15	3,13	4,36	25	3,77
Total	319	344	100,00	100,00	663	100,00

When minor classes of property in which fire has broken out is analyzed from Figure 4.14, it is seen that apartment (flat) fires within residential property class has the majority with 27,15% percent. House and commercial property class including shops, offices are in the second and third ranks. Recreational usages as cinemas, restaurants, bars, associations, and industrial and manufacturing usages have also significant percent within the distribution of fires according to property classes. Public buildings including administrative and defense buildings, hotels, hospitals, and educational buildings have small portions. It is remarkable that squatter house fires have an underlying percent with 40 fires in total.

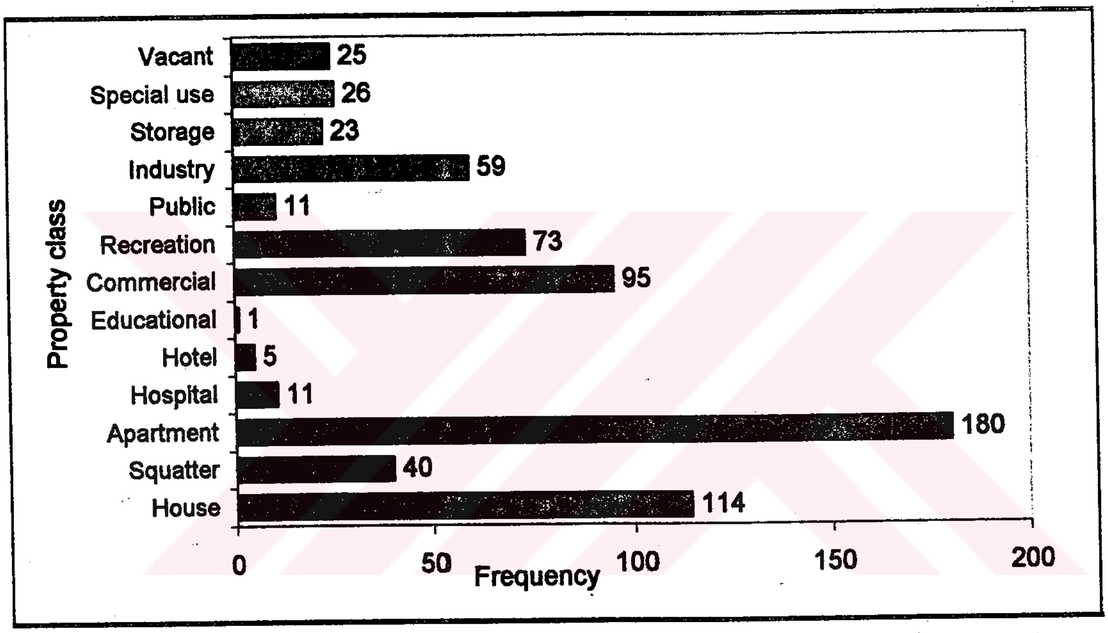

Figure 4.14: Frequency distribution of major property classes in which fire occurred, 1998

Even there seen no remarkable difference within general property usage between Altındağ and Çankaya districts, the minor breakdown of property classes reflects underlying differences. (Table 4.14) In Altındağ district, including historical core experienced more house fires within residential fires, whereas Çankaya district experienced more apartment fires. Also industrial property usage fires are mainly seen in Altındağ district containing small-scale industry complexes within its boundaries.

Table 4.14: Frequency distribution of major property classes of structural fires - Altındağ and Çankaya Districts, 1998

Property Class	Frequency		Percent		Total	
	Altındağ	Çankaya	Altındağ	Çankaya	Freq.	Per.
Res. - House	96	18	30,09	5,23	114	17,19
Res. - Squatter house	20	20	6,27	5,81	40	6,03
Res. - Flat, apartment	40	140	12,54	40,70	180	27,15
Res. - Institutional (hospital, prison)	7	4	2,19	1,16	11	1,66
Res. - Commercial (hotel, boarding house)	2	3	0,63	0,87	5	0,75
Educational	0	1	0,00	0,29	1	0,15
Commercial	40	55	12,54	15,99	95	14,33
Recreation	19	54	5,96	15,70	73	11,01
Public	4	7	1,25	2,03	11	1,66
Industry and manufacturing	55	4	17,24	1,16	59	8,90
Storage	14	9	4,39	2,62	23	3,47
Special use	12	14	3,76	4,07	26	3,92
Vacant	10	15	3,13	4,36	25	3,77
Total	319	344	100,00	100,00	663	100,00

When tenure type of properties in which fire occurred is analyzed from Table 4.15, privately owned structures, which accounted for 85,95%, surpassed public and other types of tenure classes. Within private ownership, rental class of tenure is in the first rank with a percent of 34,17%, and followed by owner occupied structures whose percent is 32,11%. Commonly used and owned areas, like stairs, ventilation, chimneys also have a significant share in tenure class. Public-owned buildings analyzed in two distinct classes; first group contains governmental and administrative buildings, and second group contains hospitals and prisons. But public-owned structures do not have a significant share in tenure class breakdown.

Table 4.15: Frequency distribution of minor tenure class of structural fires - Altındağ and Çankaya Districts, 1998

Tenure class		Frequency		Percent		Total	
		Altındağ	Çankaya	Altındağ	Çankaya	Freq.	Per.
Private	Rent	127	120	39,56	33,80	247	36,54
	Owner	127	108	39,56	30,42	235	34,76
	Company	11	25	3,43	7,04	36	5,33
	Common use	7	57	2,18	16,06	64	9,47
Public	Institutional	23	24	7,17	6,76	47	6,95
	Residential	8	7	2,49	1,97	15	2,22
Other		18	14	5,61	3,94	32	4,73
Total		321	355	100,00	100,00	676	100,00

Moreover the property class, the insurance status of the property is also recorded by the Fire Department in fire incident reports. Since there is no regulation about insurance in Turkey; as expected, the share of insured buildings in the study area is very small. There are 47 properties out of 676 with 6 missing cases. Out of these 47 properties insured, the majority belongs to commercial usage including shops and offices, and recreational usage including restaurants, bars ad cafes with 30 fires in total. The rest of insured properties are industrial or storage uses. (Table 4.16)

Table 4.16: Frequency distribution of insured and not insured property classes, 1998

Property class	Not Insured	Insured	Total
Residential – Squatter	39	1	40
Residential – Institutional	9	2	11
Residential – Commercial	4	1	5
Commercial	75	18	93
Recreation – Restaurant, bar	50	12	62
Recreation - Association	9	1	10
Industry – High Ignition Risk	22	7	29
Industry – Medium Ignition Risk	14	2	16
Industry – Low Ignition Risk	13	1	14
Storage – High Fuel Risk	10	1	11
Storage – High Fuel Risk	5	1	6
Total	250	47	297
Rest	379	0	379
Missing	6		6
Grand total	635	47	682

The origin of fire is another indicator, which displays the relation between fire incident and the structure. Fires occurred within the structure have biggest share with a total percent of 88,27%, whereas fires outside the structure such as annexes or garden, and fires within other usages such as constructions, transformers have little share accounted for 81 incidences totally. When minor breakdown of fire origin is analyzed, it is determined that fires occurred within the unit of a structure have great share and followed by fires within the elements of structure such as chimney and roof fires. According to the minor classification of fire origin, room fires accounted for 284 fires in total are followed by kitchen and chimney fires. (Table 4.17)

Table 4.17: Frequency distribution of minor and major origin where fire started, 1998

Fire Origin		Frequency	Percent	Valid Percent	Cumulative Percent
Unit	Room	284	41,64	41,64	41,64
	Kitchen	86	12,61	12,61	54,25
	Bathroom	16	2,35	2,35	56,60
	Other	10	1,47	1,47	58,06
	Total	396	58,06	58,06	58,06
Common Place	Stairs, landing	35	5,13	5,13	63,20
	Ventilation	24	3,52	3,52	66,72
	Kazan dairesi	24	3,52	3,52	70,23
	Storage place	15	2,20	2,20	72,43
	Total	98	14,37	14,37	72,43
Element	Chimney	73	10,70	10,70	83,14
	Roof	35	5,13	5,13	88,27
	Total	108	15,84	15,84	88,27
Outside	Storage place	11	1,61	1,61	89,88
	Coal cellar	25	3,67	3,67	93,55
	Common oven	3	0,44	0,44	93,99
	Garden	19	2,79	2,79	96,77
	Total	58	8,50	8,50	96,77
Other	Construction	11	1,61	1,61	98,39
	Transformer	11	1,61	1,61	100,00
	Total	22	3,23	3,23	100,00
Grand Total		682	100,00	100,00	

Cross tabulation between property class and origin of fire exhibits that kitchen fires in the second row with 70 fires, coming after room fires in residential usage, which has a frequency of 132; whereas in non-residential usage, 47 chimney fires follow up room fires with a frequency of 127 fires. Within non-residential usage, chimney fires are most commonly seen in recreational usage, under which bars, restaurants, and cafes are listed. Chimney fires are also significant in apartment type of residential usage, with 25 fires. Fires broken within annexes outside the structure in residential usages is more than annexes fires in non-residential usage. Especially fires seen in annexes, which are used as coal cellar, are mainly observed in house type of residential usage. On the other hand, fires occurred in gardens are more common in non-residential usage. Fires started in commonly used and owned place, such as ventilation, stairs, lending are mostly observed in apartment type of residential usage, as well as common in commercial usage. In vacant buildings, nearly all fires occurred in room with accounted for 23 fires out of 25 vacant building fires. (Table 4.18)

Table 4.18: Cross tabulation between property classes and fire origin, 1998

Fire Origin * Property Class	Res. - House	Res. - Squatter	Res. - Apart.	Res. - Institut.	Res. - Com.	Educ.	Com.	Recrea.	Public	Industry	Storage	Special use	Vacant	Total
Room	48	21	56	6	1		50	10	2	41	19	5	23	282
Kitchen	13	4	42		1		7	16	1	2				86
Bathroom	1	2	10	1			2							16
Other			4				3	2		1				10
Stairs, landing	3	1	15	1			7		1	5				33
Ventilation	1		12				7		1	1	1			23
Coal cellar	7		8		1		5	1					1	23
Storage place			7	1		1	1	1	1	2			1	15
Chimney	4	2	18		1		2	40	2	3				72
Roof	8	4	4	1	1		8	1	2	1	2			32
Anx. - Storage	8	1						1						10
Anx. - Coal cellar	18	2	4								1			25
Anx. - Common	1	2												3
Garden	2	1					3	1	1	3		1		12
Construction				1								9		10
Transformer												11		11
Total	114	40	180	11	5	1	95	73	11	59	23	26	25	663

Another variable related with property profile is 'construction material'. Most of the structures are reinforced concrete with a total number of 456 properties out of 643. In the second, group there are 125 structures made of timber. The rest 64 structures' construction materials include brick, stone, and other. (Table 4.19) Timber structural fires are commonly seen in Altındağ district where historical buildings are located. On the other hand, within Çankaya district where newly constructed apartment type of buildings are common, fires are generally seen in concrete structures.

Table 4.19: Frequency distribution of property class of structural fires - Altındağ and Çankaya Districts, 1998

Construction Material	Frequency		Percent		Total	
	Altındağ	Çankaya	Altındağ	Çankaya	Freq.	Per.
Timber	109	16	36,21	4,68	125	19,44
Half-timbering	4	5	1,33	1,46	9	1,40
Briquette	1	9	0,33	2,63	10	1,56
Masonry	1	5	0,33	1,46	6	0,93
Brick	3	1	1,00	0,29	4	0,62
Stone	1	2	0,33	0,58	3	0,47
Concrete	163	293	54,15	85,67	456	70,92
Shed	9	5	2,99	1,46	14	2,18
Other	10	6	3,32	1,75	16	2,49
Total	301	342	100,00	100,00	643	100,00

4.2.2.3 ROOT PROFILE OF FIRES

Last general category of fire incidence reports will be root profile of fires, which covers the variables about the causes and factors of fires. Fire causes would draw the figure how influential human failure for fire ignition, whereas fire factors would display the distribution of fire ignition materials. Different than previous studies, which have been analyzed causes of fires within one group; in this study, roots of fires are analyzed into two distinct groups, as causes of fires, and factors of fires[9]. Fire causes are those including human behavior that caused the ignition such as ignorance, carelessness, whereas fire factors are those pointing out the ignition source and reason, such as smoking, heating or cooking materials.

Overall, cause of nearly half of fire incidences is negligence which means person did not take necessary precautions against fire break down even he was aware of, such as throwing a burning cigarette. Accident or breakdown in materials is in the second rank with a percent of 24,23%. One-quarter of all fires are broken out due to lack of care, points out not taking necessary precautions within flammable materials. Arson, signifies suspiciously set fire, and ignorance, means that person does not know necessary precautions against fire have little share with 61 cases in total. (Figure 4.15)

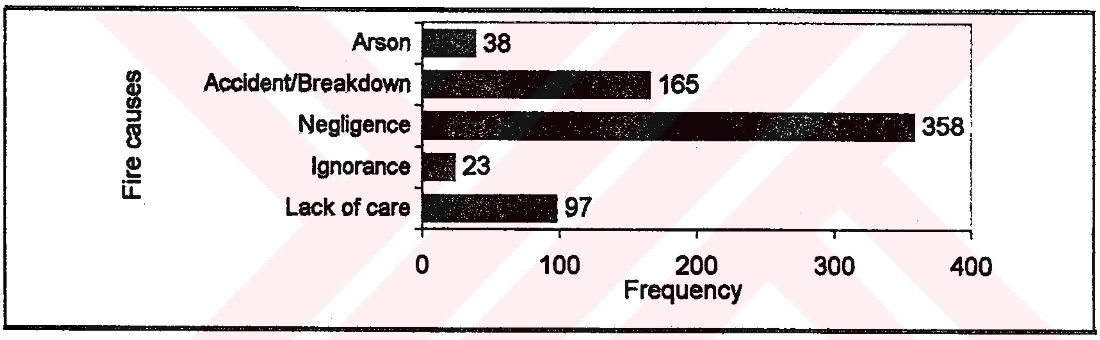

Figure 4.15: Frequency distribution of major fire causes, 1998

Different that other causes of fires, accident or breakdown as a cause of fire indicates not a direct human failure; nevertheless, as seen in Table 4.20, minor distribution of causes illustrates that nearly half of fires broken out accidentally or breakdown have a minor cause mainly human failure based such as lack of care or negligence. This points out that nearly all fires were broken out basically because of human failure with a total percent of 85,76%.

[9] Causes of fires are classified according to major and minor group, and this classification is formed with a combination of causes stated in literature and Ankara Fire Department classification. Factors of fire also classified as major and minor groups; where in minor groups, major variables are listed in detail.

Table 4.20: Frequency distribution of minor fire causes, 1998

Fire causes	Frequency	Percent	Valid Percent	Cum. Percent
Lack of care	93	13,64	13,66	13,66
Lack of care and ignorance	4	0,59	0,59	14,24
Ignorance	10	1,47	1,47	15,71
Ignorance and negligence	13	1,91	1,91	17,62
Negligence and lack of care	90	13,20	13,22	30,84
Negligence and lack of care	268	39,30	39,35	70,19
Accident and lack of care	51	7,48	7,49	77,68
Accident and negligence	17	2,49	2,50	80,18
Accident, breakdown	97	14,22	14,24	94,42
Arson	38	5,57	5,58	100,00
Total	681	99,85	100,00	
Missing	1	0,15		
Grand total	682	100,00		

Fire factor, other variable of root of fire, is the source of spark or flame, which generally indicates a flammable or burning material. With a percent of 26,43%, the major factor causes ignition in study is smoking materials including cigarettes, or other tobacco materials, but not matches. Electrical appliances and electric installation fires are in the second row with a percent of 22,91%. Fires arose due to cooking and heating materials are in the third and fourth lines. Fires caused by other appliances such as weld and geyser, open flames due to candle, explosives, sparks, and fires caused by children playing with matches or lighters constitute the rest of factors. (Figure 4.16)

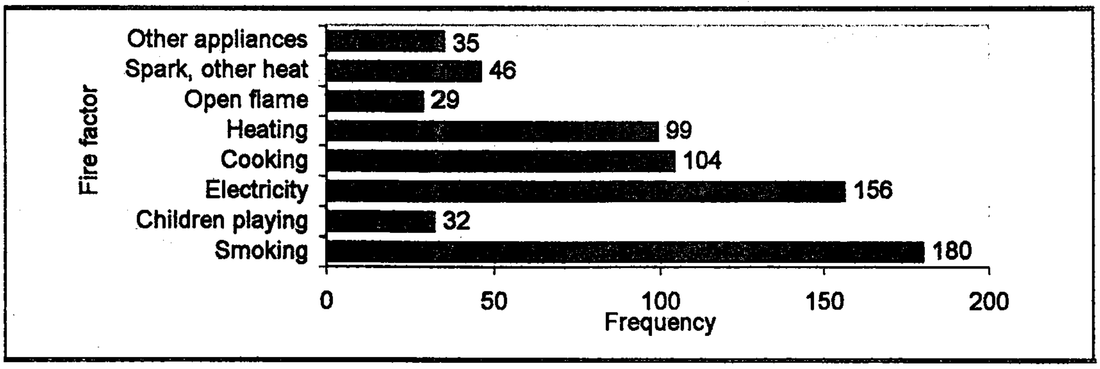

Figure 4.16: Frequency distribution of major factors of fires, 1998

When minor distribution of fire factors is analyzed, fires caused by a spark either from heating and cooking appliances, or other heat sources have a majority, followed by fires ignited due to electricity and smoking materials. Within minor distribution, fires initiated by LPG tubes used either in cooking, heating, open flame or other appliances are also notable with 51 fires in total.

The cross tabulation between causes and factors of fires, shown in Figure 4.17, demonstrates that nearly all of fires ignited by smoking materials and all of fires initiated by children playing with matches and lighters are basically caused by negligence. Fires occurred due to electricity or other appliances are generally based on an accident or breakdown. Lack of care is dominant in cooking and heating appliance fires, which indicates that people do not care so much to potential fire-set appliances, which they use in everyday life.

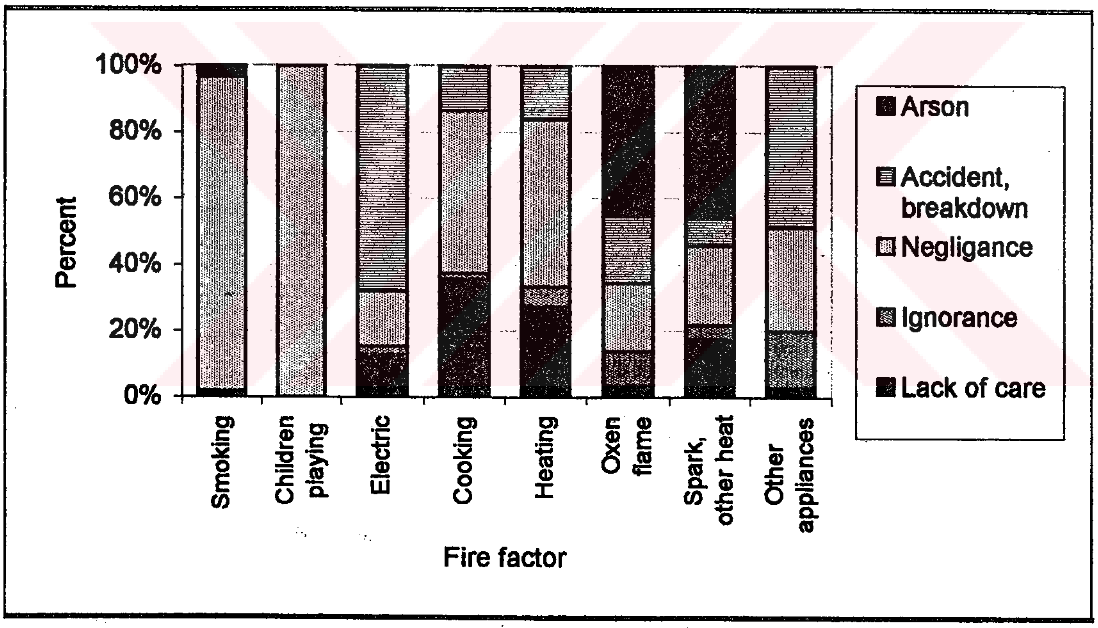

Figure 4.17: Percentage distribution of causes of fires according to fire factors, 1998

4.2.3 FINDINGS OF FIRES IN ALTINDAĞ AND ÇANKAYA

The acquisition of fire incident reports presents an opportunity to analyze fires in study area, and also represents an example for standard coding of incidence reports, which is a deficiency of reports in Turkey. When 682 fires in study area is analyzed, it is seen that there is no considerable damage to people, whereas notable damage to property.

When property class relation with the time fire occurred, it is seen that residential, public, industrial and recreational fires are occurred at time when property is in use, but differently, commercial and storage property class fires are observed when they are not used by occupants. Vacant property class fires are also seen at those times residential fires commonly occurred, which shows these vacant buildings are illegally occupied and used. (Table 4.21)

Table 4.21: Cross tabulation between property class and fire time 2 hour interval, 1998

Property class * Time fire occurred (2 hours interval)	00:01-02:00	02:01-04:00	04:01-06:00	06:01-08:00	08:01-10:00	10:01-12:00	12:01-14:00	14:01-16:00	16:01-18:00	18:01-20:00	20:01-22:00	22:01-00:00
Residential	24	16	6	9	17	37	50	42	44	40	32	33
Educational												1
Commercial	10	4	5	6	8	6	6	7	5	14	14	10
Recreation	2	1	1	3	3	12	8	3	10	11	14	5
Public		1			1		1	3	2	2		1
Industry	3	1	3	3	6	4	4	8	8	1	13	5
Storage	2	1	3		1	1	1	2	3	4	3	2
Special use		2	1		1	6	1	4	6	1	3	1
Vacant	2	1	1		1	2	1	5	3	4	4	1

When causes of fires are analyzed within the general breakdown of property classes, within all classes, negligence is the dominant fire cause. The other ranks are also parallel within residential and non-residential usages. Nevertheless, when fire causes are analyzed according to minor property classes, the significant observation is that arson fires are dominantly seen in commercial usages. This could figure out the general tendency of arsons for getting money from insurance companies, however, this tendency is not relevant for the study area. Since when arson fires are analyzed according to property class and insurance situation, there determined only 5 insured properties in which fire is set out consciously, out of 47 insured properties in total. Other underlying finding is that more than one third of fires caused due to lack of care are seen in restaurants, bars, and cafes.

The parallelism between fire causes and general property classes is also broken down when minor classification of property classes is analyzed according to causes of fires. Within minor property classes, again negligence is the major cause within most of property classes, however some usages differ from others according to causes of fires. Within public institution, defense and transformer usages accident or breakdown is the dominant fire cause, whereas in commercial and recreational usages lack of care is the dominant cause.

This picture reveals the inadequate and ineffective safety inspections of competent authorities within commercial and recreational usages. Also it is understood that necessary care would not be carried upon public institutions and transformers, as potential ignition sources within urban areas. Overall, by relying on general findings of fire causes, it could be said that occupants do not see fire as a risk of their daily life; therefore negligence is the basic cause of fires. Also, lack of necessary education about fire risk, and precaution and prevention methods increases accidentally ignited fires and fires caused by lack of care.

General property class distribution along with fire factors is represented in Figure 4.18. Smoking material is the leading factor within vacant structures with a percent of 76 %. Smoking material as a fire factor is also in the first rank for non-residential structures, whereas in the second rank for residential buildings. The leading factor for residential buildings is electrical appliances and electrical installation with a frequency of 79 fires out of 350. Cooking appliance fires are nearly in same frequency for residential and non-residential buildings, since non-residential group covers restaurant, bar, and café usages.

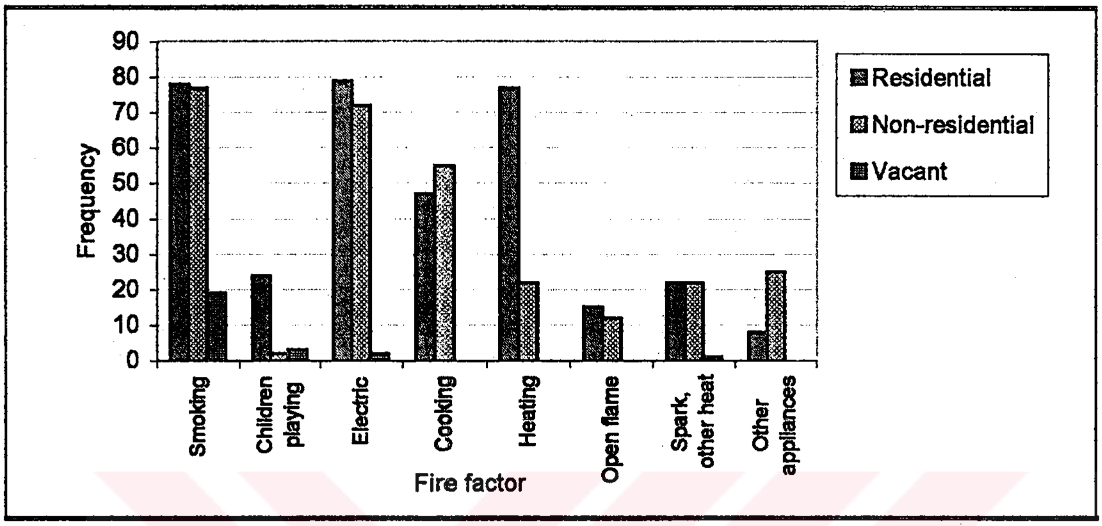

Figure 4.18: Frequency distribution of general property classes according to fire factors, 1998

Minor property class relation with fire factors represents parallel results with fire cause – property class analysis. The majority of cooking fires in restaurants, bars and cafés with a percent of 42,42 % strengthen the remark that security controls by authorities over these kinds of usages is inadequate, as stated previously. Moreover, one third of all fires in industrial usage are caused due to smoking materials, and nearly all fires arose due to children playing with matches and lighters are seen in residential property. These observations also support the previous statement about lack of education and attention of occupants and users.

4.2.4 FIRE PROBLEM AT QUARTER SCALE [10]

The most remarkable difference between quarters is observed in dominant property class in which fire occurred. It is found that the dominant property class in which fire occurred generally reflects the major property class profile of the quarter. (Figure 4.19) The fire rate for industry and manufacturing property class is more than it was expected within the quarters where small-scale industry complexes are concentrated, such as Siteler and Önder, specialized on furniture manufacturing; Zübeyde Hanım quarter, including repair workshops; Ulubey and Ali Ersoy quarters, specialized on iron-works. Similarly, fires originated in commercial usages are more than they were expected in main commercial centers of Ankara, in Kızılay and Ulus zones. Vacant structures are clustered in two zones within the study area. One zone is the transition area around the Ankara Citadel where historical buildings are concentrated, and the second zone is in Çankaya District, near Dikmen, in which squatter houses were transforming to high-rise apartments, therefore they have been discharged. Accommodation and recreational usages are highly concentrated in certain quarters, in which cafes, bars, cinemas are dominant, such as Cumhuriyet (Yüksel Pedestrian Area) and Güzeltepe (Farabi) quarters. Moreover, in the periphery of the city, the dominance of house and squatter house fires observed clearly, as expected. Apartment fires are dominantly observed in quarters where apartment building stock is relatively older than other parts. These are quarters of Ankara where earlier apartment development is seen, as Aydınlıkevler, Bahçelievler, Anıttepe, Esat and Cebeci neighborhoods.

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[10] In this section, fire data will be analyzed at quarter scale. The dominant factor of each categorical variable was assigned to quarters by using signed chi-square method. For continuous variables, means only the time variables of fire data set both average and dominant values are determined for quarters. When fires are analyzed at quarter scale, significant differentiations between quarter tracts were observed and findings were obtained reflecting the quarter profile.

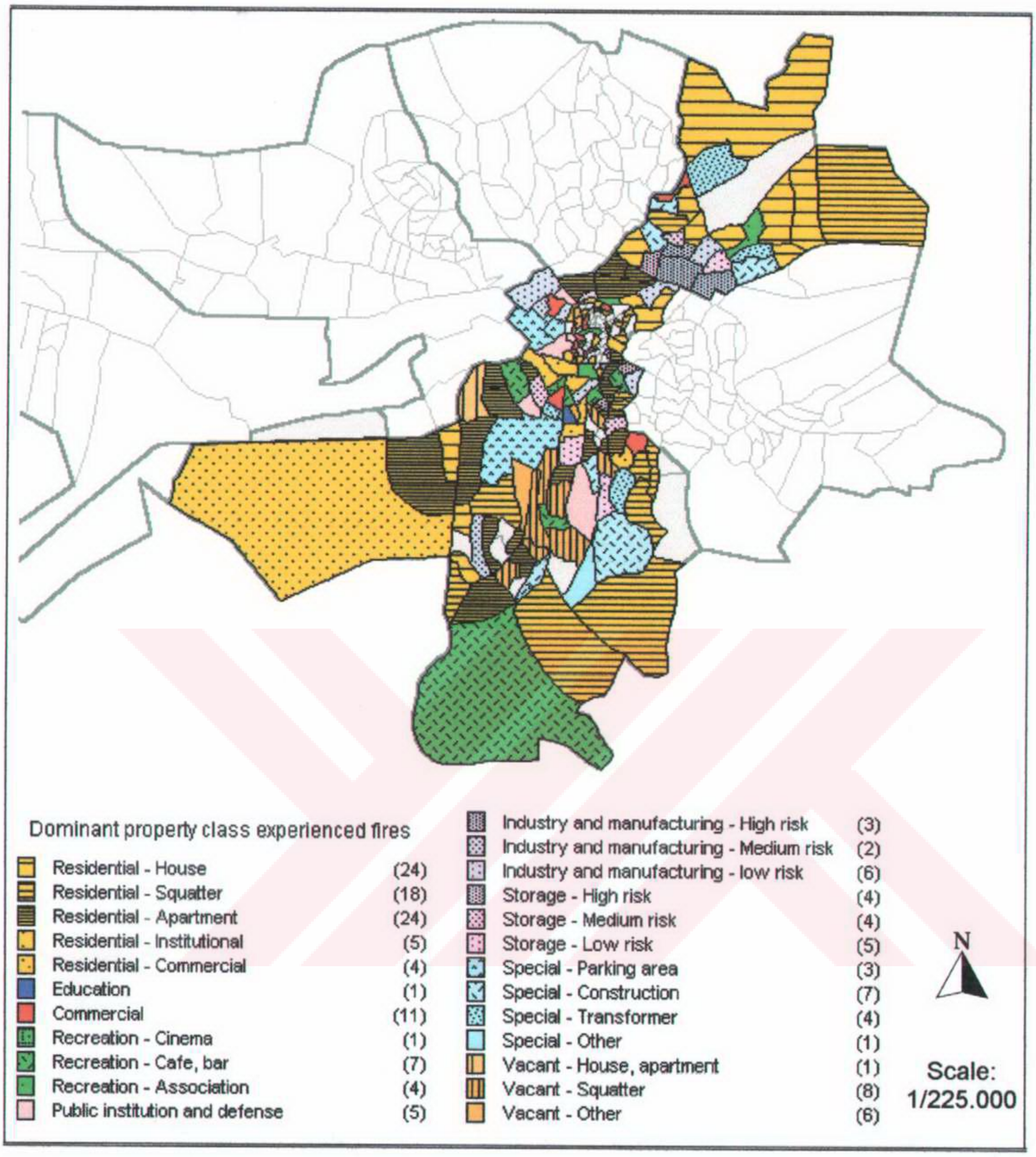


Figure 4.19: Dominant property class experienced fires at quarter scale, Altındağ and Çankaya Districts, 1998

The dominant construction materials of the structures, which experienced fire within the quarters, also reflect the existing construction material characteristics of the quarter. (Figure 4.20) As expected, historical core of the city in Altındağ district experienced a large amount of fires in timber and half-timbering structures. Another zone where timber structure fires are dominantly observed is the periphery of Altındağ district where squatter houses are located. In Çankaya district, briquette, masonry and timber structure fires also dominate in quarters where squatter houses are located. Shed structure fires are those generally occurred in annexes, therefore dominantly observed in quarter where houses or squatter houses are sited. Correspondingly, concrete building fires are observed in many quarters containing mostly apartment type of structures.

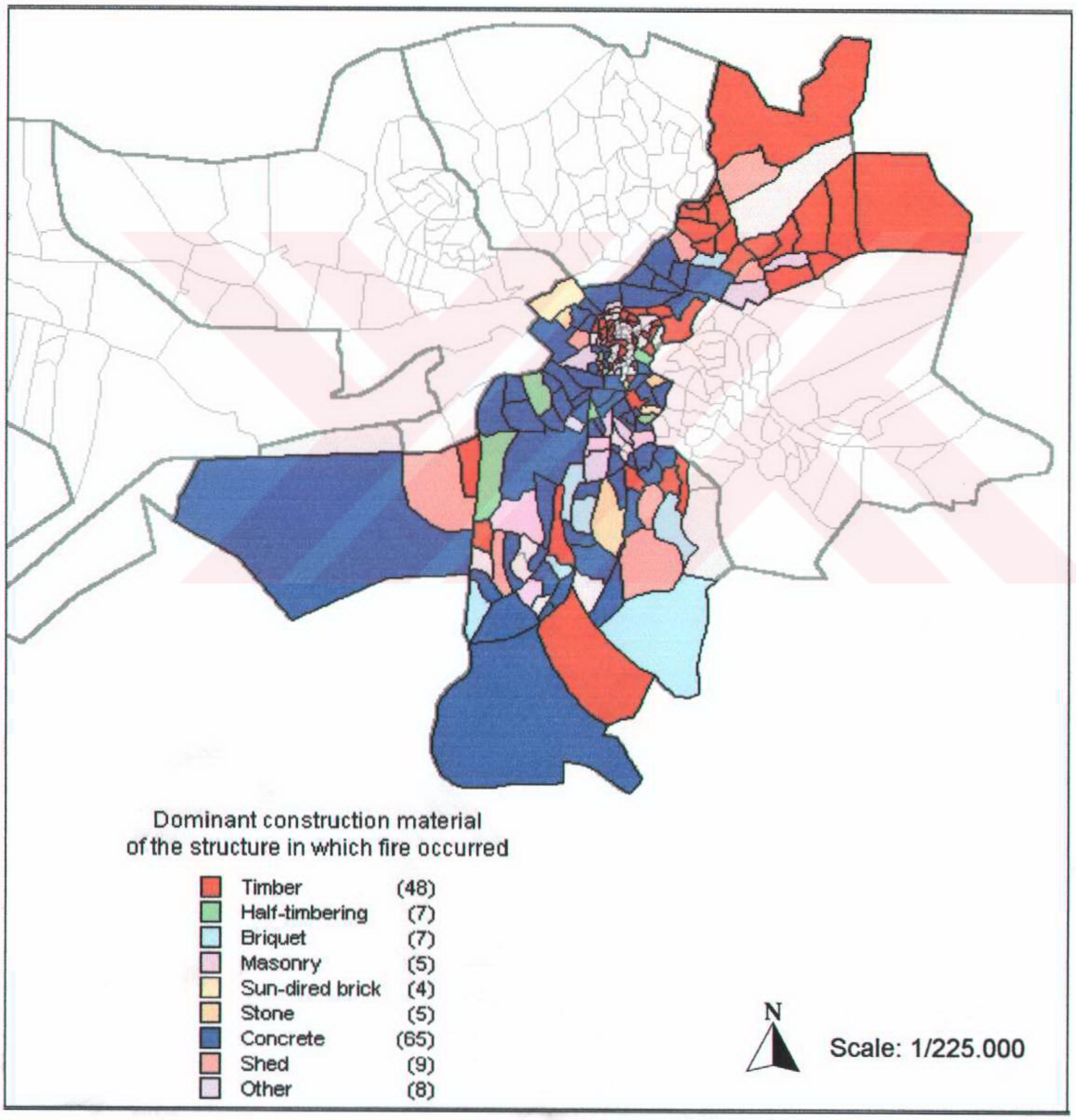


Figure 4.20: Dominant construction material of structures experienced fire at quarter scale, Altındağ and Çankaya Districts, 1998

The analysis of dominant fire cause distribution at quarter scale displays a crucial finding. Within the quarters located in the historical center of the city, arson fires are dominant. Since this area is under control of Protection and Preservation Laws, it is not allowed to demolish historical buildings located within the core. Therefore, people start fire for building new structures instead of restoring the old ones. Also, accident fires are widely spread in historical core, due to old structures' inadequate upkeep and restoration. (Figure 4.21) Fire factor map also reflects the same finding that fires caused by electrical appliances of installation are dominant in the historical core. (Figure 4.22)

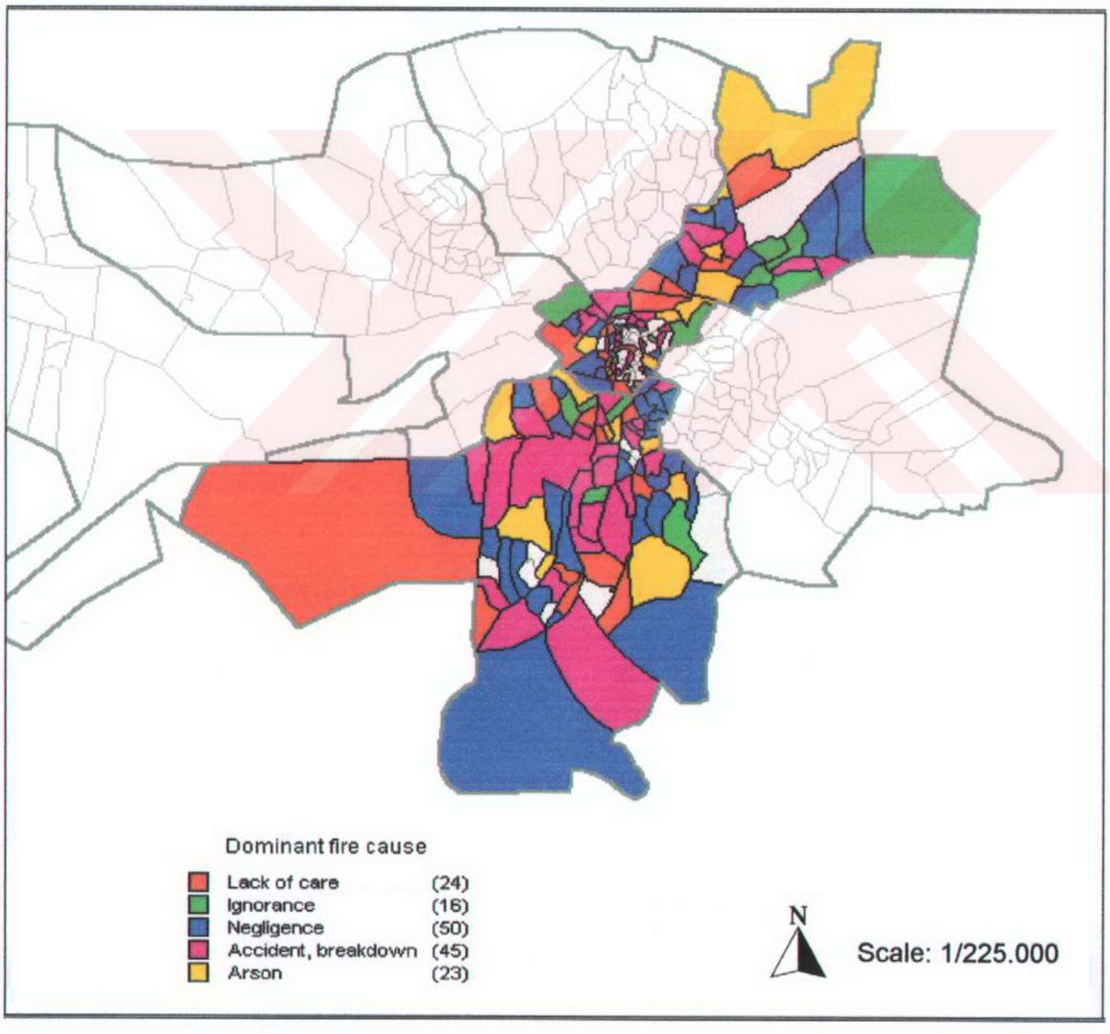


Figure 4.21: Dominant fire causes at quarter scale, Altındağ and Çankaya Districts, 1998

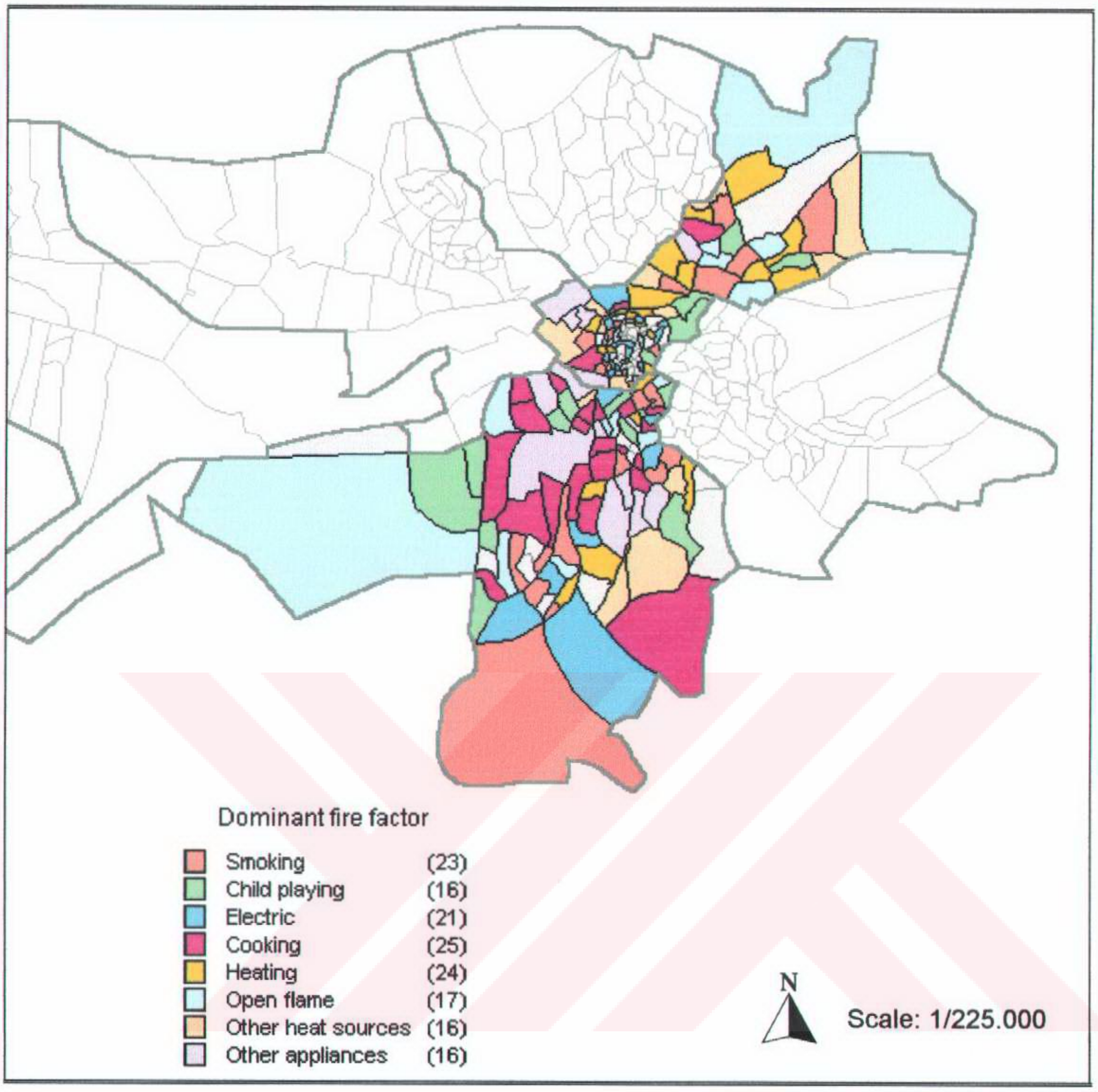


Figure 4.22: Dominant fire factor at quarter scale, Altındağ and Çankaya Districts, 1998

Dominant property loss estimation due to fire analysis at quarter scale represents that the huge property losses, means 'wholly spread the structure' and 'conflagration' are seen in the historical core of the city, where structures are generally timber or half-timbering. (Figure 4.23)

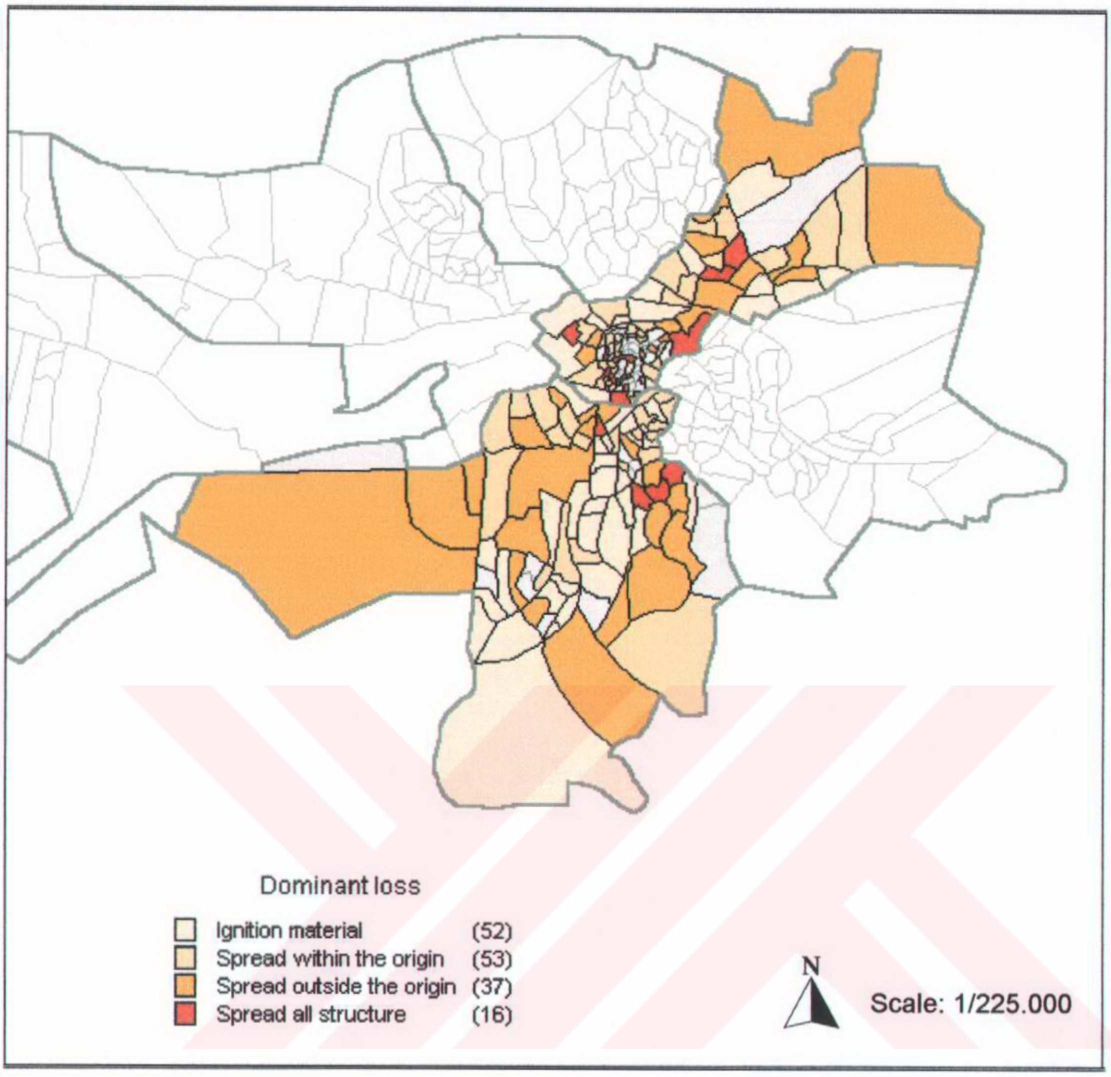


Figure 4.23: Dominant property loss estimation due to fire at quarter scale, Altındağ and Çankaya Districts, 1998

CHAPTER V

URBAN FIRE RISK ASSESSMENT – FIRE INCIDENT RELATION WITH SOCIOECONOMIC CHARACTERISTICS

The conceptual fire risk management model structured in Chapter III indicates that the fire risk assessment is a crucial step for determining risky areas within the urban environment. Without understanding the fire problem and relation between location population and activity as urban elements, it is nearly impossible to determine specific policies both for determining precaution and prevention efforts and for reducing the fire risk. Above all, socioeconomic variables are seen as the best explanatory indicators of fire incidents, since human is the main reason of fire ignition even fires occur at buildings.

Previous chapter has described the processing of data from two sources into a suitable form for analysis, besides shaping urban fire problem in study area by analyzing fire incidents in general and at quarter scales. In this chapter, based on variables determined in factor classification stage, statistical measures of association between structural fires and socioeconomic characteristics will be applied. The first section will try to determine related socioeconomic factors with fires by scatterplot and correlation analysis. Then, a series of multiple regression models will be specified and tested for evaluating the fire risk at quarter scale. Regression models will be used for explaining variations in fire rate between quarters in study area based on factors determined as related with fire risk in fire risk determination stage.

5.1 FIRE RISK DETERMINATION - SOCIOECONOMIC FACTOR ANALYSIS

In this section, the relation of fires with socioeconomic variables will be analyzed. The primary measure of fire incidence in this study is the fire rate, which represents the number of structural fires per 1000 residence. Fire rate is calculated for each quarter in the study area. The distribution of fire rate within quarters is given in Figure 5.1.

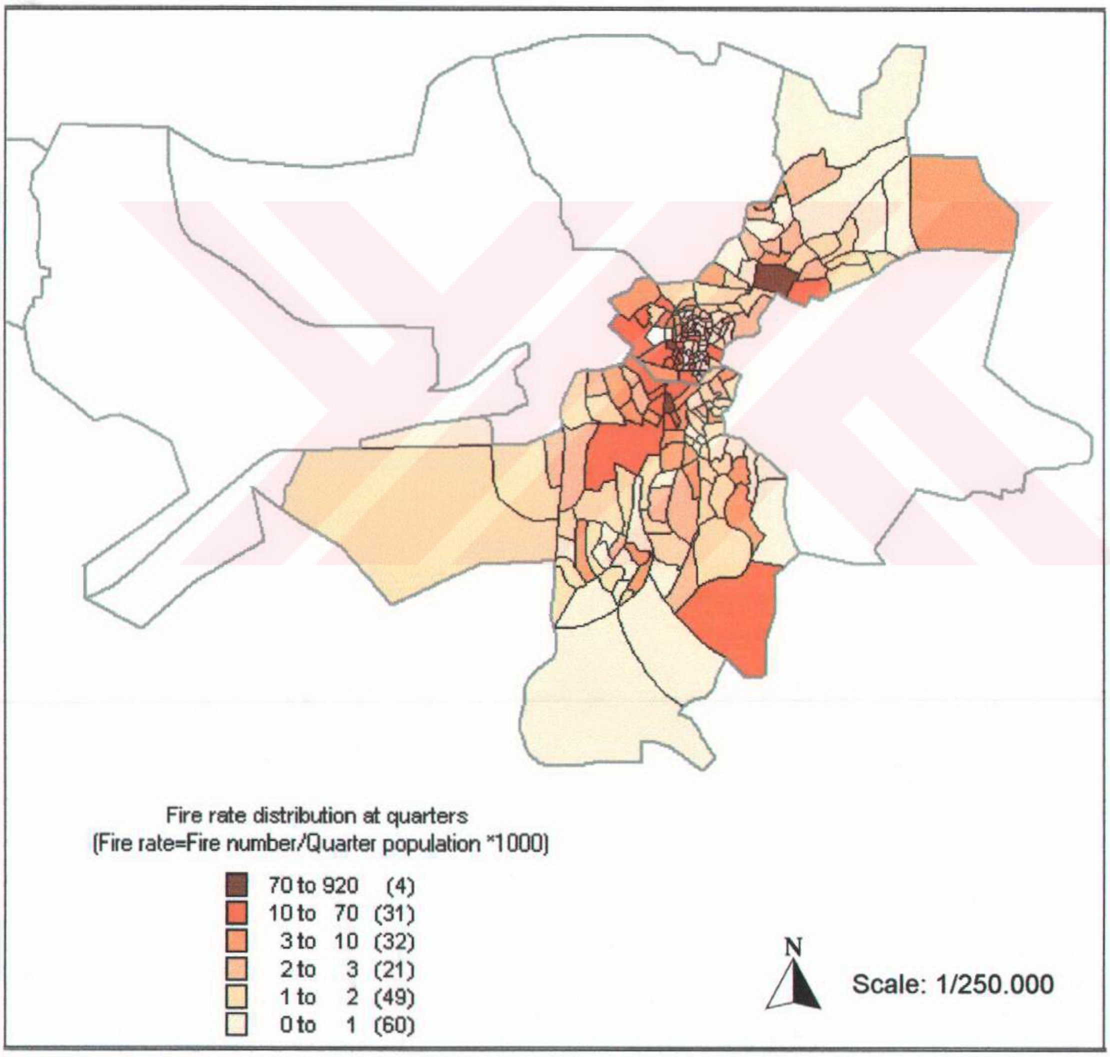


Figure 5.1: Distribution of fire rates within quarters, Altındağ and Çankaya districts, 1998

There are four quarters where fire rate is so high. The highest fire rate, 920 fires per 1000 population, is observed in Siteler quarter, which serves as a small-scaled industrial area. Cumhuriyet quarter, which is located within the Kızılay commercial central area, is in the second row with 350 fires per 1000 population. Anafartalar and Şenyurt quarters, located in the Ulus center are other quarters where fire rate is high with 266 and 120 fires per 1000 population. These extremely high fire rate values are also assigned as missing values within analysis like zero values, which represent there was no fires within the quarter for the year 1998.

As listed in Chapter 3 where fire risk factors are determined, there are mainly ten individual factors reflecting the socioeconomic characteristics of occupants. These factors are income, poverty, unemployment, ownership, education, age structure, family structure, household size, migration, and population density. Since there is no monetary equivalent of income or money household earn, poverty cannot be determined from the Census data. Therefore, poverty factor will not be examined within socioeconomic analysis of fire incidents in the study area. Similar to poverty, household size can not be analyzed within this study; even it is an indicator for crowdedness within a household. In previous analysis, household size is represented as household member per room, and as it increases, fire rate is also expected to increase. But for the case study area, there is no data available about the room number of the building household live. Therefore, household size will not be used within assessment analysis. Thus, out of ten socioeconomic factors, eight of them will be used for analysis. For converting categorical socioeconomic factors from individual or household level to quarter level, percentages of each categorical value of factors are used. Therefore, each socioeconomic factor is represented as a group of categorical values' percentages in the final data set at quarter level. (Chapter IV, Section 4.1.3) (Table 5.1)

Table 5.1: Factors and variables representing socioeconomic factors

Socioeconomic factor	Factor code in the final data set	Number of variables for socioeconomic factor represented as percentage
Income	income	3 variables (income_1, income_2, income_3)
Unemployment	work	3 variables (work_1, work_2, work_3)
Ownership	own	2 variables (own_1, own_2)
Education	sch	2 variables (lit_4, lit_5)
	lit	3 variables (sch_1, sch_2, sch_3)
Age structure	age	4 variables (age_1, age_2, age_3, age_4)
Family structure	hhtype	6 variables (hhtype_1, hhtype_2, hhype_3, hhtype_4, hhtype_5, hhytpe_6)
Migration	res	2 variables (res_1, res_6)
	res5	2 variables (res5_1, res5_6)
Population density	allpop,	-
	density	-

To examine the relationship between fire rate and socioeconomic characteristics at quarter scale, firstly, scatter diagrams between fire rate and each variables are used[1] for every socioeconomic factor separately. For constituting a base for further analysis, regression prediction lines at %95 confidence interval[2] is also shown. Two-variable regression model is applied firstly to each variable within a given socioeconomic factor, intended for determining each variable effect on fire rate individually. Thereafter, linear multiple regression equations between fire rate and all variables of a given socioeconomic factor are estimated and tested for determining the overall affect of each socioeconomic factor's significance simultaneously on fire rate. The zero value of each of each variable is assigned as missing value within scatter diagram analysis. However within regression analysis, the zero value is used, since all variables are simultaneously representing the given socioeconomic factor.

[1] For each quarter, percentages of every variable of each socioeconomic factor are determined at quarter level. Consequently, scatter diagram analysis could be operated.

[2] Confidence interval shows the average relationship between the dependent variable and explanatory variable.

5.1.1 MULTIPLE REGRESSION ANALYSIS OF SOCIOECONOMIC FACTORS

Fire problem is not depended only to a factor, but a number of factors affect the fire risk in the urban environment simultaneously, as defined in conceptual fire risk management model in Chapter 3. Therefore, it is needed to use an extended model for testing the influence of socioeconomic factors on fire rate at the same time in this study. Thus, multiple linear regression model, in which the dependent variable, *Y* depends on two or more explanatory variables, *X* is selected in this study[3]. Scatter diagrams and two-variable regression analysis[4] are also conducted between fire rate and each explanatory variable of a given socioeconomic factor. Even strong correlations are useful for identifying variables worth of study, they do not control the effects of other possible stronger relations with other variables. (Gujarati, 1995) Therefore, following two-variable regressions, variables of each socioeconomic factor are examined by multiple regression analysis together for determining which variable within each factor has significant effect on fire rate and for determining overall effect of the factor on the dependent variable. The general equation of the multiple linear regression, which will be used in this analysis is;

$$Y = ß_1 + ß_2X_{2i} + ß_3X_3 + ß_4X_4 + \ldots + ß_kX_k + u$$

where *Y* is the dependent variable, X_2, X_3, X_k are explanatory variables, $ß_1$ is the intercept term, $ß_2$, $ß_3$, $ß_k$ are coefficient parameters, *k* is the number of parameters in the model including the intercept term, and *u* is the stochastic

---

3 Dependent variable Y= Fire rate at quarter
(number of fires at quarter / total population of quarter x 1000)
Explanatory variables X_k= Percents of each variables of socioeconomic factors at quarter (for example, percentage of low-income group = number of low-income households at quarter / total household at quarter x 100)

4 Two-variable regression analaysis is the analysis where the influence of one explanatory variable is tested on the dependent variable. It is the simplest regression analysis with equation;

$$Y_i = ß + ß_2X_2$$

disturbance term. $ß_1$ presents the mean or average effect on Y "...of all the variables excluded from the model, although its mechanical interpretation is the average value of Y when X_2 and X_3 are set equal to zero." (Gujarati, 1995:192) The coefficients $ß_2$, $ß_3$, $ß_k$ are called the partial regression coefficients. Partial regression coefficient, $ß_2$ measures the change in the meaning of Y, per unit change in X_2 holding other explanatory variables, X_3, X_k constant. (Gujarati, 1995)

The reliance of dependent variable, fire rate, on explanatory variables is tested by four values in regression outputs. The first value is multiple coefficient of determination, R^2. Multiple coefficient of determination is used in the multiple regression analysis for determining how much the effect of the explanatory variable on variation in the dependent variable. R^2 has a role in regression analysis for measuring the goodness of fit of a sample least square linear regression analysis. However, the classical linear regression analysis does not require a high R^2. "Hence a high R^2 is not evidence in favor of the model and a low R^2 is not evidence against it." (Gujarati, 1995:211) Therefore, a second value, F value, is used for defining the reliance of the dependent variable on the explanatory variable. F-test is used for testing the overall significance of the estimated multiple regression equation. F-test is used for finding out if all the partial slope coefficients are simultaneously equal to zero in this study. Null hypothesis in F-test is;

$$H_0 : ß_2 = ß_3 = \ldots = ß_k = 0$$

which means all explanatory variables are not significant in explaining the variance of dependent variable.

The opposite hypothesis, which needs to be proved in this study, is;

$$H_1 : ß_2 \neq ß_3 \neq \ldots \neq ß_k \neq 0$$

which means not all slope coefficients are simultaneously zero. Therefore, the variance in dependent variable can be explained by the change in at least one explanatory variable.

When observed F value, F, is grater than the critical F value, F_α in a given k-variable regression model and a given significance level, α, the null hypothesis is rejected, which means that the explanatory variables have an effect on the variation of dependent variable. The general decision rule of F-test at the α level of significance is;

Reject H_0 if ----------$F_\alpha (k-1, n-1) < F$

Accept H_0 if ----------$F_\alpha (k-1, n-1) > F$

There is a close relationship between the coefficient of determination, R^2 and the F value in the analysis of variance. These indicators vary simultaneously. The larger the R^2 is, the greater the F value is. "Thus, the f test, which is a measure of the overall significance of the estimated regression, is also a test of significance of R^2." (Gujarati, 1995:249)

Other than testing overall significance of explanatory variables of a given socioeconomic factor, each explanatory variable entered into the equation is also tested by using ß and t values. t-test is used for testing an individual partial regression coefficient of an explanatory variable in a multiple regression model. Null hypothesis, H_0 states that holding other explanatory variables constant, X_1 has no linear influence on the dependent variable. Hypothesis in t-test are;

$H_0 : \beta_2 = 0$

$H_1 : \beta_2 \neq 0$

If the computed t value, t exceeds the critical t value, $t_{\alpha/2}$ at the α level of significance, the null hypothesis can be rejected; otherwise it is not. The situation when null hypothesis is rejected shows that β_2 is statistically significant. The decision rule of t-test at the α level of significance in k-variable regression model is;

Reject H_0 if ----------- $-t_{\alpha/2}(n\text{-}k) < t < +t_{\alpha/2}(n\text{-}k)$

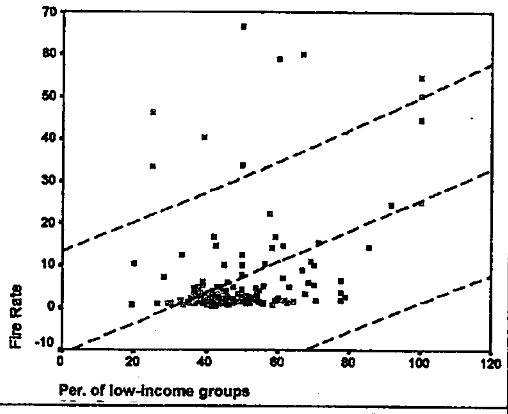
Accept H_0 if ---------- $-t_{\alpha/2}(n\text{-}k) > t$ or $t > +t_{\alpha/2}(n\text{-}k)$

5.1.1.1 INCOME FACTOR

The most remarkable variable, defined as related with fire incidence in previous researches is income of household[5]. Accordingly, fire rate is negatively correlated with income, which means that as income increases, fire rate is expected to decrease. It is observed that fire rate and income status of household is slightly related with each other as it is expected. The clear positive distribution is observed between fire rate and low-income household groups, whereas a weak negative correlation is observed between fire rate and middle-income groups. However, fire risk is positively associated with high-income groups, even fire rate is expected to increase by decrease in percentage of high-income groups. (Table 5.2) t-test results from two-variable regression outputs reflect that low-income and high-income groups are statistically significant, whereas middle-income groups are not.

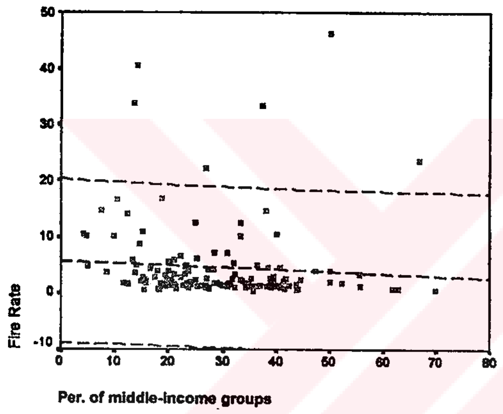
[5] However, direct monetary income of household is not recorded in censuses in Turkey. Therefore, income status of household was determined as low, middle and high by using ownership status to the dwelling, ownership to another dwelling and employment status of the household head. (Güvenç, 2001) (Appendix C)

Table 5.2: Scatter diagram and two-variable regression outputs between variables of income factor and fire rate



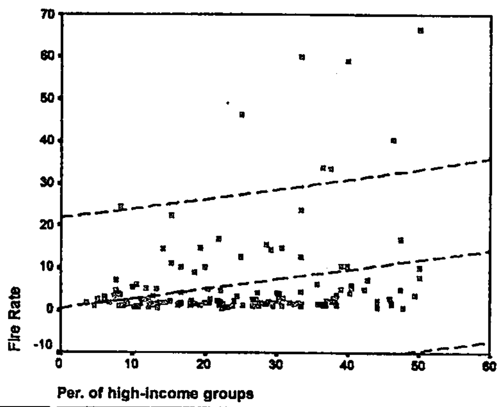
Y (firerate)= $\beta_1 + \beta_2 X_2$ (income_1)

	Sum of Squares	Mean of Squares	df
Regression	5015,7264	5015,7264	1
Residual	21174,7697	142,1125	149
Total	26190,4961		150
R	0,438	R^2	0,192
$t_{0,05/2}$(148)	± 1,980	Adj. R^2	0,186
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,366	0,062	0,438	5,941



Y (firerate)= $\beta_1 + \beta_2 X_2$ (income_2)

	Sum of Squares	Mean of Squares	df
Regression	33,1878	33,1878	1
Residual	7151,4122	52,2001	137
Total	7184,6000		138
R	0,068	R^2	0,005
$t_{0,05/2}$(136)	± 1,980	Adj. R^2	-0,003
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
-0,038	0,048	-0,068	-0,797



Y (firerate)= $\beta_1 + \beta_2 X_2$ (income_3)

	Sum of Squares	Mean of Squares	df
Regression	1209,7226	1209,7226	1
Residual	16099,6828	113,3780	142
Total	17309,4055		143
R	0,264	R^2	0,070
$t_{0,05/2}$(141)	± 1,980	Adj. R^2	0,063
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,231	0,071	0,264	3,266

As explained above, variables of income factor have an effect on fire rate individually. The multiple regression analysis also represents this association between income and fire rate. The income, which was assumed to have an affect on fire risk, can explain 22% of all fires occurred in study area in 1998. (Table 5.3) Even R^2=0,22 is not so high for the explanation of variation, F-test and t-test represent that the model is correct and all variables of income factor can be used in the final model for assessing fire risk in the study area. (Table 5.4)

Table 5.3: Output of four-variable multiple regression model for fire rate relation with income factor

Estimated Equation	$Y (firerate) = ß_1 + ß_2X_2 (income\_1) + ß_3X_3 (income\_2) + ß_4X_4 (income\_3)$				
	Sum of Squares	df	Mean Square	F	Sig.
Regression	5700,736	2	2850,368	20,474	0,000
Residual	20743,299	149	139,217		
Total	26444,035	151			
R	0,464	R Square	0,216	Std. Error of the Estimate	11,7990
		Adjusted R Square	0,205		
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
income_2	-0,44504	0,06955	-0,49201	-6,39876	0,000
income_3	-0,16499	0,075637	-0,16772	-2,18132	0,031
income_1 is excluded					

Even middle-income group separately did not reflect any association with fire rate in scatterplot and two-variable regression analysis; multiple regression analysis shows that both middle and high-income groups has a negative correlation with fire rate. Besides, middle-income groups within the quarter, ß(income_2)=-0,49, affect fire risk more than high-income groups, ß(income_3)=-0,17. Low-income group, defined as significant in two-variable regression analysis, is excluded from the model because of collinearity problem. (For correlation values, refer to Appendix D)

Table 5.4: F and t-tests results in multiple regression analysis for income factor

F-test	For n = 151 and k = 3, $F_{0,05}(149,2)$ is 19,5 at 0,05 level of significance.		
	Hypothesis		Ho: $\beta_1 = \beta_3 = \beta_4 = 0$ H_1: $\beta_1 \neq \beta_3 \neq \beta_4 \neq 0$
	Excepted		Reject Ho if F_α(k-1, n-1) < F
	Decision		Since F = 20,474 and F > $F_{0,05}$ in model, H_0 is rejected. Therefore, the model is accepted that income explains the variation in fire rate.
t-test	For n = 151 and k = 3, $t_{0,05/2}(148)$ is ± 1,980 at 0,05 level of significance.		
	Expected		Reject H_0 if - $t_{\alpha/2}$ (n-k) > t or t > + $t_{\alpha/2}$ (n-k)
	Hypothesis		H_0: $\beta_k = 0$ H_1: $\beta_k \neq 0$
	Decision	For β_3	Since t for β_3 = -2,18 and -$t_{0,05/2}$ > t in model, H_0 is rejected. Therefore high-income group affect fire risk.
		For β_2	Since t for β_2 = -6,4 and -$t_{0,05/2}$ > t in the model, H_0 is rejected. Therefore high-income group affect fire risk.

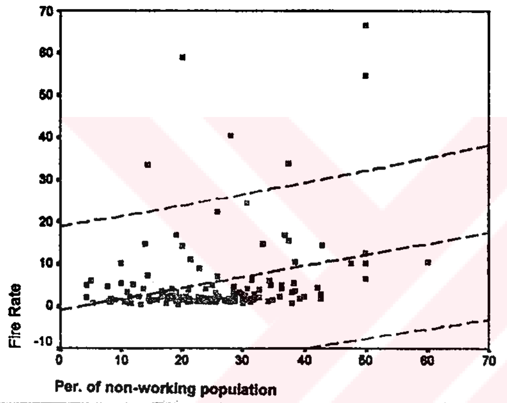
5.1.1.2 WORKING STATUS FACTOR

Fire rate is expected to increase as the percentage of working population within the quarter decreases and unemployment rate increases. The reason for this expected positive correlation is that as unemployment rate increases, fire incidents also increase due to increase in arsons and social depression according to previous researches. When scatter diagrams between variables of working status factor and fire rate is examined in the study area, it is determined that all variables represent a positive association with fire rate. Nevertheless, according to t-tests, working and non-working population is statistically significant, but unemployed population is not. The most significant variable of working status factor is the percentage of non-working population, with a beta value, ß=0,283. (Table 5.5)

Table 5.5: Scatter diagram and two-variable regression outputs between variables of working status factor and fire rate

Y (firerate) = $ß_1 + ß_2X_2$ (work_1)

	Sum of Squares	Mean of Squares	df
Regression	750,690	750,690	1
Residual	25693,346	171,289	150
Total	26444,035		151
R	0,168	R^2	0,028
$t_{0,05}(149)$	± 1,980	Adj. R^2	0,022
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,180	0,086	0,168	2,093



Y (firerate) = $ß_1 + ß_2X_2$ (work_2)

	Sum of Squares	Mean of Squares	df
Regression	1179,7816	1179,7816	1
Residual	13594,1558	97,1011	140
Total	14773,9373		141
R	0,283	R^2	0,080
$t_{0,05/2}(139)$	± 1,980	Adj. R^2	0,073
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,263	0,076	0,283	3,486

Y (firerate) = $ß_1 + ß_2X_2$ (work_3)

	Sum of Squares	Mean of Squares	df
Regression	72,1911	72,1911	1
Residual	2130,5347	21,9643	97
Total	2202,7258		98
R	0,181	R^2	0,033
$t_{0,05/2}(96)$	± 1,980	Adj. R^2	0,023
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,229	0,126	0,181	1,813

The linear relationship between working status of population and fire rate in scatter diagram analysis cannot be determined by multiple regression analysis. Even, working population and non-working population are seen as linearly associated with fire rate in scatter diagrams, the working status factor explains a small percent of fire rate with 6%, as R^2 representing in regression output. (Table 5.6)

Table 5.6: Output of three-variable multiple regression model for fire rate relation with working status factor

Estimated Equation	Y (firerate)= $\beta_1 + \beta_2 X_2$ (work_1) + $\beta_3 X_3$ (work_2) + $\beta_4 X_4$ (work_3)				
	Sum of Squares	df	Mean Square	F	Sig.
Regression	1654,866	2	827,433	4,973	0,008
Residual	24789,169	149	166,370		
Total	26444,035	151			
R	0,250	R Square	0,063	Std. Error of the Estimate	12,8985
		Adjusted R Square	0,050		
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
work_2	-0,14848	0,086032	-0,138	-1,72581	0,086
work_3	-0,85108	0,299961	-0,22688	-2,83731	0,005
work_1 is excluded					

Overall, change in the working status of population does not cause any significant change in fire rate at quarter scale according to F-test. However, t-tests for sub-variables represents that the percentage of unemployed population within the quarter has a negative effect on fire rate, whereas percentage of working population do not have any effect on variance of fire rate due to t-test result. (Table 5.7) On the other hand, percentage of non-working population sub-variable is excluded from the model because of collinearity problem. (For correlation values, refer to Appendix D) According to multiple regression analysis, there is no linear association between fire rate and the working status of the population, but there is a relation between percentage of unemployed population and fire rate, according to t-test results. Therefore, working status will not be used as a factor for the final risk estimation analysis, but will be represented by the variable, which is statistically significant.

Table 5.7: F and t-tests results in multiple regression analysis for working status factor

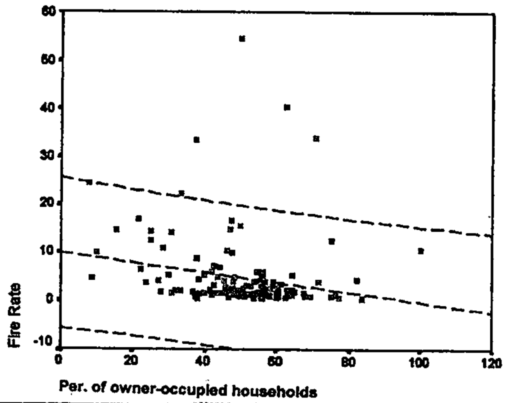
<table>
<tr><td rowspan="4">F-test</td><td colspan="3">For n = 151 and k = 3, $F_{0,05}$ (149,2) is 19,5 at 0,05 level of significance.</td></tr>
<tr><td colspan="2">Hypothesis</td><td>Ho: $ß_1 = ß_3 = ß_4 = 0$
H_1: $ß_1 \neq ß_3 \neq ß_4 \neq 0$</td></tr>
<tr><td colspan="2">Excepted</td><td>Reject Ho if F_α(k-1, n-1) < F</td></tr>
<tr><td colspan="2">Decision</td><td>Since F = 4,973 and F< $F_{0,05}$ in model, H_0 is accepted. Therefore, all variables used in the model are not significant in explaining the equation simultaneously.</td></tr>
<tr><td rowspan="5">t-test</td><td colspan="3">For n = 151 and k = 3, $t_{0,05/2}$ (148) is ± 1,980 at 0,05 level of significance.</td></tr>
<tr><td colspan="2">Expected</td><td>Reject H_0 if - $t_{\alpha/2}$ (n-k) > t or t > + $t_{\alpha/2}$ (n-k)</td></tr>
<tr><td colspan="2">Hypothesis</td><td>H_0: $ß_k = 0$
H_1: $ß_k \neq 0$</td></tr>
<tr><td rowspan="2">Decision</td><td>For $ß_2$</td><td>Since t for $ß_2$ = -1,73 and $-t_{0,05/2} < t < +t_{0,05}$ in model, H_0 is accepted; which means non-working population do not affect fire risk.</td></tr>
<tr><td>For $ß_3$</td><td>Since t for $ß_3$ = -2,84 and $-t_{0,05/2} > t$ in the model, H_0 is rejected; so unemployed population group affect fire risk at quarter.</td></tr>
</table>

5.1.1.3 OWNERSHIP FACTOR

Ownership status of the household to the building they live in is another economic indicator, which is assumed linearly related with fire risk at quarter level within the conceptual model. Since housekeeping increases when household is the owner of the unit, fire rate is expected to be less than tenant households. This assumption is valid also for the study area. Fire rate increase with the increase in percentage of tenants within the quarter, as seen in scatter diagrams and two-variable regression analysis. (Table 5.8)

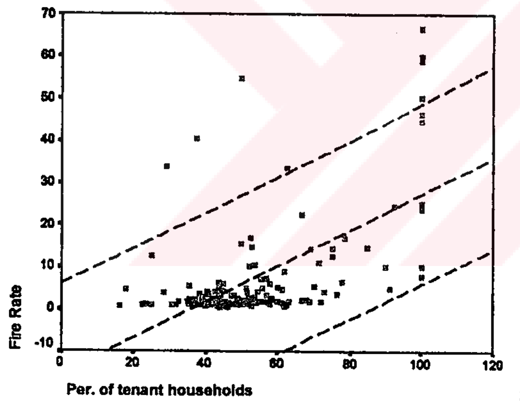
According to t-test of two-variable regression analysis, tenant population is highly significant in explaining the variance in fire rate individually, as percentage of tenant households individually can explain 37% of fire rate.

Table 5.8: Scatter diagram and two-variable regression outputs between variables of ownership factor and fire rate



Y (firerate) = $\beta_1 + \beta_2 X_2$ (own_1)

	Sum of Squares	Mean of Squares	df
Regression	297,2428	297,2428	1
Residual	7862,0973	56,9717	138
Total	8159,3401		139
R	0,191	R^2	0,036
$t_{0,05/2}(137)$	± 1,980	Adj. R^2	0,029
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
-0,102	0,045	-0,191	-2,284



Y (firerate) = $\beta_1 + \beta_2 X_2$ (own_2)

	Sum of Squares	Mean of Squares	df
Regression	9815,6430	9815,6430	1
Residual	16620,1160	111,5444	149
Total	26435,7590		150
R	0,609	R^2	0,371
$t_{0,05/2}(148)$	± 1,980	Adj. R^2	0,367
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,427	0,045	0,609	9,381

As expected and defined in scatter diagram and two-variable regression analysis, fire rate decreases as the owner-occupied household percentage increases within the quarter. The multiple regression analysis also verifies this relation. The ownership factor can explain 35% of the variation in fire rate at quarter level in the study area for the year 1998. (Table 5.9)

Table 5.9: Output of three-variable multiple regression model for fire rate relation with ownership factor

Estimated Equation	$Y (firerate)= \beta_1 + \beta_2 X_2 (own\_1) + \beta_3 X_3 (own2)$				
	Sum of Squares	df	Mean Square	F	Sig.
Regression	9192,6537	1	9192,6537	79,9297	0,0000
Residual	17251,3815	150	115,0092		
Total	26444,0351	151			
R	0,590	R Square	0,348	Std. Error of the Estimate	10,7242
		Adjusted R Square	0,343		
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
own_2	0,4024	0,0450	0,5896	8,9403	0,0000
own_1 is excluded					

Table 5.10: t-test results in two-variable regression analysis for ownership factor

t-test	For n = 151 and k = 2, $t_{0,05/2}$ (149) is ± 1,980 at 0,05 level of significance.		
	Expected		Reject H_0 if $-t_{\alpha/2}(n-k) > t$ or $t > +t_{\alpha/2}(n-k)$
	Hypothesis		H_0: $\beta_k = 0$ H_1: $\beta_k \neq 0$
	Decision	For β_3	Since t for β_3 = 8,94 and + $t_{0,05/2}$ < t in the model, H_0 is rejected. Therefore, not-owner households have a positive association with fire risk at quarter.

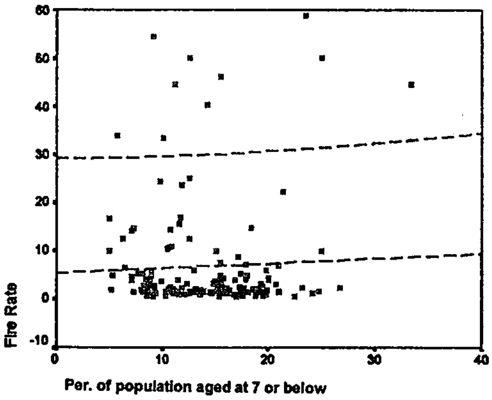
Variable representing the percentage of owner-occupied household is excluded from the model because of collinearity problem. (For correlation values, refer to Appendix D) Exclusion of one variable from the equation turned the multiple regression model to two-variable regression analysis. Since F-test is generally used for multi-variable regression analysis, F-test is not so identical for testing the significance of the model. For this reason, t-test result is used. Accordingly, the percentage of tenant households is statistically significant at the 5 percent significant level. (Table 5.10) Beta value of the percentage of tenant households shows that fire risk is increasing as tenant households increase within the quarter. Overall, ownership status of the households within the quarter has a linear relationship with fire rate and will be entered into the final estimation model.

5.1.1.4 AGE FACTOR

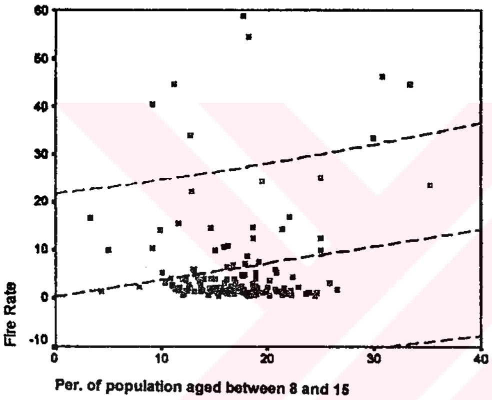
Age structure of population is examined under four variables for each quarter as percentage of population aged at 7 or below, percentage of population aged between 8 and 15, percentage of population aged between 16 and 59, and percentage of population aged at 60 or above. According to previous researches, all age groups, except the group including population between age 16 and 59, are determined as risky groups for fire ignition. Fire rate is expected to show an increasing positive correlation with age groups as age is increasing.

Scatter diagram analysis represents a parallel result to previous studies. t-test results reflects that variables representing the percentages of population aged at 7 or below and population aged between 16 and 59 are not statistically significant, whereas population aged between 8 and 15 and population aged at 60 and above have influence on the variation of fire rate at quarter level. Beta values of significant variables individually shows that the most significant variable is the percentage of population aged at 60 or above with ß= 0,440. Since carefulness and adequate upkeep of houses within this group is low, fire ignition risk is more than other risky age groups. This age group individually can explain nearly 20 percent of variation in fire rate. (Table 5.11)

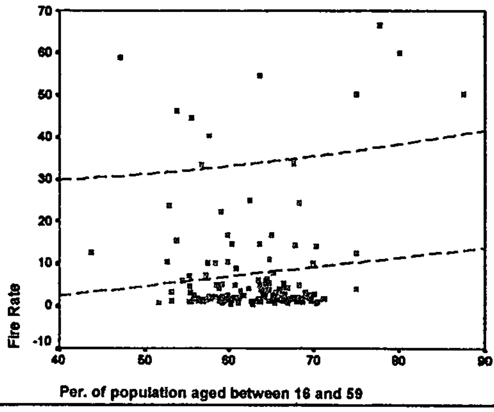
Table 5.11: Scatter diagram and two-variable regression outputs between variables of age factor and fire rate



		Sum of Squares	Mean of Squares	df
	Regression	38,9847	38,9847	1
	Residual	20100,9010	135,8169	148
	Total	20139,8858		149
	R	0,044	R^2	0,002
	$t_{0,05/2}(147)$	± 1,980	Adj. R^2	-0,005
	Unstandardized coefficients		Standardized coefficients	t
	B	Std. Error	Beta	
Y (firerate)= $ß_1 + ß_2X_2$ (age_1)	0,100	0,186	0,044	0,536

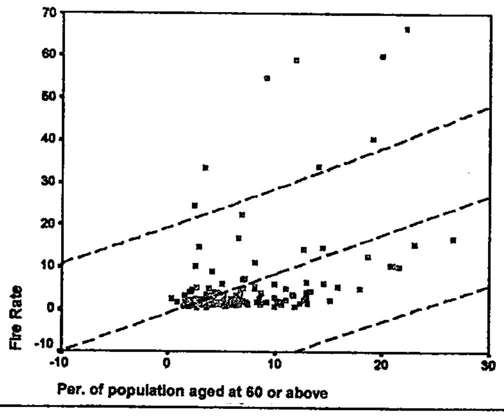


		Sum of Squares	Mean of Squares	df
	Regression	451,5747	451,5747	1
	Residual	15925,7926	109,0808	146
	Total	16377,3673		147
	R	0,166	R^2	0,028
	$t_{0,05}(145)$	± 1,980	Adj. R^2	0,021
	Unstandardized coefficients		Standardized coefficients	t
	B	Std. Error	Beta	
Y (firerate)= $ß_1 + ß_2X_2$ (age_2)	0,352	0,173	0,166	2,035



		Sum of Squares	Mean of Squares	df
	Regression	298,878	298,878	1
	Residual	26145,157	174,301	150
	Total	26444,035		151
	R	0,106	R^2	0,011
	$t_{0,05}(149)$	± 1,980	Adj. R^2	0,005
	Unstandardized coefficients		Standardized coefficients	t
	B	Std. Error	Beta	
Y (firerate)= $ß_1 + ß_2X_2$ (age_3)	0,229	0,175	0,106	1,309

Table 5.11 (continued)



	Sum of Squares	Mean of Squares	df
Regression	3418,1851	3418,1851	1
Residual	14205,1574	102,1954	139
Total	17623,3425		140
R	0,440	R^2	0,194
$t_{0,05}(138)$	± 1,980	Adj. R^2	0,188
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,926	0,160	0,440	5,783

$Y\ (firerate) = ß_1 + s_2X_2\ (age\_4)$

Although individual scatter diagrams and two-variable regression analysis represented that at least two variables of age factor are significant in explaining the fire rate variation, age groups do not represent a linear model simultaneously for explaining the variation within the quarter. The linear model for determining the relation between fire rate and variables of age factor can only explain a small part of fire rate with a percentage of 4%. Parallel to low R^2 value, F value of the model also verifies that all sub-variables of age factor are not simultaneously associated with fire rate. (Table 5.12)

Although the model is not acceptable overall, t-tests of explanatory variables represents that only percentage of population aged at 60 or above is positively associated with fire rate at the 5% significance level. On the other hand, t-tests of age groups representing population aged at 7 or below and population aged between 16 and 59 shows that they do not have any association with fire rate. (Table 5.13) Besides, age group including population aged between 8 and 15 is excluded from the model. Thus, age factor will be represented with one significant variable in the final fire risk estimation equation.

Table 5.12: Output of four-variable multiple regression model for age factor relation with fire rate

Estimated Equation	Y (firerate) = $\beta_1 + \beta_2 X_2$ (age_1) + $\beta_3 X_3$ (age_2) + $\beta_4 X_4$ (age_3) + $\beta_5 X_5$ (age_4)				
	Sum of Squares	df	Mean Square	F	Sig.
Regression	1122,873	3	374,291	2,188	0,092
Residual	25321,162	148	171,089		
Total	26444,035	151			
R	0,206	R Square	0,042	Std. Error of the Estimate	13,0801
		Adjusted R Square	0,023		
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
age_1	0,2357	0,3174	0,0951	0,7428	0,4588
age_3	0,2965	0,2242	0,1379	1,3229	0,1879
age_4	0,5266	0,2561	0,2178	2,0565	0,0415
age_2 is excluded					

Table 5.13: F and t-tests results in multiple regression analysis for age variables

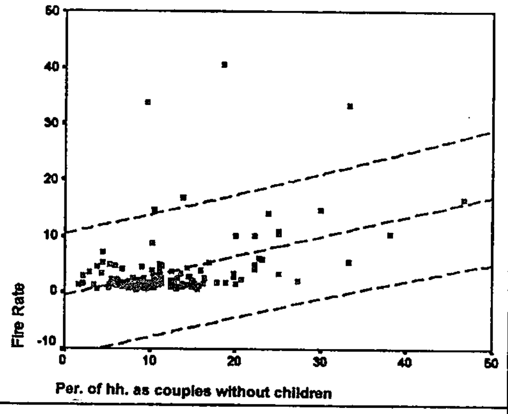
F-test	For n = 151 and k = 4, $F_{0,05}$ (147,3) is 5,66 at 0,05 level of significance.		
	Hypothesis		Ho: $\beta_1 = \beta_3 = \beta_4 = 0$ H_1: $\beta_1 \neq \beta_3 \neq \beta_4 \neq 0$
	Excepted		Reject Ho if F_α(k-1, n-1) < F
	Decision		Since F = 2,188 and F< $F_{0,05}$ in model, H_0 is accepted. Therefore, it is said that all variables used in the model are not significant in explaining the model simultaneously.
t-test	For n = 151 and k = 3, $t_{0,05}$ (148) is ± 1,980at 0,05 level of significance.		
	Expected		Reject H_0 if - $t_{\alpha/2}$ (n-k) > t or t > + $t_{\alpha/2}$ (n-k)
	Hypothesis		H_0: $\beta_k = 0$ H_1: $\beta_k \neq 0$
	Decision	For β_2	Since t for β_2 = 0,75 and $-t_{0,05/2} < t < +t_{0,05/2}$ in model, H_0 is accepted; which means population aged at 7 or below do not affect fire risk.
		For β_4	Since t for β_4 = 1,32 and $-t_{0,05/2} < t < +t_{0,05/2}$ in the model, H_0 is accepted; which means population aged between 16 and 59 does not affect fire risk at quarter level.
		For β_5	Since t for β_5 = 2,06 and t > $+t_{0,05/2}$ in the model, H_0 is rejected; which means population aged at 60 and above is statistically significant in explaining the variation of fire rate.

5.1.1.5 FAMILY STRUCTURE FACTOR

For analyzing the relation between family type and fire rate, 6 household types and their percentage distribution within each quarter is used. As result of analysis, there determined significant results parallel to findings of previous researches. Scatter diagrams show that couple groups without any children, single-parent families with children, solitaires, extended families and households without couple groups are positively associated with fire rate in the study area, as expected. On contradiction, simple families as couples with children do not display any correlation with fire rate. (Table 5.14)

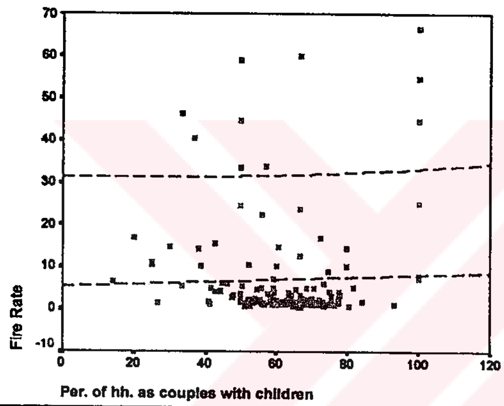
According to t-test results of each variable of household type factor individually, the most correlated variable is solitaries. They are generally households who are elder and living alone. Due to the lack of care and upkeep of houses, this group is the most risky household type according to scatter diagram analysis. The second risky group is extended families including households as couple groups with children and others, and households with more than two couple groups with children. These households are generally couple groups who are living with their elders or parents. Since these households include older population and since household size is increasing, fire rate is positively correlated. The positive relation between fire rate and households as couples without any children is because of the same reason with the positive relation between solitaries and fire rate. Couples without any children are mainly older couples whose children left home, even they have. The other positive relation is seen between fire rate and single-parent families with children. Due to inadequate children supervision, fire incidents increase as the percentage of this group increases within the quarter. The only negative relation is observed between couple groups with children and fire rate. This may be because of adequate children supervision.

Table 5.14: Scatter diagram and two-variable regression outputs between variables of household type factor and fire rate



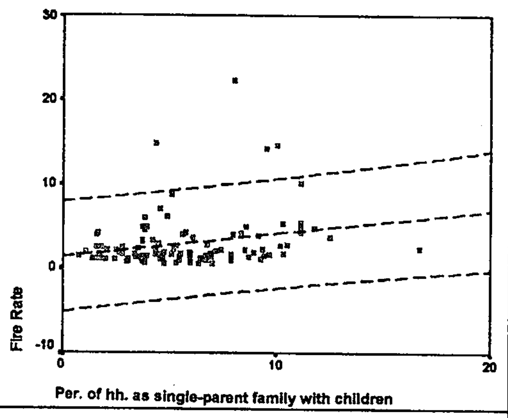
	Sum of Squares	Mean of Squares	df
Regression	843,8248	843,8248	1
Residual	3731,956	29,85565	125
Total	4575,781		126
R	0,429	R^2	0,184
$t_{0,05/2}(124)$	± 1,980	Adj. R^2	0,178
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
-0,350	0,129	-0,217	-2,719

Y (firerate) = $\beta_1 + \beta_2 X_2$ (hhtype_1)



	Sum of Squares	Mean of Squares	df
Regression	26,03127	26,03127	1
Residual	22755,25	154,7976	147
Total	22781,29		148
R	0,034	R^2	0,001
$t_{0,05/2}(146)$	± 1,980	Adj. R^2	-0,006
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,027	0,066	0,034	0,410

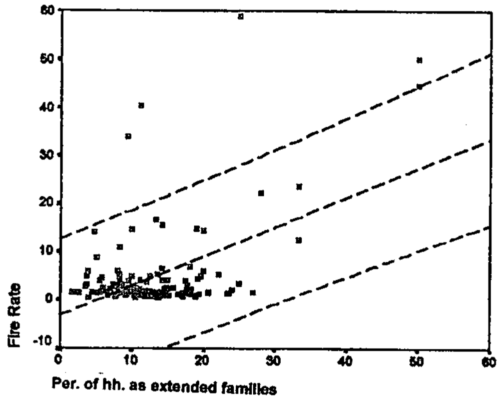
Y (firerate) = $\beta_1 + \beta_2 X_2$ (hhtype_2)



	Sum of Squares	Mean of Squares	df
Regression	70,7303	70,7303	1
Residual	1034,4788	10,3448	100
Total	1105,2091		101
R	0,253	R^2	0,064
$t_{0,05/2}(99)$	± 1,980	Adj. R^2	0,055
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,274	0,105	0,253	2,615

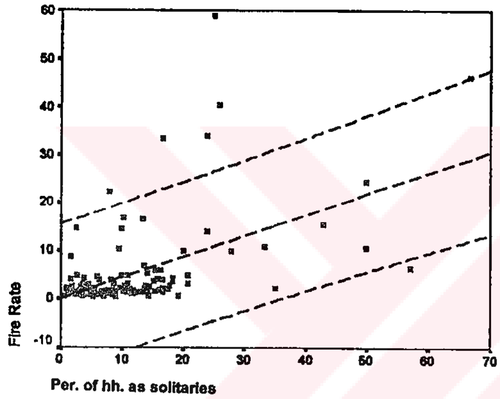
Y (firerate)= $\beta_1 + \beta_2 X_2$ (hhtype_3)

Table 5.14 (continued)



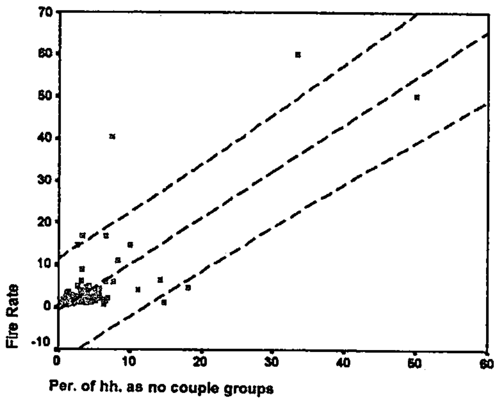
	Sum of Squares	Mean of Squares	df
Regression	2815,894	2815,894	1
Residual	8222,625	62,76813	130
Total	11038,52		131
R	0,505	R^2	0,255
$t_{0,05/2}$(129)	± 1,980	Adj. R^2	0,249
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,611	0,091	0,505	6,698

Y (firerate)= $ß_1 + ß_2X_2$ (hhtype_4)



	Sum of Squares	Mean of Squares	df
Regression	2835,1184	2835,1184	1
Residual	7106,3523	60,2233	118
Total	9941,4707		119
R	0,534	R^2	0,285
$t_{0,05/2}$(117)	± 1,980	Adj. R^2	0,279
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,434	0,063	0,534	6,861

Y (firerate)= $ß_1 + ß_2X_2$ (hhtype_5)



	Sum of Squares	Mean of Squares	df
Regression	4506,5597	4506,5597	1
Residual	3059,9988	37,7778	81
Total	7566,5585		82
R	0,772	R^2	0,596
$t_{0,05/2}$(80)	± 2,000	Adj. R^2	0,591
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
1,106	0,101	0,772	10,92

Y (firerate) = $ß_1 + ß_2X_2$ (hhtype_6)

Household type factor explains the 22 percentage of variation in fire rate within the quarter, according to multiple regression outputs, R^2 = 0,216. F-test of the multiple regression analysis verifies that all variables of household type factor simultaneously affect fire risk and the estimated linear model is acceptable for household type factor. (Table 5.15) Thus, household type factor will be entered into the final regression equation.

Table 5.15: Output of seven-variable multiple regression model for household type factor relation with fire rate

Estimated Equation	Y (firerate) = $\beta_1 + \beta_2X_2$(hhtype_1) + β_3X_3(hhtype _2) + β_4X_4(hhtype _3) + β_5X_5(hhtype _4) + β_6X_6(hhtype _5) + β_7X_7(hhtype _6)				
	Sum of Squares	df	Mean Square	F	Sig.
Regression	5724,716	6	954,119	6,677	0,000
Residual	20719,319	145	142,892		
Total	26444,035	151			
R	0,465	R Square	0,216	Std. Error of the Estimate	11,9537
		Adjusted R Square	0,184		
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Hhtype_1	-0,767	0,162	-0,476	-4,731	0,000
Hhtype_2	-0,407	0,123	-0,543	-3,320	0,001
Hhtype_3	-0,548	0,162	-0,357	-3,385	0,001
Hhtype_4	-0,489	0,163	-0,308	-3,004	0,003
Hhtype_5	-0,216	0,146	-0,180	-1,475	0,142
Hhtype_6	0,228	0,216	0,096	1,056	0,293

For determining the effect of variables, partial coefficients are analyzed by t-tests. t-test results reflect that percentages of household types as solitaries and no-couple groups are not significant at the 5 percent level. Whereas, couples, couples with children, single-parent families with children and extended families are statistically significant in explaining the variation. The most remarkable variable is the percentage of households as couples with children, closely followed by the percentage of households as couples.

Overall the model, all significant variables of household type factor affect fire risk negatively, which means as their percentage within the quarter increases, the fire rate is decreasing. (Table 5.16)

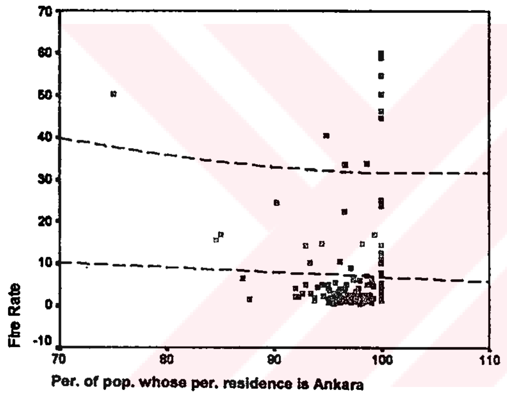
Table 5.16: F and t-tests results in multiple regression analysis for variables of household type factor

F-test	For n = 151 and k = 7, $F_{0,05}$ (144,6) is 3,70 at 0,05 level of significance.		
	Hypothesis		Ho: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$ H_1: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq 0$
	Excepted		Reject Ho if F_α(k-1, n-1) < F
	Decision		Since F = 6,677 and F> $F_{0,05}$ in model, H_0 is rejected. Therefore, it is said that not all slope coefficients are simultaneously zero.
t-test	For n = 151 and k = 7, $t_{0,05/2}$ (144) is ± 1,980 at 0,05 level of significance.		
	Expected		Reject H_0 if $-t_{\alpha/2}(n-k) > t$ or $t > +t_{\alpha/2}(n-k)$
	Hypothesis		H_0: $\beta_k = 0$ H_1: $\beta_k \neq 0$
	Decision	For β_2	Since t for β_2 = -4,73 and $-t_{0,05/2} > t$ in model, H_0 is rejected; which means percentage of couple groups is significant individually within the model.
		For β_3	Since t for β_3 = -3,32 and $-t_{0,05/2} > t$ in model, H_0 is rejected; which means percentage of couple groups with children affect variation in dependent variable, fire rate.
		For β_4	Since t for β_4 = -3,39 and $-t_{0,05/2} > t$ in model, H_0 is rejected. Therefore percentage of lone parent with children is statistically significant at 5 percent level.
		For β_5	Since t for β_5 = -3,00 and $-t_{0,05/2} > t$ in model, H_0 is rejected; which means percentage of extended families is significant individually within the model.
		For β_6	Since t for β_6 = -1,47 and $-t_{0,05/2} < t < +t_{0,05/2}$ in model, H_0 is accepted; which means percentage of solitaries do not have any affect on fire rate individually.
		For β_7	Since t for β_7 = 1,06 and $-t_{0,05/2} < t < +t_{0,05/2}$ in model, H_0 is accepted; which shows that percentage of no-couple groups is not individually significant.

5.1.1.6 MIGRATION FACTOR

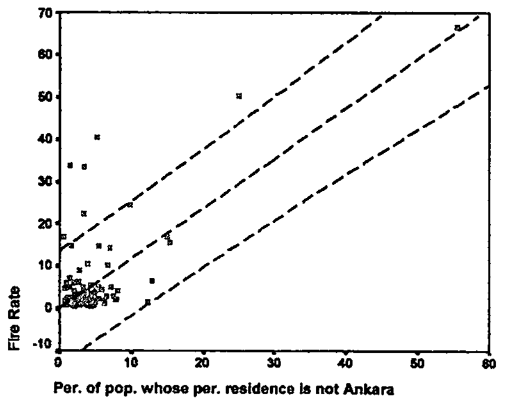
For analyzing migration effect on fire rate, two different factors are used, including two variables individually. The first factor is the permanent residence of population, whereas the second factor is the permanent residence of the population 5 years ago. Variables for permanent residence factor are determined according to whether the permanent residence of the individual is Ankara or not, whereas for the permanent residence five years ago factor, variables are determined according to whether the permanent residence of the individual was Ankara 5 years ago or not.

Table 5.17: Scatter diagram and two-variable regression outputs between variables of permanent residence factor and fire rate



	Sum of Squares	Mean of Squares	df
Regression	19,5750	19,5750	1
Residual	22919,4925	153,8221	149
Total	22939,0675		150
R	0,029	R^2	0,001
$t_{0,05/2}(148)$	± 1,980	Adj. R^2	-0,006
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
-0,111	0,310	-0,029	-0,357

Y (firerate)= $\beta_1 + \beta_2 X_2$ (res_6)

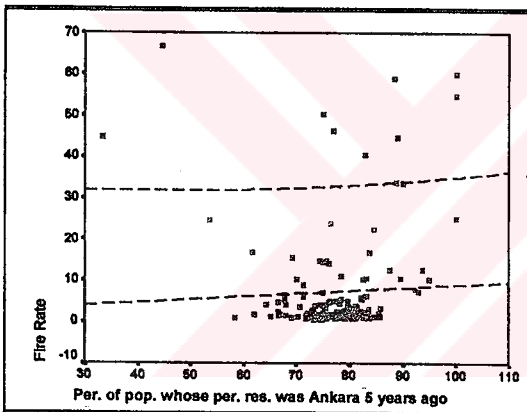


	Sum of Squares	Mean of Squares	df
Regression	5476,4483	5476,4483	1
Residual	5713,9856	46,4552	123
Total	11190,4339		124
R	0,700	R^2	0,489
$t_{0,05/2}(122)$	± 1,980	Adj. R^2	0,485
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
1,181	0,109	0,700	10,86

Y (firerate)= $\beta_1 + \beta_2 X_2$ (res_1)

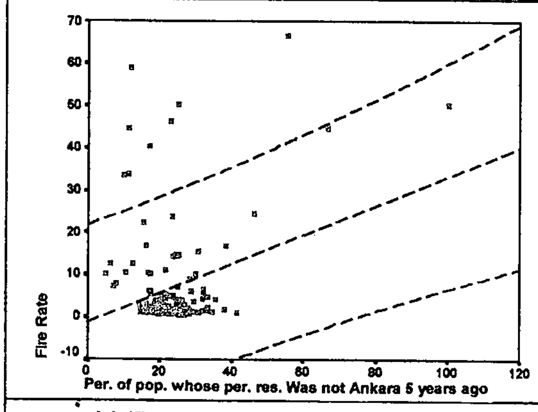
According to scatter diagrams of variables representing population whose residence is Ankara or not, population living in Ankara does not have any effect on fire rate, whereas there is a clear positive linear association between fire rate and population whose permanent residence is not Ankara. t-tests and R^2 of these two variables also verify that population whose permanent residence is not Ankara individually explains nearly half of variance in fire rate at quarter level. (Table 5.17) Similarly, scatter diagrams of variables within the second migration factor represent that population whose permanent residence was Ankara five years ago do not have a linear association with fire rate. However, population whose permanent residence was not Ankara reflects a positive association with fire rate. (Table 5.18)

Table 5.18: Scatter diagram and two-variable regression outputs between variables of permanent residence five years ago and fire rate



	Sum of Squares	Mean of Squares	df
Regression	54,7258	54,7258	1
Residual	24584,6736	164,9978	149
Total	24639,3994		150
R	0,047	R^2	0,002
$t_{0,05/2}$ (148)	± 1,980	Adj. R^2	-0,004
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,071	0,123	0,047	0,576

Y (firerate)= $\beta_1 + \beta_2X_2$ (res5_6)



	Sum of Squares	Mean of Squares	df
Regression	1816,1731	1816,1731	1
Residual	19298,0280	131,2791	147
Total	21114,2010		148
R	0,293	R^2	0,086
$t_{0,05/2}$ (146)	± 1,980	Adj. R^2	0,080
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,346	0,093	0,293	3,719

Y (firerate)= $\beta_1 + \beta_2X_2$ (res5_1)

According to three-variable multiple regression analysis of each factor, it is seen that one variable is excluded from each analysis. Percentage of population whose residence is Ankara is excluded from the first equation and percentage of population whose permanent residence was Ankara five years ago is excluded from the second equation, due to high correlation between other sub-variables. (For correlation results, refer to Appendix D) Since multiple regression models are turned into simple regression equations, F-test is not taken into consideration. Within the first equation, t-test represented that percentage of population whose permanent residence is not Ankara is statistically significant at 5 percent level. (Table 5.19 and Table 5.20) This group represented the population who come Ankara either for studying at universities or working in temporary jobs. As this group's percentage increases within the quarter, fire rate also increases.

Table 5.19: Output of three-variable multiple regression model for fire rate relation with permanent residence factor

Estimated Equation	$Y \text{(firerate)} = \beta_1 + \beta_2 X_2 \text{(res\_1)} + \beta_3 X_3 \text{(res\_6)}$				
	Sum of Squares	df	Mean Square	F	Sig.
Regression	2471,896	1	2471,896	15,467	0,000
Residual	23972,139	150	159,814		
Total	26444,035	151			
R	0,306	R Square	0,093	Std. Error of the Estimate	12,6418
		Adjusted R Square	0,087		
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
res_1	0,756	0,192	0,306	3,933	0,000
res_6 is excluded					

Table 5.20: t-tests results in two-variable regression analysis for permanent residence factor

t-test	For n = 151 and k = 2, $t_{0,05/2}$ (149) is ± 1,980at 0,05 level of significance.		
	Expected		Reject H_0 if $- t_{\alpha/2}(n-k) > t$ or $t > + t_{\alpha/2}(n-k)$
	Hypothesis		H_0: $ß_k = 0$ H_1: $ß_k \neq 0$
	Decision	For $ß_2$	Since t for $ß_2$ = 3,93 and $t > t_{0,05}$ in model, H_0 is rejected; which means percentage of population whose permanent residence is not Ankara is significant individually in the model.

On the other hand, t-test in second equation shows that percentage of population whose permanent residence was not Ankara five years ago do not have any affect on variation in fire rate at quarter level. (Table 5.21 and Table 5.22) However, this group of population is representing the migrated group to Ankara from other cities. Consequently, it can be stated that migration do not really affect on fire rate, but population settle in Ankara temporarily affects the increase of fire rate within quarters. Thus, statistically significant migration variables will be used within the final regression analysis.

Table 5.21: Output of three-variable multiple regression model for fire rate relation with permanent residence five years ago

Estimated Equation	Y (firerate)= $ß_1 + ß_2X_2$ (res5_1) + $ß_3X_3$ (res5_6)				
	Sum of Squares	df	Mean Square	F	Sig.
Regression	374,742	1	374,742	2,156	0,144
Residual	26069,293	150	173,795		
Total	26444,035	151			
R	0,119	R Square	0,014	Std. Error of the Estimate	13,1831
		Adjusted R Square	0,008		
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
res5_1	0,149	0,102	0,119	1,468	0,144
res5_6 is excluded					

Table 5.22: t-tests results in two-variable regression analysis for permanent residence five years ago factor

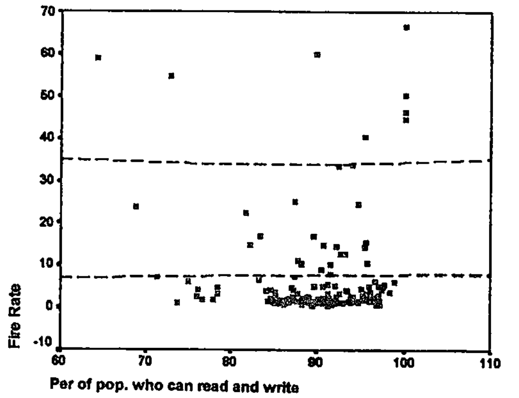
t-test	For n = 151 and k = 2, $t_{0,05/2}$ (149) is ± 1,980 at 0,05 level of significance.		
	Expected		Reject H_0 if $-t_{\alpha/2}(n-k) > t$ or $t > +t_{\alpha/2}(n-k)$
	Hypothesis		H_0: $\beta_k = 0$ H_1: $\beta_k \neq 0$
	Decision	For β_2	Since t for β_2 = 1,47 and $-t_{0,05/2} < t < +t_{0,05/2}$ in model, H_0 is accepted; which means percentage of population whose permanent residence was not Ankara five years ago does not affect the variation in fire rate at quarter level.

5.1.1.7 EDUCATION FACTOR

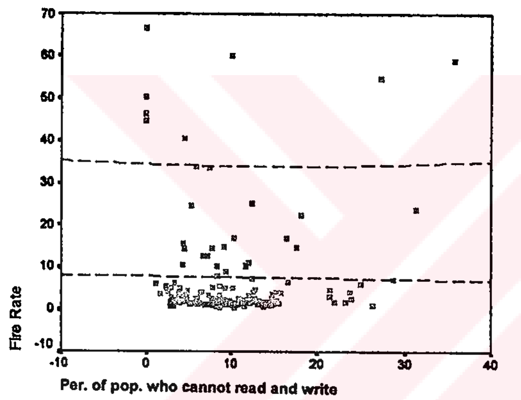
Similar to migration factor, education is also examined by two different factors. The first factor is the literacy status of population and the second is the last school individual graduated. For literacy status of individuals, two variables, percentage of population either who can read and write or who cannot within quarters are used. For the school factor, percentage of population graduated at least from middle school, percentage of population graduated from high school and percentage of population graduated from university are entered into analysis.

Scatter diagram and two-variable regression analysis between variables of literacy factor and fire rate do not represent expected results. It was expected that as percentage of population who cannot read and write is increasing, fire rate is also increasing, since the population who cannot read and write represents mainly the elder population group and fire risk is expected to be high within quarters where elder population is highly concentrated. As seen in scatter diagrams, both the population who can read and write and population who cannot do not reflect a linear relation with fire rate. (Table 5.23)

Table 5.23: Scatter diagram and two-variable regression outputs between variables of literacy factor and fire rate



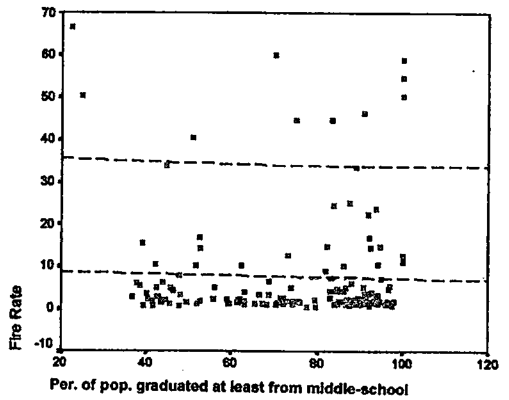
		Sum of Squares	Mean of Squares	df
	Regression	3,5946	3,5946	1
	Residual	26440,4405	176,2696	150
	Total	26444,0351		151
	R	0,012	R^2	0,000
	$t_{0,05/2}(149)$	± 1,980	Adj. R^2	-0,07
	Unstandardized coefficients		Standardized coefficients	t
	B	Std. Error	Beta	
Y (firerate)= $ß_1 + ß_2X_2$ (lit_4)	0,024	0,169	0,012	0,143



		Sum of Squares	Mean of Squares	df
	Regression	3,5946	3,5946	1
	Residual	26440,4405	176,2696	150
	Total	26444,0351		151
	R	0,012	R^2	0,000
	$t_{0,05/2}(149)$	± 1,980	Adj. R^2	-0,07
	Unstandardized coefficients		Standardized coefficients	t
	B	Std. Error	Beta	
Y (firerate)= $ß_1 + ß_2X_2$ (lit_5)	-0,024	0,169	-0,012	-0,143

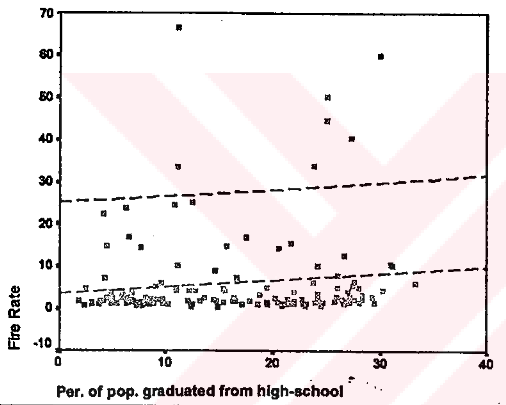
Other education factor, the last school individual graduated, represents unexpected correlation with fire rate in scatter diagram analysis. Even it was expected that fire incidents decrease with an increase in education level at quarters, it is opposite in the study area for the year 1998. Fire rate is not representing a decreasing trend as the school level is increasing. Population graduated al least from middle school do not represent a linear association with fire rate, whereas both population graduated from high school and population graduated from university are positively related with fire rate. (Table 5.24)

Table 5.24: Scatter diagram and two-variable regression outputs between variables of education factor and fire rate



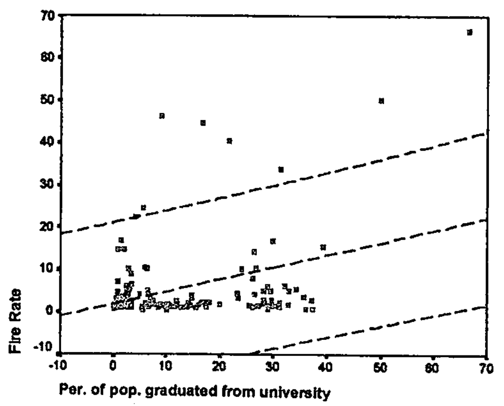
	Sum of Squares	Mean of Squares	df
Regression	20,2325	20,2325	1
Residual	26423,8027	176,1587	150
Total	26444,0351		151
R	0,028	R^2	0,001
$t_{0,05/2}(149)$	± 1,980	Adj. R^2	-0,006
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
-0,018	0,054	-0,028	-0,339

Y (firerate)= $ß_1 + ß_2X_2$ (sch_1)



	Sum of Squares	Mean of Squares	df
Regression	264,4881	264,4881	1
Residual	16337,1756	115,8665	141
Total	16601,6636		142
R	0,126	R^2	0,016
$t_{0,05/2}(140)$	± 1,980	Adj. R^2	0,009
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,157	0,104	0,126	1,511

Y (firerate)= $ß_1 + ß_2X_2$ (sch_2)



	Sum of Squares	Mean of Squares	df
Regression	1837,5440	1837,5440	1
Residual	11794,0232	92,8663	127
Total	13631,5672		128
R	0,367	R^2	0,135
$t_{0,05/2}(126)$	± 1,980	Adj. R^2	0,128
Unstandardized coefficients		Standardized coefficients	t
B	Std. Error	Beta	
0,292	0,066	0,367	4,448

Y (firerate)= $ß_1 + ß_2X_2$ (sch_3)

Due to high correlation between two sub-variables, percentage of population who can read and write is excluded from three-variable multiple regression model. (For correlation results refer to Appendix D) Therefore, for literacy status of population F-test is not used. According to t-test and R^2, it is determined that fire rate does not vary according to the literacy status of the population. (Table 5.25, Table 5.26) Therefore, literacy status of the population will not be used in the final risk estimation equation.

Table 5.25: Output of three-variable multiple regression model for literacy factor relation with fire rate

Estimated Equation	$Y (firerate) = \beta_1 + \beta_2 X_2 (lit\_4) + \beta_3 X_3 (lit\_5)$				
	Sum of Squares	df	Mean Square	F	Sig.
Regression	3,595	1	3,595	0,020	0,887
Residual	26440,441	150	176,270		
Total	26444,035	151			
R	0,012	R Square	0,000	Std. Error of the Estimate	13,2767
		Adjusted R Square	- 0,007		
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
lit_5	-0,02407	0,16852	-0,01166	-0,1428	0,886637
lit_4 is excluded					

Table 5.26: t-tests results in multiple regression analysis for literacy factor

t-test	For n = 151 and k = 2, $t_{0,05/2}$ (149) is ± 1,980 at 0,05 level of significance.		
	Expected		Reject H_0 if $-t_{\alpha/2}(n-k) > t$ or $t > +t_{\alpha/2}(n-k)$
	Hypothesis		H_0: $\beta_k = 0$ H_1: $\beta_k \neq 0$
	Decision	For β_2	Since t for $\beta_2 = -0,14$ and $-t_{0,05/2} < t < t_{0,05/2}$ in model, H_0 is accepted. Thus, population who cannot read and write does not have any affect on fire rate.

significant in explaining the 7% of the variation in fire rate. Even F-test result shows that all variables of school factor do not explain the variation of fire rate simultaneously; t-test results reflect that there are variables individually significant at 5 percent level. When coefficient values of explanatory variables in regression equation are compared, it is determined that population graduated from high school is negatively correlated with fire rate, β_2 = -2,99, whereas population graduated from university is positively correlated, β_2 = 3,07. (Table 5.27 and Table 5.28) This values show that as education level increases within the quarter, fire rate is also increasing. Even overall model for schooling year is not significant for fire rate, individually significant variables will be used for the final risk estimation equation.

Table 5.27: Output of four-variable multiple regression model for education factor relation with fire rate

Estimated Equation	$Y (firerate) = \beta_1 + \beta_2 X_2 (sch\_1) + \beta_3 X_3 (sch\_2) + \beta_4 X_4 (sch\_3)$				
	Sum of Squares	df	Mean Square	F	Sig.
Regression	1830,09	2	915,0448	5,539	0,005
Residual	24613,95	149	165,1943		
Total	26444,04	151			
R	0,263	R Square	0,069	Std. Error of the Estimate	12,8528
		Adjusted R Square	0,057		
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
sch_2	-0,449	0,150	-0,313	-2,985	0,003
sch_3	0,332	0,108	0,322	3,072	0,003
sch_1 is excluded					

Table 5.28: F and t-tests results in multiple regression analysis for education factor

F-test	For n = 151 and k = 4, $F_{0,05}$ (148,3) is 19,5 at 0,05 level.		
	Hypothesis		H_0: $\beta_1 = \beta_3 = \beta_4 = 0$ H_1: $\beta_1 \neq \beta_3 \neq \beta_4 \neq 0$
	Excepted		Reject Ho if F_α (k-1, n-1) > F
	Decision		Since F = 5,539 and F< $F_{0,05}$ in model, H_0 is accepted. Therefore, it is said that not all slope coefficients are simultaneously zero and the equation is not explanatory with all variables simultaneously.
t-test	For n = 151 and k = 4, $t_{0,05/2}$ (144) is ± 1,980 at 0,05 level of significance.		
	Expected		Reject H_0 if - $t_{\alpha/2}$ (n-k) > t or t > + $t_{\alpha/2}$ (n-k)
	Hypothesis		H_0: $\beta_k = 0$ H_1: $\beta_k \neq 0$
	Decision	For β_3	Since t for β_3 = -2,99 and -$t_{0,05/2}$ > t in model, H_0 is rejected; which means percentage of population graduated from high school is significant individually within the model.
		For β_4	Since t for β_2 = 3,07 and $t_{0,05/2}$ < t in model in model, H_0 is rejected; which means percentage of population graduated from university can explain the variation of fire rate individually.

5.1.1.8 POPULATION FACTOR

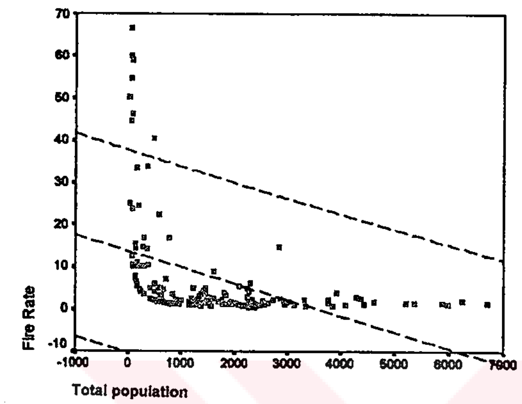
Besides social and economic variables, two other factors were assumed to be related with fire risk; total population of the quarter and density within the quarter. As seen in scatter diagrams, total population of the quarter is clearly negatively associated with fire rate. This distribution shows that as population increases, fire incidents also increase[6]. (Table 5.29)

[6] Since fire rate is calculated as fire incident number per 1000 population, population correlation with fire rate is defined as negatively.

Fire rate = All fire incidents occurred at the quarter / Total population of the quarter * 1000

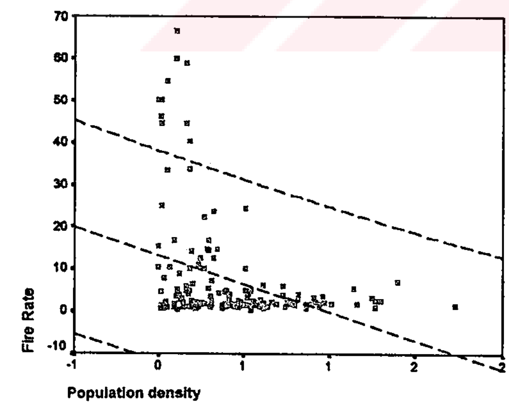
Fire rate negatively distributed according to population density which represents the number of population per km^2 in each quarter, even it was expected to represent a positive relation with fire rate according to previous researches indicated that high density increase fire risk. (Table 5.30)

Table 5.29: Scatter diagram and two-variable regression outputs between total population of the quarter and fire rate



	Sum of Squares	Mean of Squares	df
Regression	4679,2611	4679,2611	1
Residual	21764,7741	145,0985	150
Total	26444,0351		151
R	0,421	R^2	0,177
$t_{0,05/2}(149)$	± 1,980	Adj. R^2	0,171
	Unstandardized coefficients		Standardized coefficients	t
	B	Std. Error	Beta	
Y (firerate)= $ß_1 + ß_2X_2$ (allpop)	-0,004	0,001	-0,421	-5,679

Table 5.30: Scatter diagram and two-variable regression outputs between population density of the quarter and fire rate



	Sum of Squares	Mean of Squares	df
Regression	3034,2701	3034,2701	1
Residual	23409,7650	156,0651	150
Total	26444,0351		151
R	0,339	R^2	0,115
$t_{0,05/2}(149)$	± 1,980	Adj. R^2	0,109
	Unstandardized coefficients		Standardized coefficients	t
	B	Std. Error	Beta	
Y (firerate)= $ß_1 + ß_2X_2$ (density)	-13,414	3,042	-0,339	-4,409

Similar to scatter diagram analysis, both factors are determined as associated with fire rate. Two-variable regression analysis also reflects the parallel results. Total population of the quarter explains 17 percent of the fire rate variation, whereas population density explains 11 percent. t-tests reflect that both explanatory variables are statistically significant in each equation at 5% significance level. (Table 5.31 and Table 5.32) Although population density and total population of the quarter are needed to be used for final risk estimation model according to analysis results, they will not; since the dependent variable, fire rate, which is represented as the number of fire incidents per 1000 population, includes these factors in itself.

Table 5.31: t-test results for two-variable regression analysis for total population of the quarter

t-test	For n = 151 and k = 2, $t_{0,05/2}$ (149) is ± 1,980 at 0,05 level of significance.		
	Expected		Reject H_0 if $-t_{\alpha/2}(n\text{-}k) > t$ or $t > +t_{\alpha/2}(n\text{-}k)$
	Hypothesis		H_0: $ß_k = 0$ H_1: $ß_k \neq 0$
	Decision	For $ß_2$	Since t for $ß_2$ = -5,68 and $-t_{0,05/2} > t$ in model in model, H_0 is rejected; which means total population of the quarter is significant.

Table 5.32: t-test results for two-variable regression analysis for population density of the quarter

t-test	For n = 151 and k = 2, $t_{0,05/2}$ (149) is ± 1,980 at 0,05 level of significance.		
	Expected		Reject H_0 if $-t_{\alpha/2}(n\text{-}k) > t$ or $t > +t_{\alpha/2}(n\text{-}k)$
	Hypothesis		H_0: $ß_k = 0$ H_1: $ß_k \neq 0$
	Decision	For $ß_2$	Since t for $ß_2$ = -4,41 and $-t_{0,05/2} > t$ in model in model, H_0 is rejected; which means population density of the quarter can explain the variation of fire rate within the model.

As result of multiple regression analysis, some socioeconomic factors are determined as related with fire rate. Findings of previous section are summarized in Table 5.33.

Table 5.33: Results of multiple regression analysis between fire rate and socioeconomic variables

VARIABLES				F-test results	t-test results	Entrance
INDIVIDUAL FACTORS – OCCUPANT FACTORS	ECONOMIC	Income Factor	income_1	Model is significant	excluded	-
			income_2		Individually significant	+
			income_3		Individually significant	+
		Work Status Factor	work_1	Model is not significant	excluded	-
			work_2		Not significant	-
			work_3		Individually significant	+
		Ownership Factor	own_1	-	excluded	-
			own_2		Significant	+
	SOCIAL	Age Structure Factor	age_1	Model is not significant	Not significant	-
			age_2		excluded	-
			age_3		Not significant	-
			age_4		Individually significant	+
		Household Type Factor	hhtype_1	Model is significant	Individually significant	+
			hhtype_2		Individually significant	+
			hhtype_3		Individually significant	+
			hhtype_4		Individually significant	+
			hhtype_5		Not significant	+
			hhtype_6		Not significant	+
		Migration Factor	res_1	-	Individually significant	+
			res_6		excluded	-
			res5_1	-	Not significant	-
			res5_6		excluded	-
		Education Factor	lit_4	-	excluded	-
			lit_5		Not significant	-
			sch_1	Model is not significant	excluded	-
			sch_2		Individually significant	+
			sch_3		Individually significant	+
	Population Factor		allpop	-	Significant	-
			density		Significant	-

For testing overall effect of all economic and social factors simultaneously on fire rate, variables of each socioeconomic factor are selected according to their significant association with fire rate. Based on F and t-tests of each socioeconomic factor and its variables, significant variables are derived from each equation. If the model is significant and all variables are simultaneously explaining the variation in fire rate, all variables of the given socioeconomic factor are entered to new equation. If the model is not significant, but a variable is individually significant, then the significant variable is derived from the socioeconomic factor.

5.2.1 ECONOMIC FACTORS

Within the first multiple regression model, significant variables of all economic factors are entered into analysis for testing their simultaneous effect on the dependent variable, fire rate, in Altındağ and Çankaya districts for the year 1998. It is found that equation explains about 38 percent of the variation in structural fires per 1000 population. (Figure 5.2)

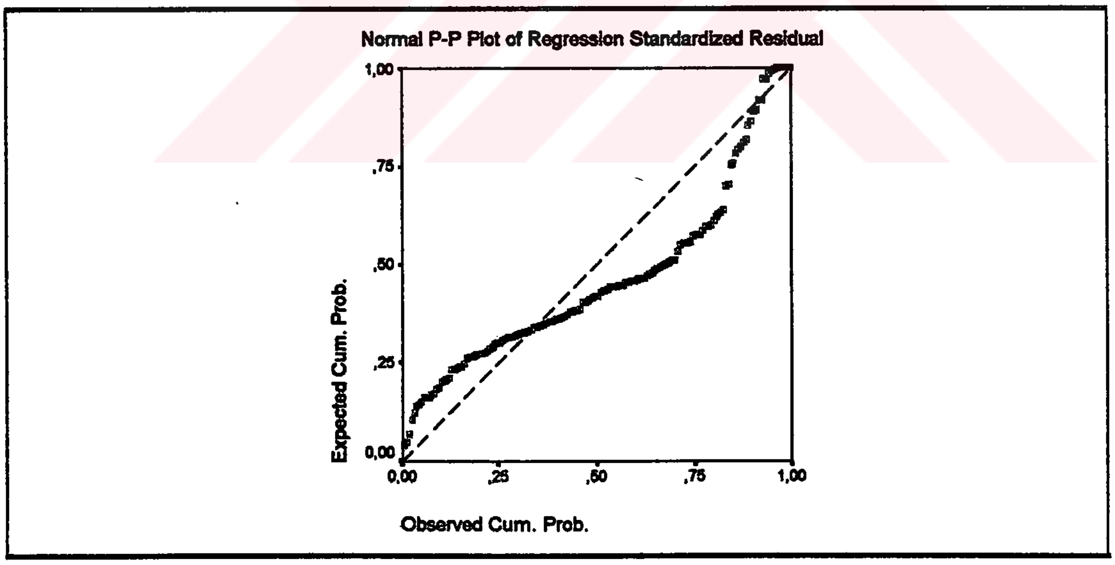


Figure 5.2: Normal P-P plot of regression standardized residual for economic factors

Table 5.34: Output of five-variable multiple regression model for economic factor relation with fire rate

Estimated Equation	$Y (firerate) = \beta_1 + \beta_2 X_2 (income\_2) + \beta_3 X_3 (income\_3) + \beta_4 X_4 (work\_3) + \beta_5 X_5 (own\_2)$				
	Sum of Squares	df	Mean Square	F	Sig.
Regression	10105,5973	4	2526,3993	22,7305	0,0000
Residual	16338,4379	147	111,1458		
Total	26444,0351	151			
R	0,618	R Square	0,382	Std. Error of the Estimate	10,5426
		Adjusted R Square	0,365		
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
income_2	-0,1850	0,0751	-0,2045	-2,464	0,015
income_3	-0,0739	0,0743	-0,0751	-0,994	0,322
work_3	-0,3577	0,2648	-0,0954	-1,351	0,179
own_2	0,3155	0,0545	0,4623	5,787	0,000

According to F-test results, not all coefficients of variables are zero and fire rate is varying according to at least one explanatory variable within the equation. F value and R^2 represents that the economic equation of fire rate is explanatory. t-test results of explanatory variables reflects that only percentages of middle-income group and tenant households are statistically significant within the equation. Coefficients of significant explanatory variables show that ownership is the most significant economic factor in explaining the fire rate variation at quarter level. One unit change in percentage of tenant households in the quarter causes 0,46 unit change in fire rate. The other significant economic factor is income status of the household. One unit increase in middle-income group percentage reflects itself as 0,20 unit decreases in fire rate. (Table 5.34 and Table 5.35)

Table 5.35: F and t-tests results in multiple regression analysis for economic factor

<table>
<tr><td rowspan="4">F-test</td><td colspan="3">For n = 151 and k = 5, $F_{0,05}$ (146,4) is 5,66 at 0,05 level of significance.</td></tr>
<tr><td colspan="2">Hypothesis</td><td>Ho: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$
$H_1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$</td></tr>
<tr><td colspan="2">Excepted</td><td>Reject Ho if F_α (k-1, n-1) < F</td></tr>
<tr><td colspan="2">Decision</td><td>Since F = 22,73 and F> $F_{0,05}$ in model, H_0 is rejected. Therefore, it is said that all slope coefficients are not simultaneously zero and the equation is explanatory with all variables simultaneously.</td></tr>
<tr><td rowspan="7">t-test</td><td colspan="3">For n = 151 and k = 5, $t_{0,05/2}$ (146) is ± 1,980 at 0,05 level of significance.</td></tr>
<tr><td colspan="2">Expected</td><td>Reject H_0 if $- t_{\alpha/2}$ (n-k) > t or t > + $t_{\alpha/2}$ (n-k)</td></tr>
<tr><td colspan="2">Hypothesis</td><td>H_0: $\beta_k = 0$
H_1: $\beta_k \neq 0$</td></tr>
<tr><td rowspan="4">Decision</td><td>For β_2</td><td>Since t for β_2 = -2,464 and $-t_{0,05/2}$ > t in model, H_0 is rejected; which means middle-income group is individually significant within the model.</td></tr>
<tr><td>For β_3</td><td>Since t for β_3 = -0,994 and $-t_{0,05/2}$ < t < $+t_{0,05/2}$ in model, H_0 is accepted. Therefore, it is said that high-income group do not have any effect on fire rate individually.</td></tr>
<tr><td>For β_4</td><td>Since t for β_4 = -1,351 and $-t_{0,05/2}$ < t < $+t_{0,05/2}$ in model, H_0 is accepted, which means unemployed population is not individually significant.</td></tr>
<tr><td>For β_5</td><td>Since t for β_5 = 5,787 and $t_{0,05/2}$ < t in model in model, H_0 is rejected; which means not-owner population has effect on variance in fire rate within the quarter.</td></tr>
</table>

5.2.2 SOCIAL FACTORS

Second multiple regression equation is tested for determining the influence of social factors together. Ten explanatory variables, determined as significant in previous regression analysis are used. It is determined that these ten variables of social factors explain 35 percent of all variation in fire rate, R^2 = 0,352. (Figure 5.3)

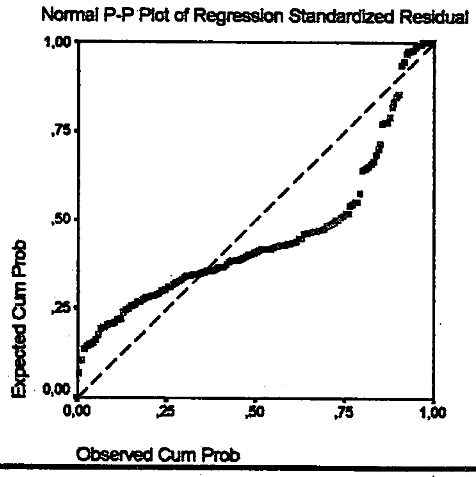


Figure 5.3: Normal P-P plot of regression standardized residual for social factors

Table 5.36: Output of eleven-variable multiple regression model for social factor relation with fire rate

Estimated Equation	$Y (firerate) = \beta_1 + \beta_2X_2 (hhtype\_1) + \beta_3X_3 (hhtype\_2) + \beta_4X_4 (hhtype\_3) + \beta_5X_5 (hhtype\_4) + \beta_6X_6 (hhtype\_5) + \beta_7X_7 (hhtype\_6) + \beta_8X_8 (res\_1) + \beta_9X_9 (age\_4) + \beta_{10}X_{10} (sch\_2) + \beta_{11}X_{11} (sch\_3)$				
	Sum of Squares	df	Mean Square	F	Sig.
Regression	9312,8915	10	931,2891	7,6651	0,0000
Residual	17131,1437	141	121,4975		
Total	26444,0351	151			
R	0,593	R Square	0,352	Std. Error of the Estimate	11,0226
		Adjusted R Square	0,306		
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
hhtype_1	-0,8293	0,1776	-0,5142	-4,670	0,000
hhtype_2	-0,3889	0,1246	-0,5180	-3,121	0,002
hhtype_3	-0,4233	0,1601	-0,2756	-2,644	0,009
hhtype_4	-0,6652	0,1781	-0,4187	-3,736	0,000
hhtype_5	-0,3234	0,1513	-0,2703	-2,137	0,034
hhtype_6	0,3809	0,2189	0,1595	1,740	0,084
res_1	0,2560	0,2296	0,1035	1,115	0,267
age_4	0,7525	0,2447	0,3112	3,075	0,003
sch_2	-0,5527	0,1606	-0,3860	-3,442	0,001
sch_3	0,0903	0,1254	0,0876	0,720	0,473

Table 5.37: F and t-tests results in multiple regression analysis for social factor

F-test	For n = 151 and k = 11, $F_{0,05}$ (140,10) is 2,58 at 0,05 significance level.		
	Hypothesis		Ho: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = 0$ H_1 : $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq \beta_8 \neq \beta_9 \neq \beta_{10} \neq \beta_{11} \neq 0$
	Excepted		Reject Ho if $F_{\alpha}(k-1, n-1) < F$
	Decision		Since F = 7,66 and F> $F_{0,05}$ in model, H_0 is rejected. Therefore, it is said that not all slope coefficients are simultaneously zero and the equation is explanatory with all variables simultaneously.
t-test	For n = 151 and k = 11, $t_{0,05/2}$ (140) is ± 1,980 at 0,05 significance level.		
	Expected		Reject H_0 if $-t_{\alpha/2}(n-k) > t$ or $t > +t_{\alpha/2}(n-k)$
	Hypothesis		H_0: $\beta_k = 0$ H_1: $\beta_k \neq 0$
	Decision	For β_2	Since t for t_2 = -4,607 and $-t_{0,05/2} > t$ in model, H_0 is rejected; which means couple groups are individually significant within the model.
		For β_3	Since t for t_3 = -3,121 and $-t_{0,05/2} > t$ in model, H_0 is rejected. So, couples with children have an effect on fire rate individually.
		For β_4	Since t for t_4 = -2,644 and $-t_{0,05/2} > t$ in model, H_0 is rejected, which means lone parent with children is individually significant.
		For β_5	Since t for t_5 = -3,736 and $-t_{0,05/2} > t$ in model, H_0 is rejected, so extended families affect fire risk.
		For β_6	Since t for t_6 = -2,137 and $-t_{0,05/2} > t$ in model, H_0 is rejected; and this means that fire rate varies according to changes in percent of solitaries.
		For β_7	Since t for t_7 = 1,740 and $-t_{0,05/2} < t < +t_{0,05/2}$ in model, H_0 is accepted; which means no-couple groups do not have influence on fire rate.
		For β_8	Since t for t_8 = 1,115 and $-t_{0,05/2} < t < +t_{0,05/2}$ in model, H_0 is accepted; which means population whose permanent residence is not Ankara is not significant.
		For β_9	Since t for t_9 = 3,074 and $t > +t_{0,05/2}$ in model, H_0 is rejected; thus population aged at 60 and above has influence on fire rate.
		For β_{10}	Since t for t_{10} = -3,442 and $-t_{0,05/2} > t$ in model in model, H_0 is rejected. Population graduated from high school represents a relation with fire rate.
		For β_{11}	Since t for t_{11} = 0,720 and $-t_{0,05/2} < t < +t_{0,05/2}$ in model, H_0 is rejected; thus population graduated from university do not have any influence on fire rate.

The model for social factors is acceptable according to F-test, which means that at least one explanatory variable is statistically significant and has an effect on fire rate. According to t-test results, households with no-couple groups, population whose permanent residence is not Ankara, and population graduated from university do not reflect a relation with fire rate at quarter level, whereas other social factors are defined as statistically significant at 5 percent level. Within significant explanatory variables, the most remarkable variables are households as couples without children and households as couples with children. One unit decrease in percentages of these two groups cause nearly 0,4 unit increase in fire rate within the quarter. According to partial coefficients, extended households are in the second rank, followed by population graduated from high school and population aged at 60 or above. Single-parent families with children and solitaries influence fire rate less than other significant variables. (Table 5.36, Table 5.37)

5.2.3 SOCIOECONOMIC FACTORS

Several socioeconomic variables were determined as associated with fire rates either positive or negative in previous sections. Multiple regression analysis for each socioeconomic factor either individually or simultaneously represents a linear relation with fire rate. Moreover, it is found that models for social and economic factors also explain the variation in fire rate within quarters. The social and economic factor analysis verifies that socioeconomic factors, which are found significant according to F and t-test results previously, can be used for an overall fire risk equation.

The significant variables of socioeconomic factors can be used for determining specific zones or neighborhoods including high fire risk in terms of socioeconomic indicators. The regression models applied for determining influence of occupant factors, including social and economic variables in subheadings, represents results consistent with previous researches. These variables can be used for differentiating urban structural fire risk in accordance to socioeconomic factors. In this section, a general regression model will be used for determining residuals of each quarter for differentiating which quarter experienced more fire than expected. Thus, quarters carrying more fire risk than others will be determined.

A multiple regression model is estimated and tested for all variables defined as identical in regression models carried previously. (Table 5.33) The estimated regression equation is;

$$
\begin{aligned}
Y \text{ (firerate)} = {} & \beta_1 + \beta_2 X_2 \text{ (income\_2)} + \beta_3 X_3 \text{ (income\_3)} + \beta_4 X_4 \text{ (work\_3)} \\
& + \beta_5 X_5 \text{ (own\_2)} + \beta_6 X_6 \text{ (age\_4)} + \beta_7 X_7 \text{ (hhtype\_1)} + \beta_8 X_8 \text{ (hhtype\_2)} \\
& + \beta_9 X_9 \text{ (hhtype\_3)} + \beta_{10} X_{10} \text{ (hhtype\_4)} + \beta_{11} X_{11} \text{ (hhtype\_5)} \\
& + \beta_{12} X_{12} \text{ (hhtype\_6)} + \beta_{13} X_{13} \text{ (res\_1)} + \beta_{14} X_{14} \text{ (sch\_2)} \\
& + \beta_{15} X_{15} \text{ (sch\_3)}
\end{aligned}
$$

According to regression equation, all socioeconomic variables entered into equation explain 65% of variance in fire rate simultaneously. (Figure 5.4) R^2 value of 0,646 and F-test also verifies that the model is significant and not all partial coefficients are zero at 0,05 level of significance.

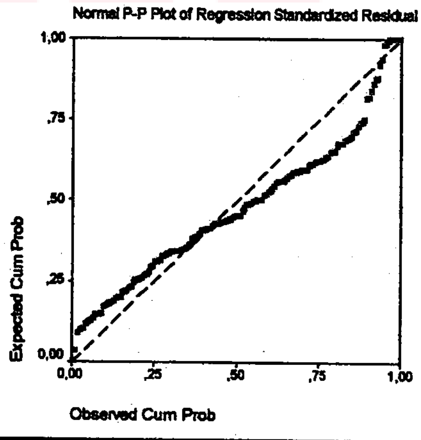


Figure 5.4: Normal P-P plot of regression standardized residual for all selected socioeconomic factors

Table 5.38: Output of fourteen-variable multiple regression model for socioeconomic factor relation with fire rate

	Sum of Squares	df	Mean Square	F	Sig.
Regression	16114,9240	14,0000	1151,0660	15,2671	0,0000
Residual	10329,1112	137,0000	75,3950		
Total	26444,0351	151,0000			
R	0,781	R Square	0,609	Std. Error of the Estimate	8,6830
		Adjusted R Square	0,569		
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
incom_2	-0,0341	0,0785	-0,0377	-0,4342	0,6648
incom_3	0,0186	0,0884	0,0190	0,2109	0,8333
work_3	-0,5270	0,2267	-0,1405	-2,3247	0,0216
own_2	0,3375	0,0557	0,4946	6,0581	0,0000
age_4	1,0884	0,2354	0,4501	4,6236	0,0000
hhtype_1	-0,7258	0,1490	-0,4500	-4,8719	0,0000
hhtype_2	-0,3030	0,1042	-0,4035	-2,9077	0,0042
hhtype_3	-0,3753	0,1346	-0,2443	-2,7873	0,0061
hhtype_4	-0,4686	0,1446	-0,2950	-3,2420	0,0015
hhtype_5	-0,3424	0,1239	-0,2862	-2,7643	0,0065
hhtype_6	0,0776	0,1780	0,0325	0,4359	0,6636
res_1	0,0118	0,1993	0,0048	0,0590	0,9530
sch_2	-0,5556	0,1268	-0,3880	-4,3835	0,0000
sch_3	0,0360	0,1195	0,0350	0,3016	0,7634
For n = 151 and k = 11, $F_{0,05}$ (134,16) is 2,06 at 0,05 significance level.					
For n = 151 and k = 11, $t_{0,05/2}$ (134) is ± 1,980 at 0,05 significance level.					

t-test for partial coefficients shows that out of fourteen socioeconomic variables, 9 of them are significant individually. The most remarkable explanatory variable is the percentage of tenant households. One unit decrease within this variable causes nearly 0,6 increase in fire rate within the quarter. Households as couples without children and population aged at 60 or above, whose coefficient values are so close to each other, are in the second rank according to partial coefficient arrangement. Middle-income households, population graduated from high school and households without any couple groups are also so significant in explaining the fire rate variation individually according to t-test and ß results. (Table 5.38)

5.2.4 FIRE RISK ZONES

For determining which quarter is more or less risky than others according to socioeconomic factors, residuals of each quarter, attained by final regression equation is used. According to economic factors, especially within the Ulus historical core, the fire risk is more than expected since the income level of this area is relatively lower than other areas within the study area. Also there are quarters with high fire risk at the peripheries where squatter house development is dominantly seen. In Çankaya district, quarters with high fire risk are in the commercial center, Kızılay and Bakanlıklar. (Figure 5.5)

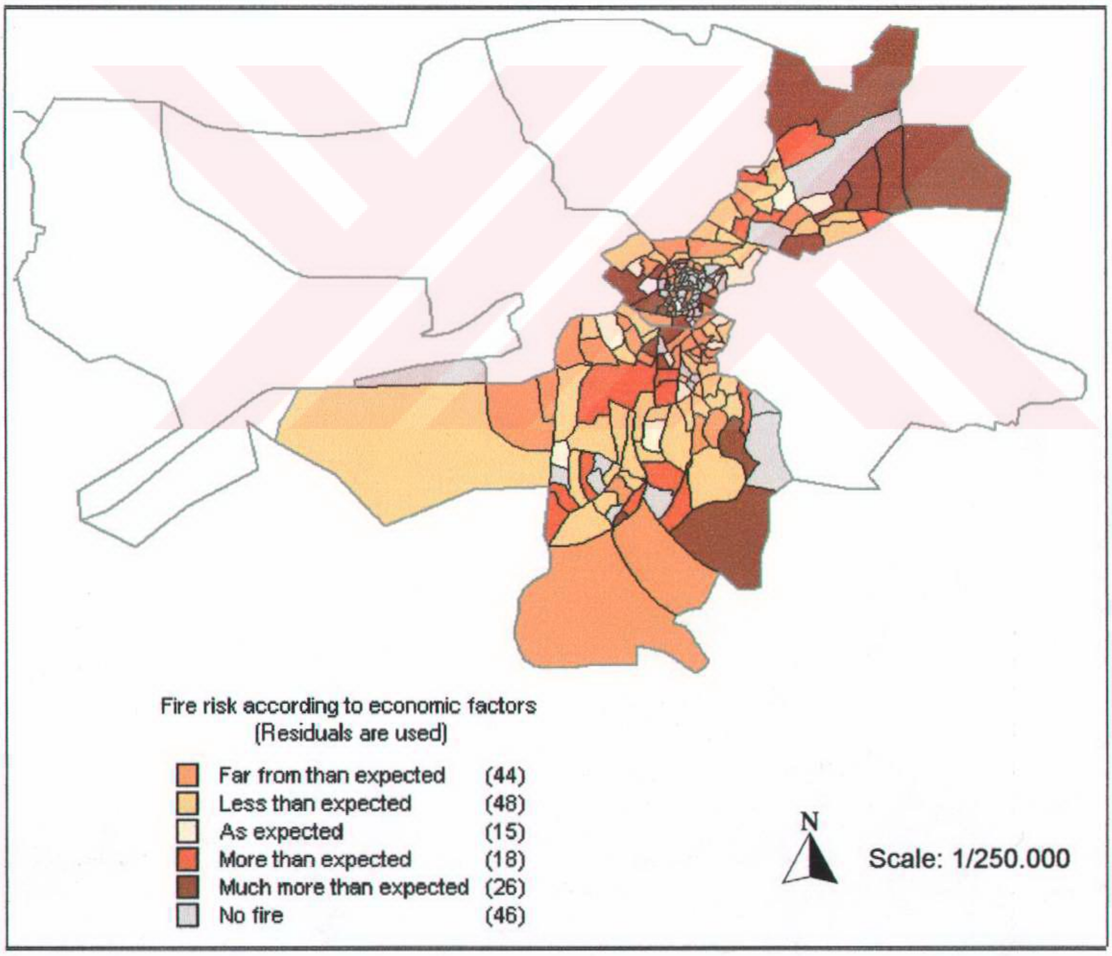


Figure 5.5: Fire risk according to economic factors by expected fire rates and residuals at quarters, Altındağ and Çankaya Districts, 1998

According to social factors, fire risk is much more than expected in 36 quarters in Altındağ and Çankaya districts. These quarters are mainly within the borders of Altındağ district and they are located at Ulus historical core and surrounding. Overall, both in Altındağ and Çankaya districts, quarters where fire risk according to social factors are more than expected are commercial areas, such as Kızılay, Sıhhiye and Ulus. (Figure 5.6)

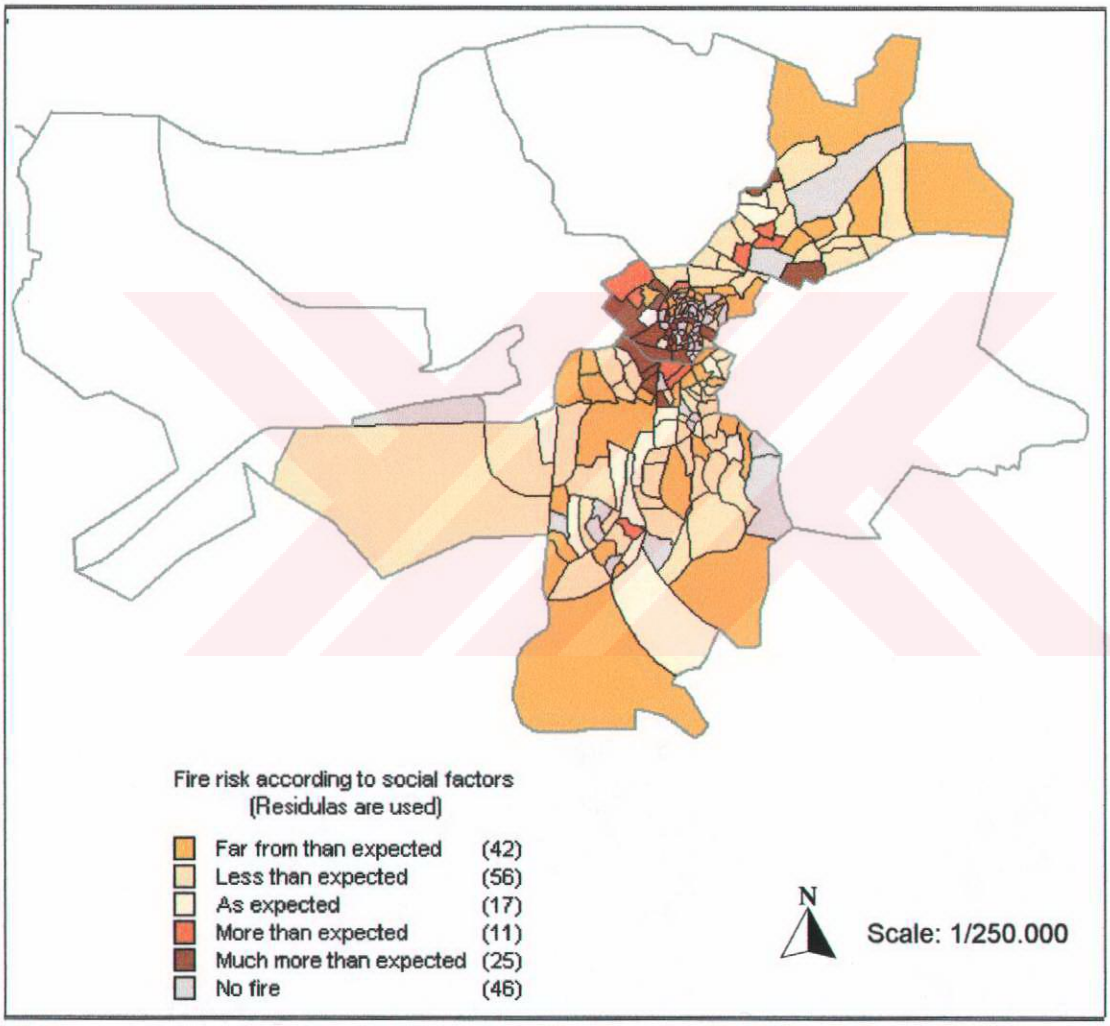


Figure 5.6: Fire risk according to social factors by expected fire rates and residuals at quarters, Altındağ and Çankaya Districts, 1998

The map given in Figure 5.5 shows quarters where fire rate according to all significant variables of socioeconomic factors is more than expected or as expected or less than expected according to economic factors. Especially at city center, Kızılay and Ulus areas, and within a linear corridor at Tunus Street and Tunalı Hilmi Street where commercial and office usages are so common, fire risk is more than it is expected. This reflects that fire risk is more at the city center where commercial activities are concentrated. On the other hand, within the peripheries of both Altındağ ad Çankaya districts where squatter houses are dominant, fires rates are less than expected.

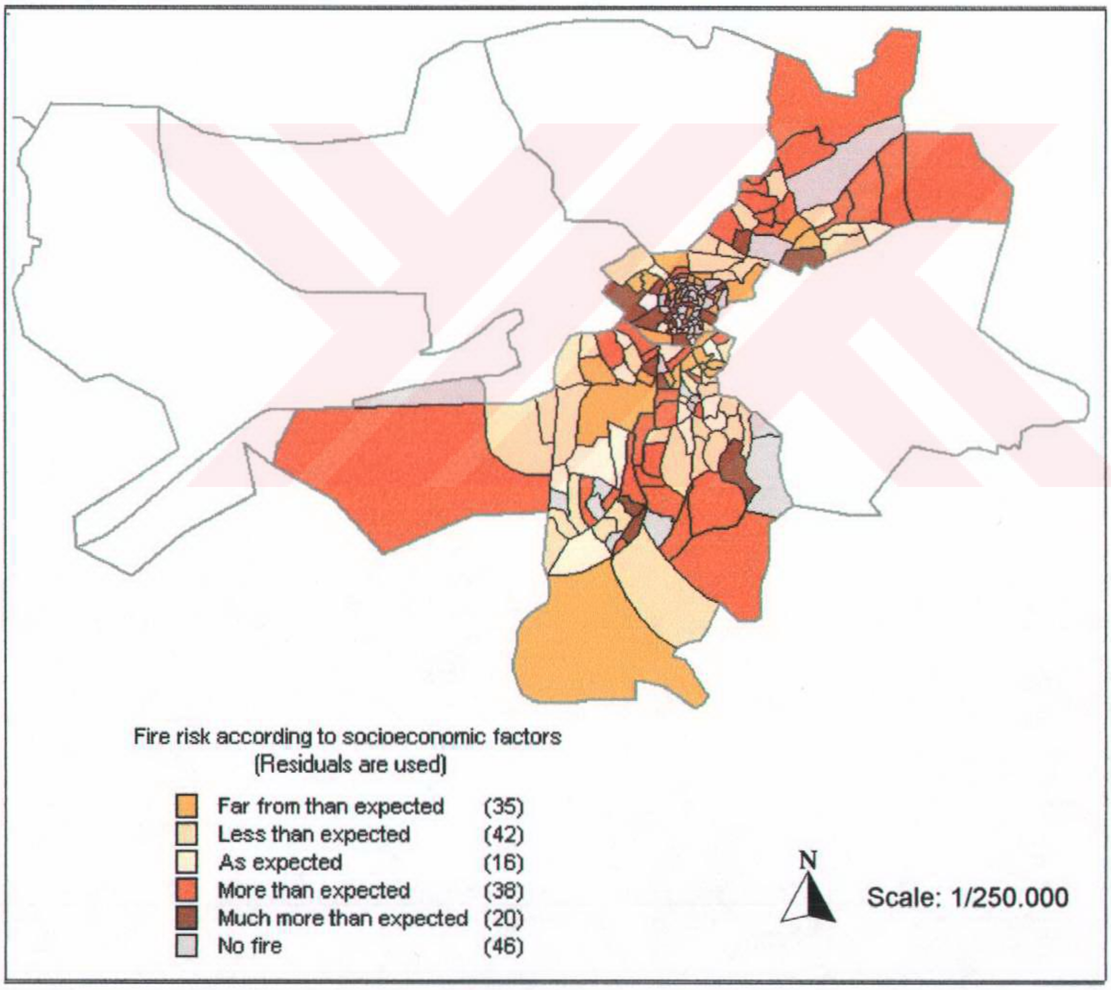


Figure 5.7: Fire risk according to socioeconomic factors by expected fire rates and residuals at quarters, Altındağ and Çankaya Districts, 1998

CHAPTER VI

CONCLUSION

Fire causes many problems from the moment it starts till the time it is extinguished. It is statically observed that fire rate is higher in urban settlements where urbanization rate and population density are high. The damage due to fire can be minimized by prevention and precaution measures, which are determined by a well-defined fire risk management model. In literature, fire risk subject is either studied in architectural approach as fire safety at building scale or analyzed in sociological approach as fire rate analysis at urban scale. Several factors are determined as influential on fire problem at urban or building scale in literature. However, fire is such a risk that all these factors, which have been studied separately in previous researches, simultaneously affect the fire risk elements; fire ignition risk, fire detection risk, fire spread risk and fire response risk.

One of the purposes of city plans is to attain a safer urban environment for the population. This safety purpose also includes the fire safety measurements at urban scale. Therefore, fire risk management studies have to start at the urban level, for constituting a basis for all other risk managements, such as fire risk management at building scale.

The thesis hypothesized that fire risk have to considered firstly at urban scale and fire risk varies according to natural, structural, environmental, individual and operational factors. Consequently, the study determined the relation between urban phenomena and fire problem. Thereafter, urban fire risk, risk factors and a broader urban fire management model were developed.

The study consisted of a review of literature on fire risk management and fire incidence analysis. Review of fire incidence analysis was used to define the fire risk factors at urban scale, whereas synthesis of previous studies about fire risk management was used to develop a conceptual model for fire risk management at urban scale. Different than previous studies focused on separate subjects of fire risk, the conceptualized model formed the basis for studying a variety of fire risk factors simultaneously. The model provided the opportunity for urban fire risk assessment in the study area.

In this thesis, 'urban fire risk' was defined as the risk threatens the community as a whole further than risks at building scale and threaten only the occupants of that structure. The study conceptualized several factors related with urban fire risk. These factors were gathered under five headings: natural factors, environmental factors, structural factors, individual factors and operational factors. Besides, the model posited that there are four urban fire risk elements: fire ignition risk, fire determination risk, fire spread risk, and fire intervention risk. The schematic representation of the fire problem indicated that the first step in fire problem is the ignition of a fire. This is basically related with the fire ignition risk, and mainly affected by individual factors including socioeconomic characteristic of occupants. Although structural and natural factors have also effect on fire incidents, the greater importance is how occupants use and maintain those structures. Thus, socioeconomic characteristics were analyzed with fire incidence for examining whether socioeconomic characteristics have an influence on fire incidents at quarter level within the case study area.

Since the study hypothesized that fire risk vary with a number of factors at urban scale, risk assessment should be done for determining quarters or neighborhoods including more fire risk than others by estimations and identifications. Hence, the fire incident reports were converted to a database and were combined with the census data for examining the relation between fire incidences and socioeconomic characteristics of the city. Based on the conceptual model, firstly fire problem was studied by using fire incident variables. Besides, fire incident variables were analyzed at quarter level. Thereafter, socioeconomic characteristics of quarters were analyzed with fire rate, as dependent variable, by using scatter diagrams, and two-variable and multiple regression models for differentiating the fire risk in different areas reflecting different socioeconomic characteristics. By defining the socioeconomic factors related with fire incidence, fire risk maps were drawn by using residual values of the multiple regression outputs.

Important findings based on past experienced fires in study area were:

1. Loss due to fire is not a problem related with response of fire brigade to the scene, but related with fire duration in study area. The first reason could be the late discovery and reporting of fire to department, whereas the second reason can be incapable intervention of fire brigade. This problem could be avoided either by improvements in fire department services or by making detection systems use widespread within the structures by the force of regulations or public education and consciousness.

2. Many fires in non-residential structures, especially in commercial usages are seen in non-used hours. Fires occurred in these structures caused more damage to property than fires in other structures, and than fires in other time of day. This could be prevented again by obligating early detection systems and suppression systems within such kind of property classes.

3. Negligence is the basic cause of fires both in residential and non-residential usages. Negligence is an indicator how occupants perceive the fire problem. Fire is not perceived as a destructive risk in daily life, and people do not take necessary precaution and prevention measurements. Thus, public education is needed.

4. The cause-property class relation reflects that inspection efforts are not capable and effective especially in recreational usages, including restaurants, bars. Even inspections are carried periodically; regulations about inspections do not have a force of sanction. Hence, there is a need for a revision in regulations about fire safety requirements in specific property classes.

The comparative analysis of fire incidences within quarters represented the quarters or zones where specific property classes are dominant. Such kind of maps would be used to direct importance for reducing the risk those usages contain by specific affords with regulations and inspections. Zones where fires in commercial, industry and manufacturing, squatter houses and storage usages are dominant were notable in study area, since loss in such usages was more than other property classes. Similarly, maps representing construction material of structure gave the opportunity to define specific areas where timber and half-timbering structures. Dominant cause of fires in quarters represented that arson fires dominantly seen in historical core and required a specific afford to be reduced.

There were nine socioeconomic factors hypothesis as related with fire risk at urban scale. Within those factors, the economic ones were income, poverty, working status and ownership, whereas the social ones were household size, education, age structure, household type and migration. Population density quarter was also considered separately as an individual factor affecting fire risk. Poverty and household size factors could not be analyzed due to the inadequacy of the data set. Thus, out of ten factors, eight of them were used for analysis. For converting categorical socioeconomic factors from individual or household level to quarter level, percentages of each categorical value of factors were determined and used. Therefore, each socioeconomic factor was represented as a group of variables in the final data set at quarter level for testing the regression equations. The dependent variable was fire rate, representing number of fires per 1000 population within the quarter.

Linear multiple regression equations between variables of each factor and fire rate were tested for determining both the significance of the factor and significant variables within the given socioeconomic factor. F-test was used for testing the simultaneous effect of variables on fire rate, whereas t-test was used for testing the effect of each variable of a given socioeconomic factor individually. When F-test results verified that all variables of a factor simultaneously affect fire rate, all variables were entered into the final regression equation. Otherwise, only the variables, which are defined as significant in t-test results, were derived. After all socioeconomic factors were analyzed and tested; significant variables were determined for the final regression equations. Fire risk maps are derived from the residuals of final regression equations in which fire rate relation with economic, social and socioeconomic factors were analyzed separately. Thus, three fire risk maps for social, economic and socioeconomic characteristics were obtained.

According to multiple regression analysis for each economic factor individually, only ownership factor is significant overall, whereas middle and high-income groups from income factor and unemployed population from working status factor were determined as significant individually. Although previous researches have indicated that the fire risk decreases with the increase in economic conditions, it was determined that income is not so significant in explaining the variation of fire rate in study area. Similarly, working population was expected to reflect the same result that as working population in household increases; income of household increases, so the fire rate decreases. However, it is found that when percentage of working population is increasing, fire rate is also increasing. Ownership factor reflected the expected result that fire risk is decreasing with the increase in owner-occupied households within the quarter. According to final multiple regression equation between significant variables of economic factors and fire rate, the 38% of the variation in fire rate could be explained by economic factors simultaneously. Percentage of tenant households is the most explanatory variable within the equation with a beta value, ß=0,46. The other significant variable is the percentage of middle-income households within the quarter.

Within social factors, only household type factor was statistically significant as a model in explaining the variation of fire rate at quarter level. Although other models for social factors were not significant simultaneously according to F-test results, percentage of population whose permanent residence is not Ankara from migration factor, percentage of population aged at 60 or above from age factor, and percentage of population graduated from high-school and percentage of population graduated from university from education factor were derived from regression equations for each social factor.

All these significant explanatory variables were entered into final regression equation for testing the overall affect of social factors simultaneously. These variables explained 35 percentage of variation in fire rate within the study area for the year 1998. According to F-test the social equation is significant, whereas according to t-test results, all variables were individually significant, except the percentage households as no couple groups inside and percentage of population whose permanent residence is not Ankara. The most significant variables are the percentage of couples without children and the percentage of couples with children. Percentage of extended families is in the second row, where percentage of population aged at 60 or above was in the third row in explaining the variation in fire rate individually. Within the final risk equation, only migration factor from social characteristics did not determined as significant in explaining the variation of fire rate.

Multiple regression analysis between socioeconomic factors and fire rate has confirmed that there is an association between several socioeconomic characteristics and fire rate. All socioeconomic factors simultaneously explained 65 percentage of variation in fire rate at quarter level. F-test results verified that the model is significant. Out of 14 significant variables of socioeconomic factors, 9 explanatory variables were determined also as significant in final fire risk model, according to t-test results. Overall socioeconomic factors, the most significant positive association was between fire rate and percentage of tenant households. The second factor increases fire risk is the population aged at 60 or above. The rest of the significant variables were negatively associated with fire rate.

At the end of analysis, residuals of final multiple regression models were used for estimating fire risk at quarter level and determining which quarter experienced more fires than expected within the study area. Thus, residuals of regression analysis are used for determining the fire risk map based on economic, social and socioeconomic factors individually within the study area. Residuals were analyzed into five groups;

1. Quarters experienced fire far from expected ....least risk
2. Quarters experienced fires less than expected ....less risk
3. Quarters experienced fires as expected ....no risk
4. Quarters experienced fires more than expected ....high risk
5. Quarters experienced fires much more than expected ....highest risk

However, developing a satisfactory theoretical explanation of urban fire risk and determining areas or zones including more risk than others necessitate a well-defined data set. Here, only socioeconomic characteristics of the city as indicator of individual factors were used, but it is needed to study all urban fire risk factors all together for a complete risk zone maps. The information gained from zoning maps would be useful while distributing fire services around the city, as well as useful for fire departments for focusing on areas or zones including high fire risk. Besides, this information would be convenient for defining fire precaution and prevention measurements.

This subject is not so much studied in Turkey; therefore, this thesis consists of several further studies. Further studies are gathered under five headings:

1. Fire incidence analysis: For attaining fire safety at urban scale, it is important to analyze fires occurred within the city. Here, only fires in selected districts for the year 1998 were analyzed. It is needed to picture the fire problem at city by analyzing and comparing all districts. Also, time series analysis would be helpful for determining the changes for urban fire problem at city scale.

2. Urban fire risk assessment: Here in this thesis, only individual fire risk assessment was conducted by comparison of fire incidences with socioeconomic characteristics. The further step would be the analysis of all other fire risk factors with fire incidences. The complete urban fire risk zoning would be attained by determination of structural, environmental, natural and operational factors with fire incidents, besides individual factors.

3. Fire database study: Fire risk assessment process needs a comprehensible data set. Combining all fire risk factors with fire incidents require a precious effort. For a complete model implementation, a data set formation is needed.

4. Urban fire service delivery: Several deployment models were structured in the literature, but most of them are based on assumptions. A step further the assessment process, deployment models would be defined by relying on past experiences and factor assessment results.

5. Fire risk management: The step, further the assessment process is the management of fire risk. Control, prevention and precaution measurements could be defined by using results gained from assessment process.

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APPENDIX A

FIRE INCIDENT REPORT FORM

T. C.
ANKARA BÜYÜKŞEHİR BELEDİYESİ
İTFAİYE DAİRE BAŞKANLIĞI

YANGIN RAPORU

Olayın Tarihi : ..../........199.......	Bildirim Sıra No.:	Bildirim Saati :	Tel : ....
Kayıt Tarihi : ..../........199.......	Kayıt No.:	Bildirimi Alan :	
Bildirilen Adres :			
Doğru Adres :			
Yangının Türü :			
Yangın Binada İse :	Yapım Şekli :	Kullanım Şekli :	

Yanan Şeyin	Sahibi		
	Kiracı veya Kullanan		
Giden Ekibin	Amiri :		
	Araç Sayısı :	Çıkış Saati :	
	Personel Sayısı:	Üst Amir :	
Yardımcı Ekip Gitmişse	Çıkış Saati :	Araç Sayısı :	Personel Sayısı : ....
	Kimin Yönetiminde Gittiği :		
Olayın Görüldüğü Durum			
Söndürme Türü			
Söndürme	Tarihi :	Saati :	
Söndürme Sonundaki Hasar Durumu			
Yangın Çıkış Nedeni			
Sigortalı İse	Şirketin Adı :	Bedeli :	
Araç, Gereç Kaybı			
Yangın Yerinin Kime Teslim Edildiği			
Ekibin Dönüş	Tarihi:	Saati :	

Varsa	Ölü	Yaralı		
Varsa	Ölü	Yaralı	RAPORU DÜZENLEYEN:	ONAYLAYAN
İtfaiyeci			Gitmişse Üst Amir: EKİP AMİRİ :	......./......./199.....
Halk				İtfaiye Daire Başkanı

APPENDIX B

VARIABLE CODES OF FIRE INCIDENCE REPORTS

DISTRICT: Districts
00000. Unknown / Non-recorded / Not-applicable
10000. Altındağ
20000. Çankaya

QUARTER: Quarter codes

FIRECODE: Unique fire code given to each fire by Fire Department

MONTH: Month when fire occurred
00. Unknown / Not-recorded / Not-applicable
01. January
02. February
03. March
04. April
05. May
06. June
07. July
08. August
09. September
10. October
11. November
12. December

HOUR1: Time of day when fire occurred

HOUR2: 2 hours interval

00. Unknown / Not-recorded / Not-applicable
01. 00:01 – 02:00
02. 02:01 – 04:00
03. 04:01 – 06:00
04. 06:01 – 08:00
05. 08:01 – 10:00
06. 10:01 – 12:00
07. 12:01 – 14:00
08. 14:01 – 16:00
09. 16:01 – 18:00
10. 18:01 – 20:00
11. 20:01 – 22:00
12. 22:01 – 00:00

HOUR6: 6 hours interval

0. Unknown / Not-recorded / Not-applicable
1. 00:01 – 06:00
2. 06:01 – 12:00
3. 12:01 – 18:00
4. 18:01 – 24:00

TIME_RES: Time in how many minutes the fire brigade arrived to the scene

0. Unknown / Non-recorded / Not-applicable
1. <2 minutes
2. 3-5 minutes
3. 6-10 minutes
4. 11-15 minutes
5. 16< minutes

TIME_DUR: Duration of the operation

0. Unknown / Non-recorded / Not-applicable
1. <15 minutes
2. 16-30 minutes
3. 31-45 minutes
4. 46-60 minutes
5. 61< minutes

TIME_ALL: (TIME_DUR+TIME_RES)

0. Unknown / Non-recorded / Not-applicable
1. <15 minutes
2. 16-30 minutes
3. 31-45 minutes
4. 46-60 minutes
5. 61< minutes

INT_TY: Intervention type of the fire brigade to the fire call

0. Unknown / Non-recorded / Not-applicable
1. Intervention
2. Turning back in halfway
3. False call
4. Good intent call

CONST_MT: Construction material of the structure in which fire occurred

0. Unknown / Non-recorded / Not-applicable
1. Timber
2. Half-timber
3. Briquette
4. Masonry
5. Brick
6. Stone
7. Concrete

8. Shed
9. Other

USE_GN: General use categories of structures
000. Unknown / Non-recorded / Not-applicable
100. Residential
200. Non-residential
300. Vacant

USE_MJ: Major use categories of structures
000. Unknown / Non-recorded / Not-applicable
110. Residential (houses, hospitals, hotels)
210. Educational (schools)
220. Commercial (offices, shops)
230. Public Assembly and Recreation (theatre, restaurants)
240 Public Institutions
250. Industry and Manufacturing (basic industry, defense, manufacturing)
260. Storage
270. Special Property (constructions, Parking areas, transformers, outdoors)
310. Vacant (both residential and non-residential)

USE_MN: Minor use categories of structures
000. Unknown / Non-recorded / Not-applicable
111. Residential / house
112. Residential / squatter house
113. Residential / flats and apartments
114. Residential / institutional (hospitals, prisons)
115. Residential / commercial (hotels, boarding-houses)
211. Educational (schools)
221. Commercial (offices, shops)
231. Public Assembly and Recreation / theatres, cinemas
232. Public Assembly and Recreation / restaurants, bars

233. Public Assembly and Recreation / associations, mosques

241. Public Institutions

251. Industry and Manufacturing / high ignition risk (oil, furniture, plastics)

252. Industry and Manufacturing / medium ignition risk (petrol stations, textile production, car repair)

253. Industry and Manufacturing / low ignition risk (metal works, electric, cement, bakery)

261. Storage / high fuel risk (chemicals, charcoal, paper)

262. Storage / medium fuel risk (scrap)

263. Storage / low fuel risk

271. Special Property / parking areas, taxi stops

272. Special Property / constructions

273. Special Property / transformers

274. Special Property / other

311. Vacant / houses and apartments

312. Vacant / squatter houses

313. Vacant / other

ORGN_GN: General origin of the fire occurred

000. Unknown / Non-recorded / Not-applicable

100. Structure

200. Outside

300. Other

ORGN_MJ: Major origin of the fire occurred

000. Unknown / Non-recorded / Not-applicable

110. Within the unit

120. Within the common places of the structure

130. Within the elements of structure

210. Within the annexes

220. Outside

310. Other

ORGN_MJ: Major origin of the fire occurred

000. Unknown / Non-recorded / Not-applicable
111. Within the unit / room
112. Within the unit / kitchen
113. Within the unit / bathroom
114. Within the unit / balcony, shop window, terrace, minaret
121. Within the common places of the structure / stairs, landing, elevator
122. Within the common places of the structure / ventilation
123. Within the common places of the structure / central heating place
124. Within the common places of the structure / coal cellar
125. Within the common places of the structure / storage place, cellar, shelter, garage
131. Within the elements of structure / chimney
132. Within the elements of structure / roof
211. Within the annexes / storage place
212. Within the annexes / coal cellar
213. Within the annexes / common oven, kitchen
221. Outside / garden, street
311. Other / Construction, repair, restoration

OWNR_MJ: Major ownership types of the structure in which fire occurred

00. Unknown / Non-recorded / Not-applicable
10. Private
20. Public
30. Vacant
40. Other

OWNR_MJ: Major ownership types of the structure in which fire occurred

00. Unknown / Non-recorded / Not-applicable
11. Private / rent
12. Private / owner
13. Private / large commercial buildings, shopping malls

14. Private / Common use of all owners within the structure

21. Public

31. Vacant

41. Other

INSUR: Insurance status of the structure or unit in which fire occurred

0. Unknown / Non-recorded / Not-applicable

1. No insurance

2. Insured

FIRE_TY1: Major types of fire occurred

00. Unknown / Non-recorded / Not-applicable

10. A-class

20. B-class

30. C-class

40. D-class

FIRE_TY2: Minor types of fire occurred

00. Unknown / Non-recorded / Not-applicable

11. A-class

21. B-class (glue, gasoline, fuel-oil)

31. C-class / electricity

32. C-class / LPG tube

33. C-class / natural gas

34. C-class / other flammable gases

41. D-class

FIRE_ST1: Fire situation when fire brigade arrived to the fire area

00. Unknown / Non-recorded / Not-applicable

11. Extinguished by self-suppression

12. Extinguished by other people

13. Extinguished but smoky

14. Extinguished but heated
21. Still burning with flames
22. Still burning with smoke
23. Still burning both with flame and smoke
31. Other

EXTNG_TY: Extinguishment method fire brigade used
0. Unknown / Non-recorded / Not-applicable
1. Control
2. Cooling
3. Smothering
4. Distributing or removing the ignited or burning materials
5. Breaking the chain reaction
6. Smoke discharge
7. Control-cooling
8. Smothering-cooling
9. Other

CAUSE_MJ: Major cause of the fire
00. Unknown / Non-recorded / Not-applicable
10. Lack of care
20. Ignorance
30. Carelessness
40. Accident, breakdown
50. Arson
60. Natural
70. Other

CAUSE_MN: Minor cause of the fire
00. Unknown / Non-recorded / Not-applicable
11. Lack of care
12. Ignorance and lack of care

22. Ignorance
23. Ignorance and carelessness
31. Carelessness and lack of care
33. Carelessness
43. Accident and carelessness
41. Lack of care and accident
44. Accident, breakdown
55. Arson
66. Natural
77. Other

FACTR_MJ: Major factor of the fire ignition
00. Unknown / Non-recorded / Not-applicable
10. Smoking
20. Children playing
30. Electric
40. Cooking
50. Heating
60. Open flame, torch, explosives
70. Other heat, spark,
80. Other appliances
90. Natural

FACTR_MN: Minor factor of the fire ignition
00. Unknown / Non-recorded / Not-applicable
11. Natural
21. Smoking
22. Smoking- sweepings
31. Children playing
41. Electric
42. Electric – sweepings
43. Electric - chimney

51. Cooking
52. Cooking – LPG tube
53. Cooking – chimney
54. Cooking – spark
55. Cooking - electric
61. Heating
62. Heating – spark
63. Heating – electric
64. Heating – LPG tube
65. Heating – gasoline
66. Heating - chimney
71. Open flame
72. Open flame – gasoline
73. Open flame – Mum, lamba
74. open flame – LPG tube
75. open flame – explosive
81. Other heat, spark
82. Spark – chimney
91. Other appliances
92. Other - welding
93. Other – LPG tube

LOSS_PROP: Damage to property

0. Unknown / Non-recorded / Not-applicable
1. No loss worth for recording
2. Fire ignition material
3. Partly spread within the place fire occurred
4. Wholly spread within the place fire occurred
5. Partly spread outside the place fire occurred
6. Wholly spread outside the place fire occurred
7. Mostly spread within the structure in which fire occurred
8. Conflagration

INJ_CVL: Civilian injuries

0. Unknown / Non-recorded / Not-applicable
1. No injuries
2. 1 injury
3. 2 injuries
4. 3 injuries

INJ_FGT: Firefighter injuries

0. Unknown / Non-recorded / Not-applicable
1. No injuries
2. 1 injury
3. 2 injuries
4. 3 injuries

DTH_CVL: Civilian fatalities

0. Unknown / Non-recorded / Not-applicable
1. No death
2. 1 deaths
3. 2 deaths
4. 3 deaths

DTH_FGT: Firefighter fatalities

0. Unknown / Non-recorded / Not-applicable
1. No death
2. 1 deaths
3. 2 deaths

FIREBRGD: Fire brigade response to the fire call

00. Unknown / Non-recorded / Not-applicable
01. Merkez
02. Sincan

03. Kurtuluş
04. Gölbaşı
05. Siteler
06. Altınpark
07. Keçiören
08. Esat
09. AŞTİ
10. Köşk
11. Batıkent
12. Hisar

APPENDIX C

CENSUS DATA SET VARIABLES AND RECODING

C.1 VARIABLE CODES FOR CENSUS DATA

DISTRICT: District code

QUARTER: Quarter code

HHCODE: Unique households code

INDCODE: Unique individual code

AGE: Age group of the individuals
0. Unknown / Non-recorded / Not-applicable
1. Aged at 7 or below
2. Aged between 8 and 15
3. Aged between 16 and 59
4. Aged at 60 or above

RESPRV: Permanent residence of the individual
0. Unknown / Non-recorded / Not-applicable
1. Not Ankara
6. Ankara

RESPRV5: Permanent residence of the individual 5 years ago

0. Unknown / Non-recorded / Not-applicable

1. Not Ankara

6. Ankara

LIT: Literacy status of the individual

0. Unknown / Non-recorded / Not-applicable

1. Can read and write

2. Cannot read and write

SCH: Last school individual graduated

0. Unknown / Non-recorded / Not-applicable

1. Graduated at least from a middle school or equivalent

2. Graduated from high-school or equivalent

3. Graduated from university or equivalent

WORK: Working status of the individual

0. Unknown / Non-recorded / Not-applicable

1. Working

2. Not-working

3. Unemployed

HHSIZE: Household size

INCOME: Income status of the household head

0. Unknown / Non-recorded / Not-applicable

1. Low-income

2. Middle-income

3. High-income

HHYYPE: Household type

0. Unknown / Non-recorded / Not-applicable
1. Couple without children
2. Couple with children
3. Single-parent family with children
4. Extended family
5. Solitary
6. Household without any couple group

OWN: Ownership to the unit in which household lives

0. Unknown / Non-recorded / Not-applicable
1. Owner occupied
2. Tenant

C.2 CENSUS DATA RECODING

Within Census data, some variables needed to be recoding for carrying out analysis. Tables below show original census data variables, their codes, and recoding system by using 'Compute' and 'Recode' options of SPSS statistics software program. The method for obtaining income by using ownership of the resident dwelling, ownership of another dwelling except the one resident, age and employment status variables is represented in Table C.1. For determining whether the individual is unemployed or not, age, last week's work status, the reason for not working and whether seeking for job variables were used. The recoding method for work status is given in the Table C.2.

Table C.2: Recoding method for obtaining income status of the household

Original Census Data Variables Used For Recoding			Obtained Variable	
owner	ownother	empstat	Income_1	income
1	3	0	1	3
1	4	0	2	2
2	3	0	3	3
2	4	0	4	1
1	3	1	5	3
1	4	1	6	3
2	3	1	7	3
2	4	1	8	3
1	3	2	9	3
1	4	2	10	2
2	3	2	11	3
2	4	2	12	2
1	3	3	13	3
1	4	3	14	1
2	3	3	15	3
2	4	3	16	1

own: Is he household the owner of the dwelling?	1: Yes 2: No
ownanother: Is the household own any other dwelling?	3: Yes 4: No
empstat: Last week's employment status	0: Employee 1: Employer 2: Self-employed 3: Unpaid family worker 9: Not applicable / not working
income: Income status of the household	1: Low-income 2: Middle-income 3: High-income

Table C.2: Recoding method for obtaining unemployed individuals

Original Census Data Variables Used For Recoding				Obtained Variables
age	wrklastwk	whynotwrk	seekjob	work
age≤11				0
age≥11	3			1
age≥11	4			1
age≥11	5	≠ 8	≠ 1	2
age≥11	9	≠ 8	≠ 1	2
age≥11	5	8	1	3
age≥11	9	≠ 8	1	3
age≥11	5	8	≠ 1	3
age≥11	9	8	1	3
age≥11		4		0

Wrklastwk: Did you work last week for money or payment in kind?	3: worked 4: did not but have a job 5: did not worked 9: unknown
Whynotwrk: Reason for not working	3: retired 4: student 5: housewife 6: rentier 7: other 8: unemployed
Seekjob: Are you looking for a job?	1: yes 2: no 9: unknown
Work: Work status of the individual	1: working 2: not working 3: unemployed 0: not applicable

APPENDIX D

CORRELATION RESULTS FROM SPSS OUTPUT

Table D.1: Variables entered to correlation analysis

Variable	N	Mean	Std. Deviation	Missing		No. of Extremes	
				Count	Percent	Low	High
firerate	152	7,659	13,234	47	23,618	0	23
hhtype_1	198	11,437	11,072	1	0,503	0	10
hhtype_2	198	58,920	19,254	1	0,503	9	0
hhtype_3	198	4,946	8,958	1	0,503	0	5
hhtype_4	198	12,126	10,958	1	0,503	0	4
hhtype_5	198	9,464	12,042	1	0,503	0	11
hhtype_6	198	2,602	5,538	1	0,503	0	10
own_1	199	46,439	19,885	0	0,000	16	3
own_2	199	53,561	19,885	0	0,000	3	16
income_1	198	51,098	17,183	1	0,503	3	11
income_2	198	26,545	15,474	1	0,503	0	3
income_3	198	22,357	14,693	1	0,503	0	1
age_1	199	14,053	6,031	0	0,000	0	2
age_2	199	16,447	6,731	0	0,000	10	4
age_3	199	62,536	7,319	0	0,000	1	5
age_4	199	6,964	6,316	0	0,000	0	15
res_1	199	96,726	5,034	0	0,000	8	0
res_6	199	3,274	5,034	0	0,000	0	8
res5_1	199	77,175	10,619	0	0,000	8	8
res5_6	199	22,825	10,619	0	0,000	8	8
lit_1	199	89,436	7,307	0	0,000	7	0
lit_2	199	10,564	7,307	0	0,000	0	7
sch_1	199	76,348	19,784	0	0,000	0	0
sch_2	199	14,129	9,942	0	0,000	0	1
sch_3	199	9,523	12,054	0	0,000	0	6
work_1	199	72,422	15,310	0	0,000	5	0
work_2	199	24,519	13,747	0	0,000	0	3
work_3	199	3,059	5,559	0	0,000	0	12

Table D.2: Correlation results

		firerate	hhtype_1	hhtype_2	hhtype_3	hhtype_4	hhtype_5
firerate	Pearson Cor.	1,000	-0,217	-0,130	-0,117	-0,009	0,146
	Sig. (2-tailed)	,	0,007	0,111	0,151	0,909	0,073
	N	152	152	152	152	152	152
hhtype_1	Pearson Cor.	-0,217	1,000	-0,390	-0,069	-0,257	0,050
	Sig. (2-tailed)	0,007	,	0,000	0,337	0,000	0,486
	N	152	198	198	198	198	198
hhtype_2	Pearson Cor.	-0,130	-0,390	1,000	-0,296	-0,267	-0,488
	Sig. (2-tailed)	0,111	0,000	,	0,000	0,000	0,000
	N	152	198	198	198	198	198
hhtype_3	Pearson Cor.	-0,117	-0,069	-0,296	1,000	-0,122	-0,093
	Sig. (2-tailed)	0,151	0,337	0,000	,	0,086	0,193
	N	152	198	198	198	198	198
hhtype_4	Pearson Cor.	-0,009	-0,257	-0,267	-0,122	1,000	-0,175
	Sig. (2-tailed)	0,909	0,000	0,000	0,086	,	0,014
	N	152	198	198	198	198	198
hhtype_5	Pearson Cor.	0,146	0,050	-0,488	-0,093	-0,175	1,000
	Sig. (2-tailed)	0,073	0,486	0,000	0,193	0,014	,
	N	152	198	198	198	198	198
hhtype_6	Pearson Cor.	0,257	-0,037	-0,348	0,043	0,141	-0,010
	Sig. (2-tailed)	0,001	0,607	0,000	0,551	0,047	0,886
	N	152	198	198	198	198	198
own_1	Pearson Cor.	-0,590	0,054	-0,011	-0,063	0,277	-0,034
	Sig. (2-tailed)	0,000	0,454	0,874	0,375	0,000	0,633
	N	152	198	198	198	198	198
own_2	Pearson Cor.	0,590	-0,054	0,011	0,063	-0,277	0,034
	Sig. (2-tailed)	0,000	0,454	0,874	0,375	0,000	0,633
	N	152	198	198	198	198	198
income_1	Pearson Cor.	0,397	-0,072	-0,050	-0,008	-0,155	0,097
	Sig. (2-tailed)	0,000	0,314	0,484	0,915	0,029	0,175
	N	152	197	197	197	197	197
income_2	Pearson Cor.	-0,436	-0,186	0,125	-0,078	0,387	-0,164
	Sig. (2-tailed)	0,000	0,009	0,079	0,279	0,000	0,021
	N	152	197	197	197	197	197
income_3	Pearson Cor.	-0,005	0,299	-0,080	0,097	-0,246	0,066
	Sig. (2-tailed)	0,952	0,000	0,266	0,175	0,001	0,360
	N	152	197	197	197	197	197
age_1	Pearson Cor.	-0,111	-0,216	0,173	-0,253	0,350	-0,177
	Sig. (2-tailed)	0,173	0,002	0,015	0,000	0,000	0,013
	N	152	198	198	198	198	198
age_2	Pearson Cor.	-0,182	-0,186	0,456	-0,070	-0,060	-0,249
	Sig. (2-tailed)	0,025	0,009	0,000	0,324	0,403	0,000
	N	152	198	198	198	198	198

Table D.2 (continue'2)

		firerate	hhtype_1	hhtype_2	hhtype_3	hhtype_4	hhtype_5
age_3	Pearson Cor.	0,106	-0,039	-0,175	0,274	-0,090	-0,017
	Sig. (2-tailed)	0,192	0,587	0,014	0,000	0,206	0,808
	N	152	198	198	198	198	198
age_4	Pearson Cor.	0,176	0,442	-0,455	0,016	-0,170	0,448
	Sig. (2-tailed)	0,030	0,000	0,000	0,824	0,017	0,000
	N	152	198	198	198	198	198
res_1	Pearson Cor.	-0,306	0,009	0,034	0,055	0,152	-0,075
	Sig. (2-tailed)	0,000	0,897	0,637	0,441	0,033	0,292
	N	152	198	198	198	198	198
res_6	Pearson Cor.	0,306	-0,009	-0,034	-0,055	-0,152	0,075
	Sig. (2-tailed)	0,000	0,897	0,637	0,441	0,033	0,292
	N	152	198	198	198	198	198
res5_1	Pearson Cor.	-0,119	0,002	0,256	0,129	-0,310	-0,016
	Sig. (2-tailed)	0,144	0,982	0,000	0,071	0,000	0,822
	N	152	198	198	198	198	198
res5_6	Pearson Cor.	0,119	-0,002	-0,256	-0,129	0,310	0,016
	Sig. (2-tailed)	0,144	0,982	0,000	0,071	0,000	0,822
	N	152	198	198	198	198	198
lit_1	Pearson Cor.	0,012	-0,104	-0,010	0,046	-0,067	0,024
	Sig. (2-tailed)	0,887	0,146	0,883	0,523	0,352	0,738
	N	152	198	198	198	198	198
lit_2	Pearson Cor.	-0,012	0,104	0,010	-0,046	0,067	-0,024
	Sig. (2-tailed)	0,887	0,146	0,883	0,523	0,352	0,738
	N	152	198	198	198	198	198
sch_1	Pearson Cor.	-0,028	-0,132	0,208	-0,075	0,249	-0,247
	Sig. (2-tailed)	0,735	0,064	0,003	0,291	0,000	0,000
	N	152	198	198	198	198	198
sch_2	Pearson Cor.	-0,101	0,080	-0,209	0,122	-0,192	0,245
	Sig. (2-tailed)	0,215	0,265	0,003	0,086	0,007	0,001
	N	152	198	198	198	198	198
sch_3	Pearson Cor.	0,116	0,152	-0,170	0,024	-0,252	0,206
	Sig. (2-tailed)	0,154	0,033	0,017	0,740	0,000	0,004
	N	152	198	198	198	198	198
work_1	Pearson Cor.	0,168	-0,111	0,220	-0,107	0,092	-0,357
	Sig. (2-tailed)	0,038	0,120	0,002	0,133	0,198	0,000
	N	152	198	198	198	198	198
work_2	Pearson Cor.	-0,109	0,106	-0,237	0,101	-0,083	0,378
	Sig. (2-tailed)	0,180	0,136	0,001	0,157	0,245	0,000
	N	152	198	198	198	198	198
work_3	Pearson Cor.	-0,209	0,045	-0,030	0,048	-0,050	0,066
	Sig. (2-tailed)	0,010	0,526	0,676	0,501	0,486	0,353
	N	152	198	198	198	198	198

Table D.2 (continue'3)

		hhtype_6	own_1	own_2	income_1	income_2	income_3
firerate	Pearson Cor.	0,257	-0,590	0,590	0,397	-0,436	-0,005
	Sig. (2-tailed)	0,001	0,000	0,000	0,000	0,000	0,952
	N	152	152	152	152	152	152
hhtype_1	Pearson Cor.	-0,037	0,054	-0,054	-0,072	-0,186	0,299
	Sig. (2-tailed)	0,607	0,454	0,454	0,314	0,009	0,000
	N	198	198	198	197	197	197
hhtype_2	Pearson Cor.	-0,348	-0,011	0,011	-0,050	0,125	-0,080
	Sig. (2-tailed)	0,000	0,874	0,874	0,484	0,079	0,266
	N	198	198	198	197	197	197
hhtype_3	Pearson Cor.	0,043	-0,063	0,063	-0,008	-0,078	0,097
	Sig. (2-tailed)	0,551	0,375	0,375	0,915	0,279	0,175
	N	198	198	198	197	197	197
hhtype_4	Pearson Cor.	0,141	0,277	-0,277	-0,155	0,387	-0,246
	Sig. (2-tailed)	0,047	0,000	0,000	0,029	0,000	0,001
	N	198	198	198	197	197	197
hhtype_5	Pearson Cor.	-0,010	-0,034	0,034	0,097	-0,164	0,066
	Sig. (2-tailed)	0,886	0,633	0,633	0,175	0,021	0,360
	N	198	198	198	197	197	197
hhtype_6	Pearson Cor.	1,000	-0,222	0,222	0,159	-0,182	0,010
	Sig. (2-tailed)	,	0,002	0,002	0,026	0,010	0,888
	N	198	198	198	197	197	197
own_1	Pearson Cor.	-0,222	1,000	-1,000	-0,440	0,509	-0,022
	Sig. (2-tailed)	0,002	,	0,000	0,000	0,000	0,763
	N	198	199	199	198	198	198
own_2	Pearson Cor.	0,222	-1,000	1,000	0,440	-0,509	0,022
	Sig. (2-tailed)	0,002	0,000	,	0,000	0,000	0,763
	N	198	199	199	198	198	198
income_1	Pearson Cor.	0,159	-0,440	0,440	1,000	-0,600	-0,538
	Sig. (2-tailed)	0,026	0,000	0,000	,	0,000	0,000
	N	197	198	198	198	198	198
income_2	Pearson Cor.	-0,182	0,509	-0,509	-0,600	1,000	-0,352
	Sig. (2-tailed)	0,010	0,000	0,000	0,000	,	0,000
	N	197	198	198	198	198	198
income_3	Pearson Cor.	0,010	-0,022	0,022	-0,538	-0,352	1,000
	Sig. (2-tailed)	0,888	0,763	0,763	0,000	0,000	,
	N	197	198	198	198	198	198
age_1	Pearson Cor.	-0,237	0,144	-0,144	0,069	0,365	-0,465
	Sig. (2-tailed)	0,001	0,043	0,043	0,337	0,000	0,000
	N	198	199	199	198	198	198
age_2	Pearson Cor.	-0,212	0,008	-0,008	-0,140	0,348	-0,202
	Sig. (2-tailed)	0,003	0,912	0,912	0,049	0,000	0,004
	N	198	199	199	198	198	198

Table D.2 (continue'4)

		hhtype_6	own_1	own_2	income_1	income_2	income_3
age_3	Pearson Cor.	0,287	-0,202	0,202	-0,048	-0,243	0,313
	Sig. (2-tailed)	0,000	0,004	0,004	0,502	0,001	0,000
	N	198	199	199	198	198	198
age_4	Pearson Cor.	0,136	0,088	-0,088	0,131	-0,412	0,280
	Sig. (2-tailed)	0,057	0,214	0,214	0,066	0,000	0,000
	N	198	199	199	198	198	198
res_1	Pearson Cor.	0,033	0,155	-0,155	-0,009	0,181	-0,180
	Sig. (2-tailed)	0,643	0,029	0,029	0,904	0,011	0,011
	N	198	199	199	198	198	198
res_6	Pearson Cor.	-0,033	-0,155	0,155	0,009	-0,181	0,180
	Sig. (2-tailed)	0,643	0,029	0,029	0,904	0,011	0,011
	N	198	199	199	198	198	198
res5_1	Pearson Cor.	-0,433	0,204	-0,204	-0,158	0,115	0,063
	Sig. (2-tailed)	0,000	0,004	0,004	0,027	0,108	0,375
	N	198	199	199	198	198	198
res5_6	Pearson Cor.	0,433	-0,204	0,204	0,158	-0,115	-0,063
	Sig. (2-tailed)	0,000	0,004	0,004	0,027	0,108	0,375
	N	198	199	199	198	198	198
lit_1	Pearson Cor.	0,116	-0,052	0,052	-0,200	-0,133	0,373
	Sig. (2-tailed)	0,103	0,469	0,469	0,005	0,062	0,000
	N	198	199	199	198	198	198
lit_2	Pearson Cor.	-0,116	0,052	-0,052	0,200	0,133	-0,373
	Sig. (2-tailed)	0,103	0,469	0,469	0,005	0,062	0,000
	N	198	199	199	198	198	198
sch_1	Pearson Cor.	-0,053	0,033	-0,033	0,110	0,410	-0,561
	Sig. (2-tailed)	0,457	0,647	0,647	0,122	0,000	0,000
	N	198	199	199	198	198	198
sch_2	Pearson Cor.	0,117	-0,023	0,023	-0,112	-0,293	0,439
	Sig. (2-tailed)	0,100	0,751	0,751	0,117	0,000	0,000
	N	198	199	199	198	198	198
sch_3	Pearson Cor.	-0,009	-0,035	0,035	-0,089	-0,431	0,557
	Sig. (2-tailed)	0,903	0,625	0,625	0,214	0,000	0,000
	N	198	199	199	198	198	198
work_1	Pearson Cor.	0,053	-0,192	0,192	-0,138	0,271	-0,125
	Sig. (2-tailed)	0,458	0,007	0,007	0,053	0,000	0,080
	N	198	199	199	198	198	198
work_2	Pearson Cor.	-0,034	0,179	-0,179	0,047	-0,293	0,254
	Sig. (2-tailed)	0,631	0,011	0,011	0,511	0,000	0,000
	N	198	199	199	198	198	198
work_3	Pearson Cor.	-0,060	0,086	-0,086	0,261	-0,022	-0,281
	Sig. (2-tailed)	0,405	0,228	0,228	0,000	0,755	0,000
	N	198	199	199	198	198	198

Table D.2 (continue'5)

		age_1	age_2	age_3	age_4	res_1	res_6
firerate	Pearson Cor.	-0,111	-0,182	0,106	0,176	-0,306	0,306
	Sig. (2-tailed)	0,173	0,025	0,192	0,030	0,000	0,000
	N	152	152	152	152	152	152
hhtype_1	Pearson Cor.	-0,216	-0,186	-0,039	0,442	0,009	-0,009
	Sig. (2-tailed)	0,002	0,009	0,587	0,000	0,897	0,897
	N	198	198	198	198	198	198
hhtype_2	Pearson Cor.	0,173	0,456	-0,175	-0,455	0,034	-0,034
	Sig. (2-tailed)	0,015	0,000	0,014	0,000	0,637	0,637
	N	198	198	198	198	198	198
hhtype_3	Pearson Cor.	-0,253	-0,070	0,274	0,016	0,055	-0,055
	Sig. (2-tailed)	0,000	0,324	0,000	0,824	0,441	0,441
	N	198	198	198	198	198	198
hhtype_4	Pearson Cor.	0,350	-0,060	-0,090	-0,170	0,152	-0,152
	Sig. (2-tailed)	0,000	0,403	0,206	0,017	0,033	0,033
	N	198	198	198	198	198	198
hhtype_5	Pearson Cor.	-0,177	-0,249	-0,017	0,448	-0,075	0,075
	Sig. (2-tailed)	0,013	0,000	0,808	0,000	0,292	0,292
	N	198	198	198	198	198	198
hhtype_6	Pearson Cor.	-0,237	-0,212	0,287	0,136	0,033	-0,033
	Sig. (2-tailed)	0,001	0,003	0,000	0,057	0,643	0,643
	N	198	198	198	198	198	198
own_1	Pearson Cor.	0,144	0,008	-0,202	0,088	0,155	-0,155
	Sig. (2-tailed)	0,043	0,912	0,004	0,214	0,029	0,029
	N	199	199	199	199	199	199
own_2	Pearson Cor.	-0,144	-0,008	0,202	-0,088	-0,155	0,155
	Sig. (2-tailed)	0,043	0,912	0,004	0,214	0,029	0,029
	N	199	199	199	199	199	199
income_1	Pearson Cor.	0,069	-0,140	-0,048	0,131	-0,009	0,009
	Sig. (2-tailed)	0,337	0,049	0,502	0,066	0,904	0,904
	N	198	198	198	198	198	198
income_2	Pearson Cor.	0,365	0,348	-0,243	-0,412	0,181	-0,181
	Sig. (2-tailed)	0,000	0,000	0,001	0,000	0,011	0,011
	N	198	198	198	198	198	198
income_3	Pearson Cor.	-0,465	-0,202	0,313	0,280	-0,180	0,180
	Sig. (2-tailed)	0,000	0,004	0,000	0,000	0,011	0,011
	N	198	198	198	198	198	198
age_1	Pearson Cor.	1,000	0,109	-0,488	-0,505	0,216	-0,216
	Sig. (2-tailed)	,	0,126	0,000	0,000	0,002	0,002
	N	199	199	199	199	199	199
age_2	Pearson Cor.	0,109	1,000	-0,620	-0,451	0,261	-0,261
	Sig. (2-tailed)	0,126	,	0,000	0,000	0,000	0,000
	N	199	199	199	199	199	199

Table D.2 (continue'6)

		age_1	age_2	age_3	age_4	res_1	res_6
age_3	Pearson Cor.	-0,488	-0,620	1,000	-0,032	-0,240	0,240
	Sig. (2-tailed)	0,000	0,000	,	0,657	0,001	0,001
	N	199	199	199	199	199	199
age_4	Pearson Cor.	-0,505	-0,451	-0,032	1,000	-0,205	0,205
	Sig. (2-tailed)	0,000	0,000	0,657	,	0,004	0,004
	N	199	199	199	199	199	199
res_1	Pearson Cor.	0,216	0,261	-0,240	-0,205	1,000	-1,000
	Sig. (2-tailed)	0,002	0,000	0,001	0,004	,	0,000
	N	199	199	199	199	199	199
res_6	Pearson Cor.	-0,216	-0,261	0,240	0,205	-1,000	1,000
	Sig. (2-tailed)	0,002	0,000	0,001	0,004	0,000	,
	N	199	199	199	199	199	199
res5_1	Pearson Cor.	-0,205	0,252	-0,102	0,046	0,249	-0,249
	Sig. (2-tailed)	0,004	0,000	0,150	0,523	0,000	0,000
	N	199	199	199	199	199	199
res5_6	Pearson Cor.	0,205	-0,252	0,102	-0,046	-0,249	0,249
	Sig. (2-tailed)	0,004	0,000	0,150	0,523	0,000	0,000
	N	199	199	199	199	199	199
lit_1	Pearson Cor.	-0,327	-0,169	0,470	-0,053	-0,218	0,218
	Sig. (2-tailed)	0,000	0,017	0,000	0,455	0,002	0,002
	N	199	199	199	199	199	199
lit_2	Pearson Cor.	0,327	0,169	-0,470	0,053	0,218	-0,218
	Sig. (2-tailed)	0,000	0,017	0,000	0,455	0,002	0,002
	N	199	199	199	199	199	199
sch_1	Pearson Cor.	0,438	0,515	-0,454	-0,441	0,388	-0,388
	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000
	N	199	199	199	199	199	199
sch_2	Pearson Cor.	-0,425	-0,519	0,517	0,360	-0,147	0,147
	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,039	0,039
	N	199	199	199	199	199	199
sch_3	Pearson Cor.	-0,368	-0,417	0,318	0,427	-0,516	0,516
	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000
	N	199	199	199	199	199	199
work_1	Pearson Cor.	0,358	0,381	-0,195	-0,521	0,106	-0,106
	Sig. (2-tailed)	0,000	0,000	0,006	0,000	0,137	0,137
	N	199	199	199	199	199	199
work_2	Pearson Cor.	-0,395	-0,386	0,253	0,496	-0,116	0,116
	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,103	0,103
	N	199	199	199	199	199	199
work_3	Pearson Cor.	-0,008	-0,094	-0,088	0,210	-0,005	0,005
	Sig. (2-tailed)	0,912	0,187	0,216	0,003	0,948	0,948
	N	199	199	199	199	199	199

Table D.2 (continue'7)

		res5_1	res5_6	lit_1	lit_2	sch_1	sch_2
firerate	Pearson Cor.	-0,119	0,119	0,012	-0,012	-0,028	-0,101
	Sig. (2-tailed)	0,144	0,144	0,887	0,887	0,735	0,215
	N	152	152	152	152	152	152
hhtype_1	Pearson Cor.	0,002	-0,002	-0,104	0,104	-0,132	0,080
	Sig. (2-tailed)	0,982	0,982	0,146	0,146	0,064	0,265
	N	198	198	198	198	198	198
hhtype_2	Pearson Cor.	0,256	-0,256	-0,010	0,010	0,208	-0,209
	Sig. (2-tailed)	0,000	0,000	0,883	0,883	0,003	0,003
	N	198	198	198	198	198	198
hhtype_3	Pearson Cor.	0,129	-0,129	0,046	-0,046	-0,075	0,122
	Sig. (2-tailed)	0,071	0,071	0,523	0,523	0,291	0,086
	N	198	198	198	198	198	198
hhtype_4	Pearson Cor.	-0,310	0,310	-0,067	0,067	0,249	-0,192
	Sig. (2-tailed)	0,000	0,000	0,352	0,352	0,000	0,007
	N	198	198	198	198	198	198
hhtype_5	Pearson Cor.	-0,016	0,016	0,024	-0,024	-0,247	0,245
	Sig. (2-tailed)	0,822	0,822	0,738	0,738	0,000	0,001
	N	198	198	198	198	198	198
hhtype_6	Pearson Cor.	-0,433	0,433	0,116	-0,116	-0,053	0,117
	Sig. (2-tailed)	0,000	0,000	0,103	0,103	0,457	0,100
	N	198	198	198	198	198	198
own_1	Pearson Cor.	0,204	-0,204	-0,052	0,052	0,033	-0,023
	Sig. (2-tailed)	0,004	0,004	0,469	0,469	0,647	0,751
	N	199	199	199	199	199	199
own_2	Pearson Cor.	-0,204	0,204	0,052	-0,052	-0,033	0,023
	Sig. (2-tailed)	0,004	0,004	0,469	0,469	0,647	0,751
	N	199	199	199	199	199	199
income_1	Pearson Cor.	-0,158	0,158	-0,200	0,200	0,110	-0,112
	Sig. (2-tailed)	0,027	0,027	0,005	0,005	0,122	0,117
	N	198	198	198	198	198	198
income_2	Pearson Cor.	0,115	-0,115	-0,133	0,133	0,410	-0,293
	Sig. (2-tailed)	0,108	0,108	0,062	0,062	0,000	0,000
	N	198	198	198	198	198	198
income_3	Pearson Cor.	0,063	-0,063	0,373	-0,373	-0,561	0,439
	Sig. (2-tailed)	0,375	0,375	0,000	0,000	0,000	0,000
	N	198	198	198	198	198	198
age_1	Pearson Cor.	-0,205	0,205	-0,327	0,327	0,438	-0,425
	Sig. (2-tailed)	0,004	0,004	0,000	0,000	0,000	0,000
	N	199	199	199	199	199	199
age_2	Pearson Cor.	0,252	-0,252	-0,169	0,169	0,515	-0,519
	Sig. (2-tailed)	0,000	0,000	0,017	0,017	0,000	0,000
	N	199	199	199	199	199	199

Table D.2 (continue'8)

		res5_1	res5_6	lit_1	lit_2	sch_1	sch_2
age_3	Pearson Cor.	-0,102	0,102	0,470	-0,470	-0,454	0,517
	Sig. (2-tailed)	0,150	0,150	0,000	0,000	0,000	0,000
	N	199	199	199	199	199	199
age_4	Pearson Cor.	0,046	-0,046	-0,053	0,053	-0,441	0,360
	Sig. (2-tailed)	0,523	0,523	0,455	0,455	0,000	0,000
	N	199	199	199	199	199	199
res_1	Pearson Cor.	0,249	-0,249	-0,218	0,218	0,388	-0,147
	Sig. (2-tailed)	0,000	0,000	0,002	0,002	0,000	0,039
	N	199	199	199	199	199	199
res_6	Pearson Cor.	-0,249	0,249	0,218	-0,218	-0,388	0,147
	Sig. (2-tailed)	0,000	0,000	0,002	0,002	0,000	0,039
	N	199	199	199	199	199	199
res5_1	Pearson Cor.	1,000	-1,000	-0,119	0,119	0,068	0,040
	Sig. (2-tailed)	,	0,000	0,093	0,093	0,339	0,580
	N	199	199	199	199	199	199
res5_6	Pearson Cor.	-1,000	1,000	0,119	-0,119	-0,068	-0,040
	Sig. (2-tailed)	0,000	,	0,093	0,093	0,339	0,580
	N	199	199	199	199	199	199
lit_1	Pearson Cor.	-0,119	0,119	1,000	-1,000	-0,583	0,513
	Sig. (2-tailed)	0,093	0,093	,	0,000	0,000	0,000
	N	199	199	199	199	199	199
lit_2	Pearson Cor.	0,119	-0,119	-1,000	1,000	0,583	-0,513
	Sig. (2-tailed)	0,093	0,093	0,000	,	0,000	0,000
	N	199	199	199	199	199	199
sch_1	Pearson Cor.	0,068	-0,068	-0,583	0,583	1,000	-0,877
	Sig. (2-tailed)	0,339	0,339	0,000	0,000	,	0,000
	N	199	199	199	199	199	199
sch_2	Pearson Cor.	0,040	-0,040	0,513	-0,513	-0,877	1,000
	Sig. (2-tailed)	0,580	0,580	0,000	0,000	0,000	,
	N	199	199	199	199	199	199
sch_3	Pearson Cor.	-0,144	0,144	0,533	-0,533	-0,918	0,614
	Sig. (2-tailed)	0,042	0,042	0,000	0,000	0,000	0,000
	N	199	199	199	199	199	199
work_1	Pearson Cor.	-0,096	0,096	0,168	-0,168	0,161	-0,211
	Sig. (2-tailed)	0,176	0,176	0,018	0,018	0,023	0,003
	N	199	199	199	199	199	199
work_2	Pearson Cor.	0,088	-0,088	0,012	-0,012	-0,251	0,272
	Sig. (2-tailed)	0,219	0,219	0,871	0,871	0,000	0,000
	N	199	199	199	199	199	199
work_3	Pearson Cor.	0,049	-0,049	-0,491	0,491	0,178	-0,091
	Sig. (2-tailed)	0,496	0,496	0,000	0,000	0,012	0,202
	N	199	199	199	199	199	199

Table D.2 (continue'9)

		sch_3	work_1	work_2	work_3	allpop	density
firerate	Pearson Cor.	0,116	0,168	-0,109	-0,209	-0,421	-0,339
	Sig. (2-tailed)	0,154	0,038	0,180	0,010	0,000	0,000
	N	152	152	152	152	152	152
hhtype_1	Pearson Cor.	0,152	-0,111	0,106	0,045	-0,033	0,056
	Sig. (2-tailed)	0,033	0,120	0,136	0,526	0,645	0,431
	N	198	198	198	198	198	197
hhtype_2	Pearson Cor.	-0,170	0,220	-0,237	-0,030	0,181	0,041
	Sig. (2-tailed)	0,017	0,002	0,001	0,676	0,011	0,565
	N	198	198	198	198	198	197
hhtype_3	Pearson Cor.	0,024	-0,107	0,101	0,048	-0,027	0,083
	Sig. (2-tailed)	0,740	0,133	0,157	0,501	0,702	0,245
	N	198	198	198	198	198	197
hhtype_4	Pearson Cor.	-0,252	0,092	-0,083	-0,050	-0,013	-0,050
	Sig. (2-tailed)	0,000	0,198	0,245	0,486	0,857	0,488
	N	198	198	198	198	198	197
hhtype_5	Pearson Cor.	0,206	-0,357	0,378	0,066	-0,163	-0,060
	Sig. (2-tailed)	0,004	0,000	0,000	0,353	0,022	0,403
	N	198	198	198	198	198	197
hhtype_6	Pearson Cor.	-0,009	0,053	-0,034	-0,060	-0,051	-0,051
	Sig. (2-tailed)	0,903	0,458	0,631	0,405	0,475	0,481
	N	198	198	198	198	198	197
own_1	Pearson Cor.	-0,035	-0,192	0,179	0,086	0,349	0,087
	Sig. (2-tailed)	0,625	0,007	0,011	0,228	0,000	0,223
	N	199	199	199	199	199	198
own_2	Pearson Cor.	0,035	0,192	-0,179	-0,086	-0,349	-0,087
	Sig. (2-tailed)	0,625	0,007	0,011	0,228	0,000	0,223
	N	199	199	199	199	199	198
income_1	Pearson Cor.	-0,089	-0,138	0,047	0,261	-0,303	0,031
	Sig. (2-tailed)	0,214	0,053	0,511	0,000	0,000	0,668
	N	198	198	198	198	198	198
income_2	Pearson Cor.	-0,431	0,271	-0,293	-0,022	0,200	0,054
	Sig. (2-tailed)	0,000	0,000	0,000	0,755	0,005	0,449
	N	198	198	198	198	198	198
income_3	Pearson Cor.	0,557	-0,125	0,254	-0,281	0,144	-0,093
	Sig. (2-tailed)	0,000	0,080	0,000	0,000	0,043	0,193
	N	198	198	198	198	198	198
age_1	Pearson Cor.	-0,368	0,358	-0,395	-0,008	-0,007	0,082
	Sig. (2-tailed)	0,000	0,000	0,000	0,912	0,925	0,252
	N	199	199	199	199	199	198
age_2	Pearson Cor.	-0,417	0,381	-0,386	-0,094	0,037	0,026
	Sig. (2-tailed)	0,000	0,000	0,000	0,187	0,605	0,715
	N	199	199	199	199	199	198

Table D.2 (continue'10)

		sch_3	work_1	work_2	work_3	allpop	density
age_3	Pearson Cor.	0,318	-0,195	0,253	-0,088	0,058	-0,027
	Sig. (2-tailed)	0,000	0,006	0,000	0,216	0,416	0,709
	N	199	199	199	199	199	198
age_4	Pearson Cor.	0,427	-0,521	0,496	0,210	-0,100	-0,073
	Sig. (2-tailed)	0,000	0,000	0,000	0,003	0,160	0,310
	N	199	199	199	199	199	198
res_1	Pearson Cor.	-0,516	0,106	-0,116	-0,005	0,027	0,035
	Sig. (2-tailed)	0,000	0,137	0,103	0,948	0,707	0,628
	N	199	199	199	199	199	198
res_6	Pearson Cor.	0,516	-0,106	0,116	0,005	-0,027	-0,035
	Sig. (2-tailed)	0,000	0,137	0,103	0,948	0,707	0,628
	N	199	199	199	199	199	198
res5_1	Pearson Cor.	-0,144	-0,096	0,088	0,049	-0,030	0,075
	Sig. (2-tailed)	0,042	0,176	0,219	0,496	0,672	0,294
	N	199	199	199	199	199	198
res5_6	Pearson Cor.	0,144	0,096	-0,088	-0,049	0,030	-0,075
	Sig. (2-tailed)	0,042	0,176	0,219	0,496	0,672	0,294
	N	199	199	199	199	199	198
lit_1	Pearson Cor.	0,533	0,168	0,012	-0,491	0,218	-0,101
	Sig. (2-tailed)	0,000	0,018	0,871	0,000	0,002	0,158
	N	199	199	199	199	199	198
lit_2	Pearson Cor.	-0,533	-0,168	-0,012	0,491	-0,218	0,101
	Sig. (2-tailed)	0,000	0,018	0,871	0,000	0,002	0,158
	N	199	199	199	199	199	198
sch_1	Pearson Cor.	-0,918	0,161	-0,251	0,178	-0,243	0,031
	Sig. (2-tailed)	0,000	0,023	0,000	0,012	0,001	0,664
	N	199	199	199	199	199	198
sch_2	Pearson Cor.	0,614	-0,211	0,272	-0,091	0,197	-0,023
	Sig. (2-tailed)	0,000	0,003	0,000	0,202	0,005	0,748
	N	199	199	199	199	199	198
sch_3	Pearson Cor.	1,000	-0,090	0,188	-0,217	0,236	-0,032
	Sig. (2-tailed)	,	0,205	0,008	0,002	0,001	0,654
	N	199	199	199	199	199	198
work_1	Pearson Cor.	-0,090	1,000	-0,932	-0,448	0,096	-0,066
	Sig. (2-tailed)	0,205	,	0,000	0,000	0,175	0,355
	N	199	199	199	199	199	198
work_2	Pearson Cor.	0,188	-0,932	1,000	0,095	-0,073	0,051
	Sig. (2-tailed)	0,008	0,000	,	0,182	0,307	0,471
	N	199	199	199	199	199	198
work_3	Pearson Cor.	-0,217	-0,448	0,095	1,000	-0,085	0,054
	Sig. (2-tailed)	0,002	0,000	0,182	,	0,230	0,447
	N	199	199	199	199	199	198

APPENDIX E

MAPS OF THE STUDY AREA ACCORDING TO THEIR SOCIOECONOMIC CAHARACTERISTICS

For obtaining the maps of the study area according to their dominant socioeconomic characteristics, each socioeconomic factor was analyzed individually. These maps represent the dominant characteristics of each quarter. By using signed chi-square method, the dominant variable, means the variable more than expected, of the given socioeconomic factor was determined within the study area.

For determining the dominant variable, a significant chi-square table, namely 'signed chi-square table' is used. Signed chi-square table represents the chi-square values of each cell, but also reflects whether the value is negative or positive, means less than expected or more than expected. For every quarter, counts, expected counts and residual values of each variable of a given socioeconomic factor are calculated by using the formula for cell x_{ij};

Chi-square $_{ij} = r_{ij}\, 2 / e_{ij}$

where r_{ij} is the residual value of x_{ij} and e_{ij} is the residual value of x_{ij}.

Afterwards, sign value of residual is calculated by dividing residual to its absolute value. The calculated chi-square value of each cell is multiplied with the signed value of residual. Thus, signed chi-square tale is obtained.

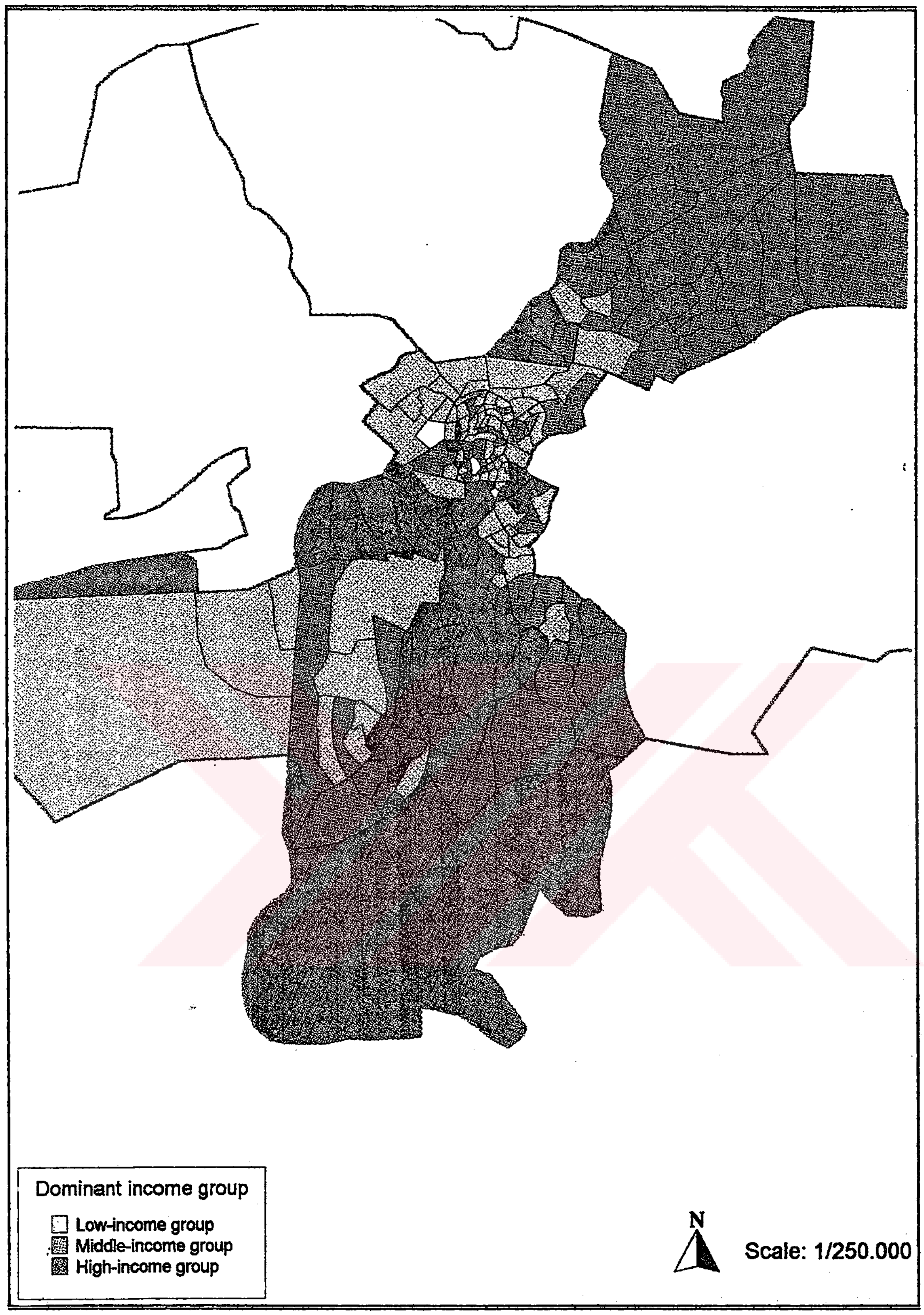

Figure E.1: Dominant income status, Altındağ and Çankaya Districts, 1990

Figure E.2: Dominant working status, Altındağ and Çankaya Districts, 1990

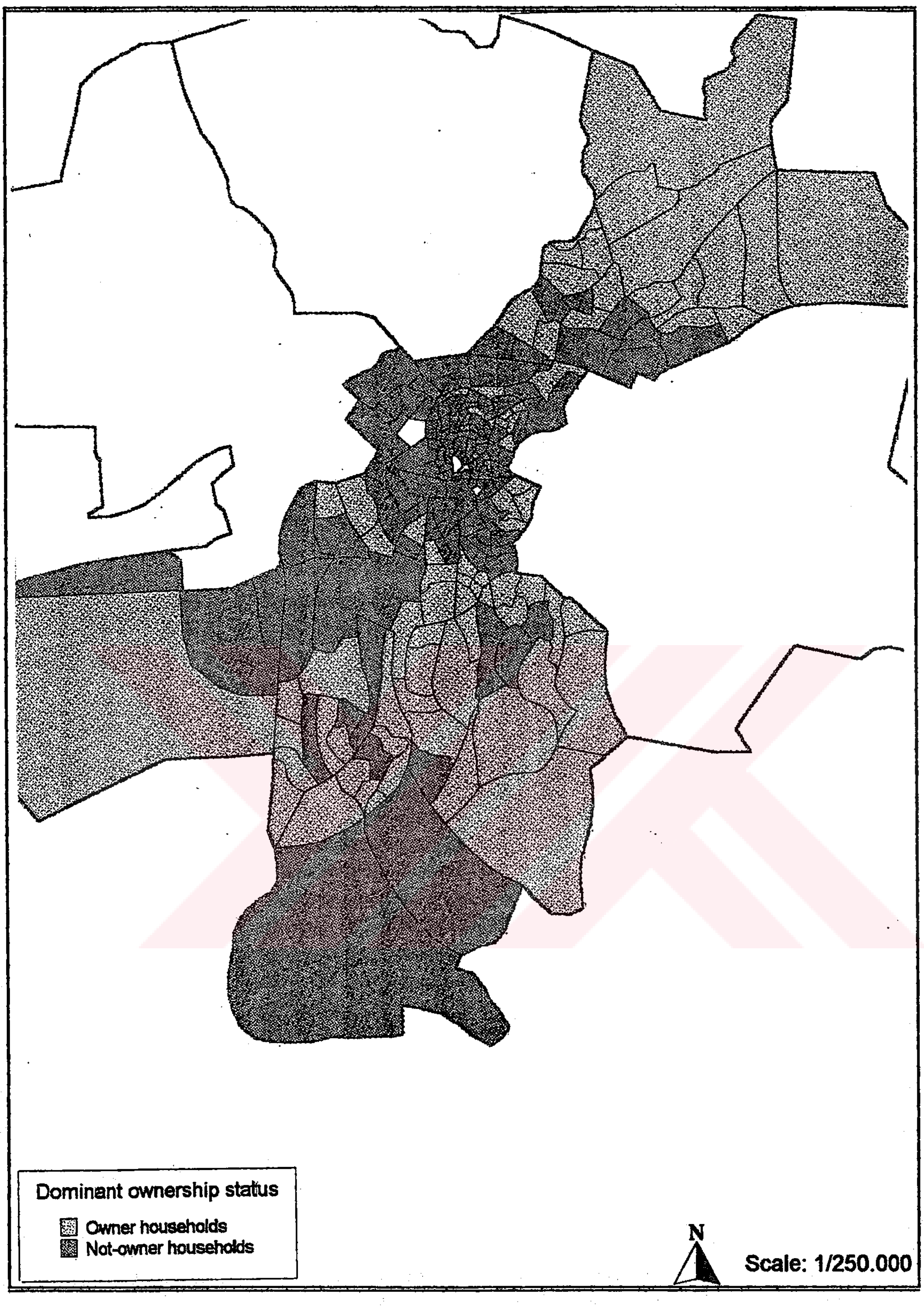

Figure E.3: Dominant ownership status, Altındağ and Çankaya Districts, 1990

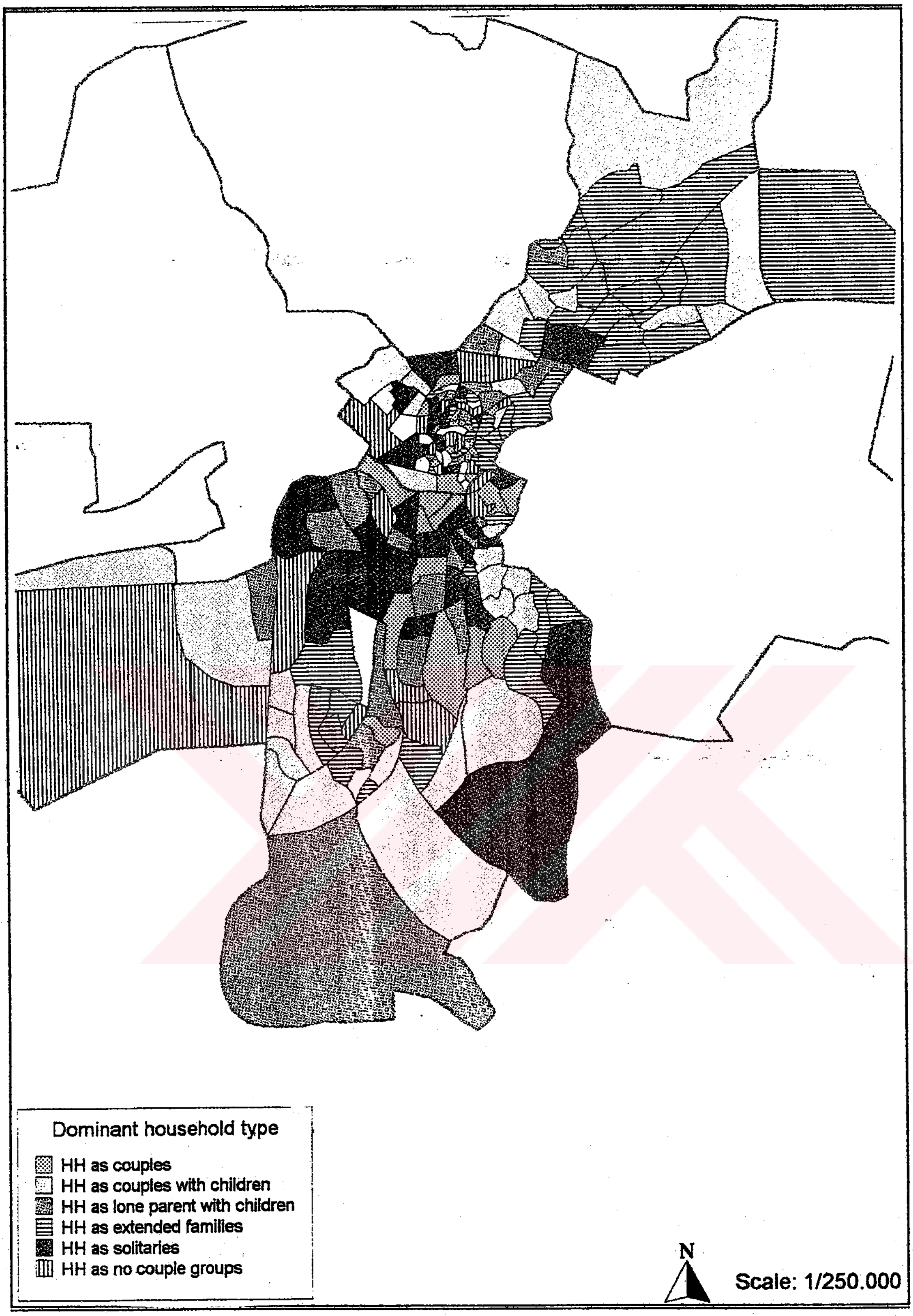

Figure E.4: Dominant household type, Altındağ and Çankaya Districts, 1990

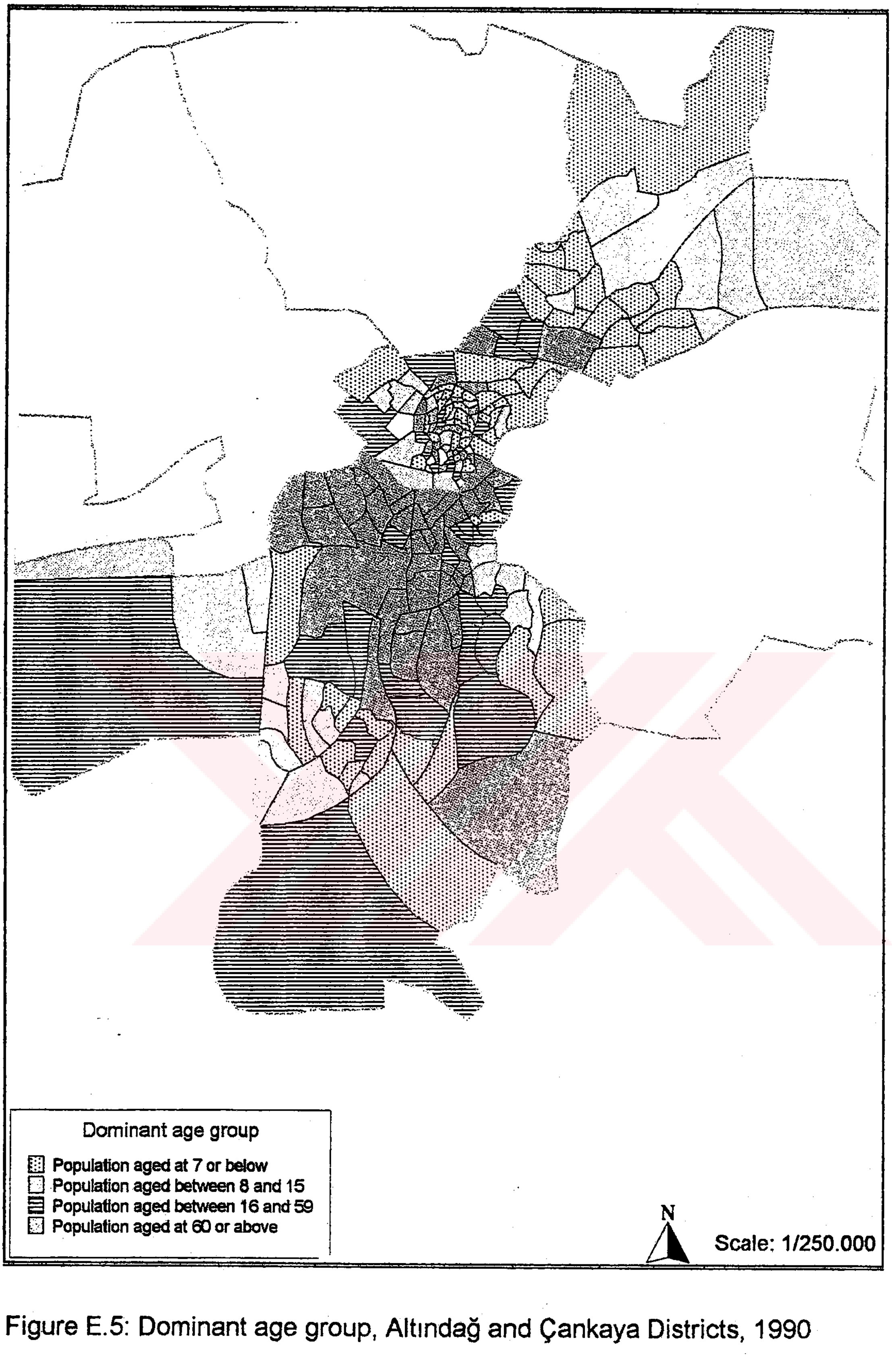

Figure E.5: Dominant age group, Altındağ and Çankaya Districts, 1990

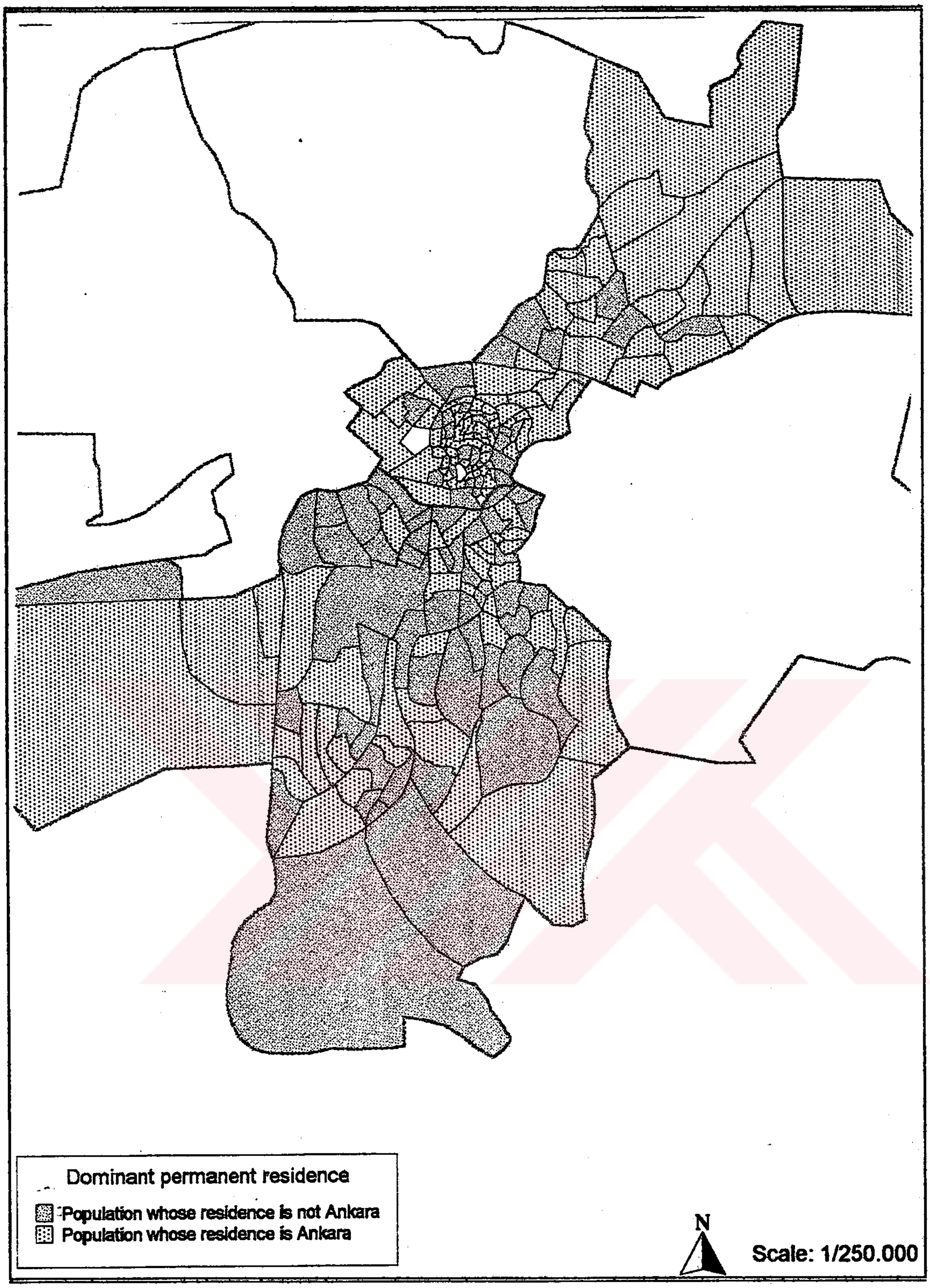

Figure E.6: Dominant permanent residence, Altındağ and Çankaya Districts, 1990

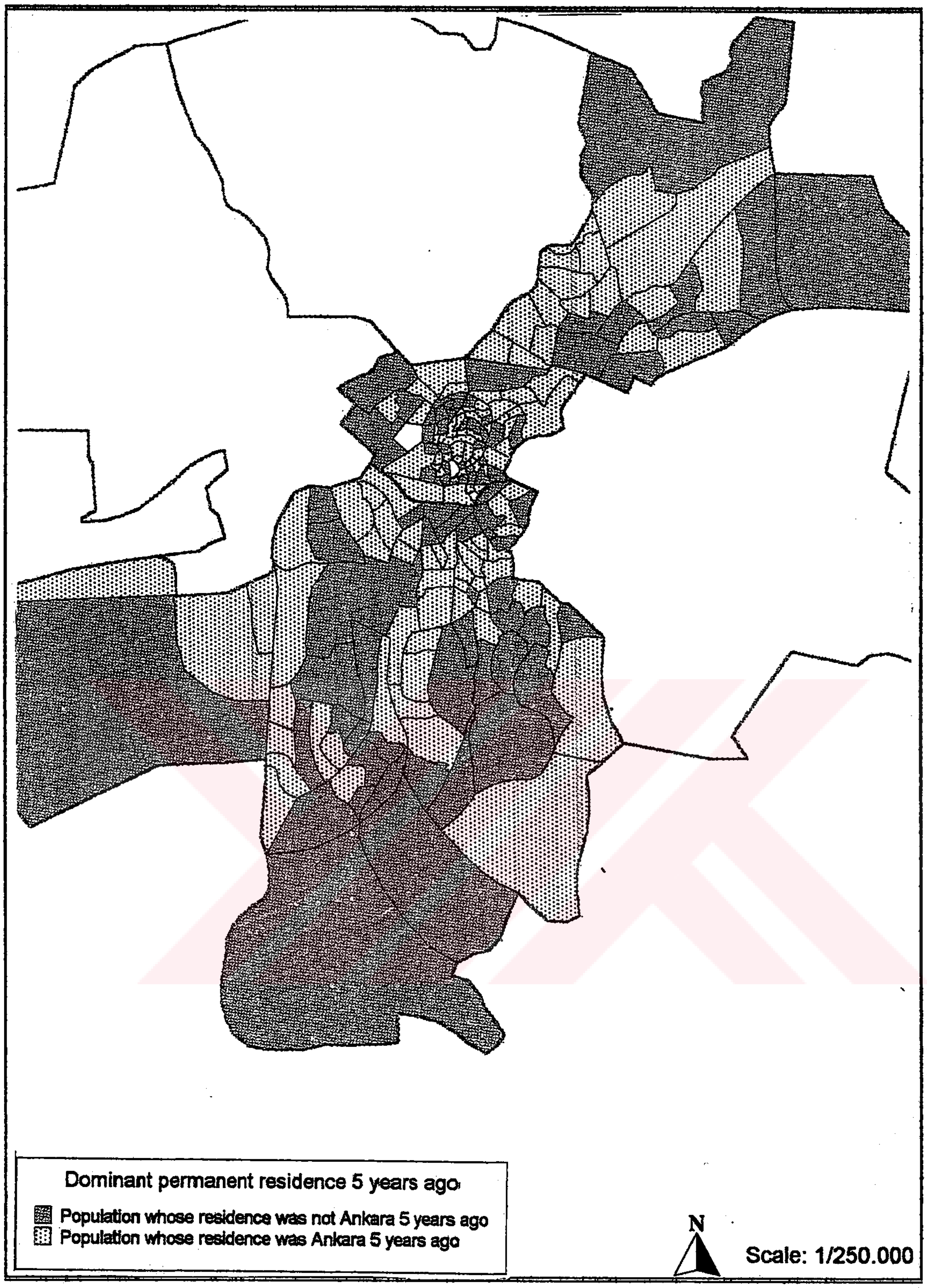

Figure E.7: Dominant permanent residence 5 years ago, Altındağ and Çankaya Districts, 1990

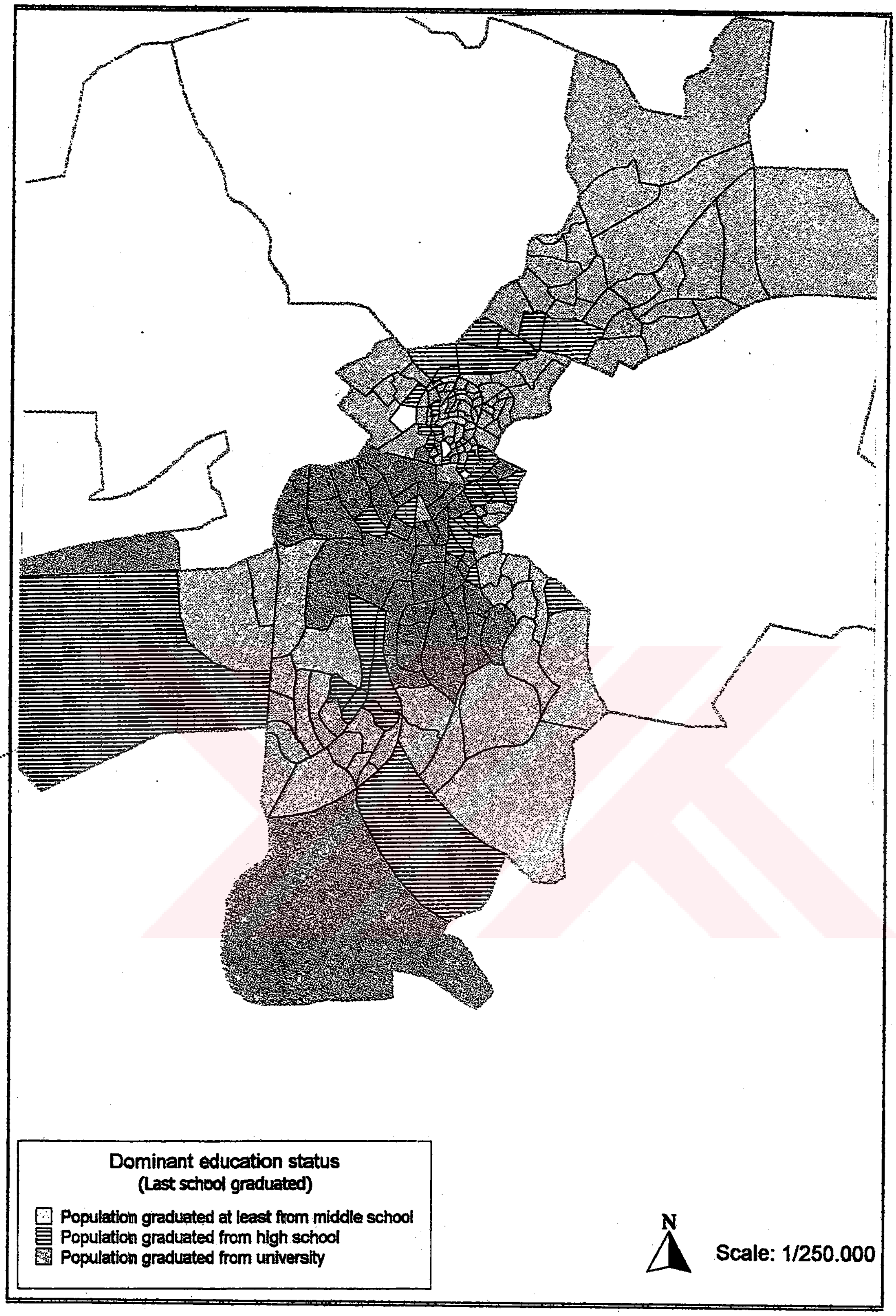

Figure E.8: Dominant education status, Altındağ and Çankaya Districts, 1990