

51st Congress of the European Regional Science Association International
30 August – 4 September 2011, Barcelona, Spain

**New Challenges for European Regions and Urban Areas
in a Globalised World**

**Spatial Distribution of Housing Investment and
Perception of Earthquake Risk in Istanbul Metropolitan Area**

Dr. Tuba Inal Cekic¹

Dr. Ela Oney Yazici²

Abstract

Istanbul, the largest metropolitan area in Turkey with a population of over 15 million inhabitants, lies close to major and active fault lines and has been previously hit by fatal earthquakes several times. Facing a high seismic risk as forecasted in a number of studies; Istanbul is particularly vulnerable due to the high density of old housing areas in the city center. Although there is a great body of knowledge in the literature focusing on the seismic risk of Istanbul and possible scenarios to strengthen the capacity for emergency preparedness in the event of future earthquakes, the attitudes and perceptions of housing investors living under the threat of the earthquake is yet to be explored.

This study is an attempt to address this gap and aims to investigate the relationship between the location of the housing investment and perception of earthquake risk of the investors. Data was collected by means of a questionnaire from 117 participants, who made an investment in housing in Istanbul since 1999 Kocaeli earthquake. ArcGIS is used to indicate the spatial distribution of investment and the results provide empirical evidence of how spatial distribution of housing investment differs depending on the earthquake risk perception of the investors.

¹ Yildiz Technical University, Faculty of Architecture, Regional Planning Division, Istanbul, tinal@yildiz.edu.tr

² Istanbul Technical University, Faculty of Architecture, Department of Architecture, Istanbul, oneyel@itu.edu.tr

I. Introduction

There is an increasing concern about the occurrence of natural hazards throughout the world. The number of studies focusing on the earthquakes- as a natural hazard- and their impact has increased during the past 20 years. The risk emerges especially for the cities of less developed countries, where the construction of earthquake resistant buildings is relatively poor.

Considering the high magnitude of the earthquakes as well as the damage they cause in the recent years; two main seismic belts stand out: the Pacific Earthquake Belt which surrounds the Great Ocean, especially effective on Japan and the Mediterranean-Himalayan seismic belt which extends from Gibraltar to Indonesia which Turkey is on. The importance of seismic risk emerges from Turkey, which has many regions on the seismic belt and more than half of the population lives in some of the big cities which are built on this first-degree seismic belt.

Istanbul, the largest city of Turkey, is located on the North Anatolian Fault Zone, one of the world's fast-moving and active faults. With a population of approximately 14 million people and a large building stock, Istanbul plays an important administrative and financial role in the whole economy. The lessons learned from the Kocaeli earthquake occurred on August 17, 1999, which also affected Istanbul; led to rapid advancement in new housing construction and investment especially in the periphery of Istanbul Metropolitan Area. Moreover, the risk of a massive earthquake that will hit directly Istanbul in the near future is underlined in a number of studies.

Since earthquake is a risk factor which is tied to a specific location, its risk assumed to be effective in local housing investment. Estimating individuals' perception on earthquake risk is crucial for evaluating the distribution of housing investment motives. Despite the relevance to effective disaster prevention policies, there have been relatively few studies on the effect of earthquake risk on housing investment. Existing studies, mostly focusing on the relation between the earthquake risk, housing prices and supply (Lindell and Perry, 2000; Onder et al, 2004; Hwang, 2003), are far from addressing other aspects of the issue such as the influence of risk perception of the households on the distribution of housing investment. With a focus on the demand side of the earthquake resistant housing development, it is of great urgency to evaluate household's perception of seismic risk in assessing the housing investment motives in Istanbul. This study is an attempt to fill this gap by examining the housing investments made in Istanbul after 1999 Kocaeli earthquake, and their spatial distribution in Istanbul Metropolitan Area with the focus on the real earthquake risk and how the investors perceive

it. Evaluating the relation between perception of earthquake risk and spatial distribution of the investment will provide information about development trends in Istanbul Metropolitan Area.

II. Seismic Risk and Risk Perception in Istanbul Metropolitan Area

Turkey is located on an active seismic belt on which destructive earthquakes occur on average once every 2-3 years. Considering the earthquakes occurred between 32 AD and 1900 AD, more than 100 devastating earthquakes hit Istanbul and the surrounding areas as a result of the tectonic movements along the arm of the Northern Anatolian Fault in the Marmara Sea. During the period from 1900 to the present day, more than 20 earthquakes of a magnitude above 6 have occurred and these earthquakes have affected this region in various intensities (Iskenderoğlu et al., 2003).

As a settlement with high seismic risk with more than 2000 years of history, today Istanbul is not only a significant center in terms of geography and geopolitics but also the largest metropolis which is integrated to the global economy as the financial and industrial center of the country. Particularly after 1950's, Istanbul has experienced intensive migration due to industrialization, and consequently a rapid and uncontrolled growth mainly towards the urban fringe. Moreover, faulty land-use planning and construction, inadequate infrastructure and services, and environmental degradation are highlighted as the factors that increase the earthquake vulnerability in Istanbul (Erdik et al., 2003).

One of the recent devastating earthquakes that affected Istanbul has occurred on August 17th, 1999, measured 7.4 on the Richter scale in Kocaeli province. The Kocaeli earthquake was felt in the whole Northwest Anatolia Region and caused extensive loss of lives and damages to property mostly in Kocaeli, Yalova, Sakarya and Bolu, also in surrounding cities such as Istanbul, Eskisehir and Zonguldak. Today it is a well known fact that destructive earthquakes are likely to occur in Istanbul and in the surrounding areas in the future. It is estimated that an earthquake which will occur as a result of breaking parts of North Anatolian Fault Line passing through the Marmara Sea, will affect a wide geography, especially the southern parts of Istanbul (JICA and GIMM, 2002). The possibility of occurrence of a massive earthquake around Mw=8.0 on Richter scale in the Marmara Region is estimated to be 90% Burton et al., (2004), while the formation period of a similar earthquake is 550 years (Kundak and Turkoğlu, 2007).

Above mentioned seismic risk of Istanbul and the prospect reached out to a wide audience through the media and accelerated the process of change in the residential developments in

Istanbul. This situation triggered the construction of new housing projects mainly in the north parts of the city especially in the urban fringe revealing the demand for such housing. Accordingly, the seismic risk and the perception of risk can be considered as a driving factor for the housing investments made after 1999 Kocaeli earthquake.

There are various definitions of “risk” which is a fuzzy word with many different meanings. Slovic and Weber (2002) proposed one of the most common definitions of risk and defined the concept as “*hazard, probability, consequence or potential adversity and threat*”. More specifically Cutter (1993) defines risk as “*measuring the probability of the occurrence of natural and technological hazards leading to certain adverse consequences*” (Hwang, 2003).

Individuals’ perceived risk plays a major role in determining how they respond to environmental hazards by interpreting warning messages or taking protective actions against hazard events (Lindell & Perry, 1992). Environmental risk perception has been defined in different ways. According to Mileti, Drabek and Haas (1975), risk perception is referred to as “*the individual’s understanding of the character and relevance of a hazard*”. Sorensen and White (1980) similarly define risk perception as “*an individual’s understanding of the temporal nature, probability, and the potential consequences of the disaster caused by a hazard*” (Galindo and Hwang, 2002).

A number of factors are proposed in the literature, which has an influence on individuals’ risk perceptions: such as experience, culture, race, gender, and socio-economic status, distance and tangible effect (Cutter, 1993:24). Some people respond by undertaking mitigatory measures, while others prefer ignoring the risk. In other words, people respond to hazards and risk in different ways. Palm (1990), in a longitudinal survey of California homeowners; found that households subscribing to earthquake insurance had steadily increased. He also stated that the geographic pattern of insurance subscription was unrelated to relative geographic risk (Asgary and Willis, 1997).

Accordingly, the relation between risk perception- which is assumed to have a role on the investment choices- and spatial distribution of housing investments is put forth as the subject of this paper.

III. Research Method

In order to investigate the spatial distribution of individuals' housing investments (to settle or rent) in Istanbul after the 1999 Kocaeli earthquake with the focus on their risk perceptions, the data was collected from 117 homeowners by means of a web-based questionnaire survey

during July-October 2010. For the ones who do not have internet access, paper-based version of the questionnaire has also been provided to the homeowners. Snowball sampling was used to select the investors since no up to date database exist on the subject. Diversity of socio-economic status of investors was the main criteria for determining the sample.

The questionnaire is composed of three parts. The first part contains questions concerning the demographic characteristics of the respondents as well as the households, such as gender, age, income, occupation, and size of the household. The second part was designed to seek information about the characteristics of the housing investment, housing unit and the factors affected their investment.

And finally the last part included question regarding the earthquake risk perception of the respondents. The literature review revealed that, risk perceptions can be measured in several ways. Jackson (1977) measured respondents' risk perception by using free-response methods. Jackson and Mukerjee (1974) asked respondents about potential troubles of their city in association with earthquakes to assess their risk perceptions. Dooley, Catalano, Mishra and Serxner (1992) evaluated respondents' risk perceptions by asking them about their level of concern about the hazard. Through previous studies, Lindell (1994, p. 305), identified four components of perceived risk characteristics: characteristics of the hazard agent, characteristics of the impact, perceived personal consequences, and affective reactions to the hazard (Galindo and Hwang, 2002).

In this study individuals' risk perceptions was measured on a 5 point Likert scale by asking them to express their agreement on the expected consequences of an earthquake such as life loss, property damage to their home, injury to themselves or members of their household where 1 is assigned to "strongly disagree", and 5 to "strongly agree". The last part of the questionnaire also examines the perceived factors of earthquake risk on a 5 point Likert scale such as distance to fault lines, soil type and construction method of the building ...etc. For spatial analysis with ArcGIS; 1-2 points (I don't agree), 3 (I'm not sure) and 4-5 points (I agree) have been defined with three categories.

Furthermore, the neighborhoods and districts, where the properties have been purchased in, were asked to the participants to bring out the spatial distribution of housing investments. Each of these investment decisions are marked with a dot in neighborhood centers of Istanbul Metropolitan Area. Figure 1 shows the distribution of participants' spatial preferences in housing investment. As a result of the snowball sampling method, the findings of the study revealed that the preferences of the reached participants distribute homogeneous in the urban

fringe and the center of the metropolitan area, but condense in the Asian side of the city due to the fact that this side is the dense residential area.

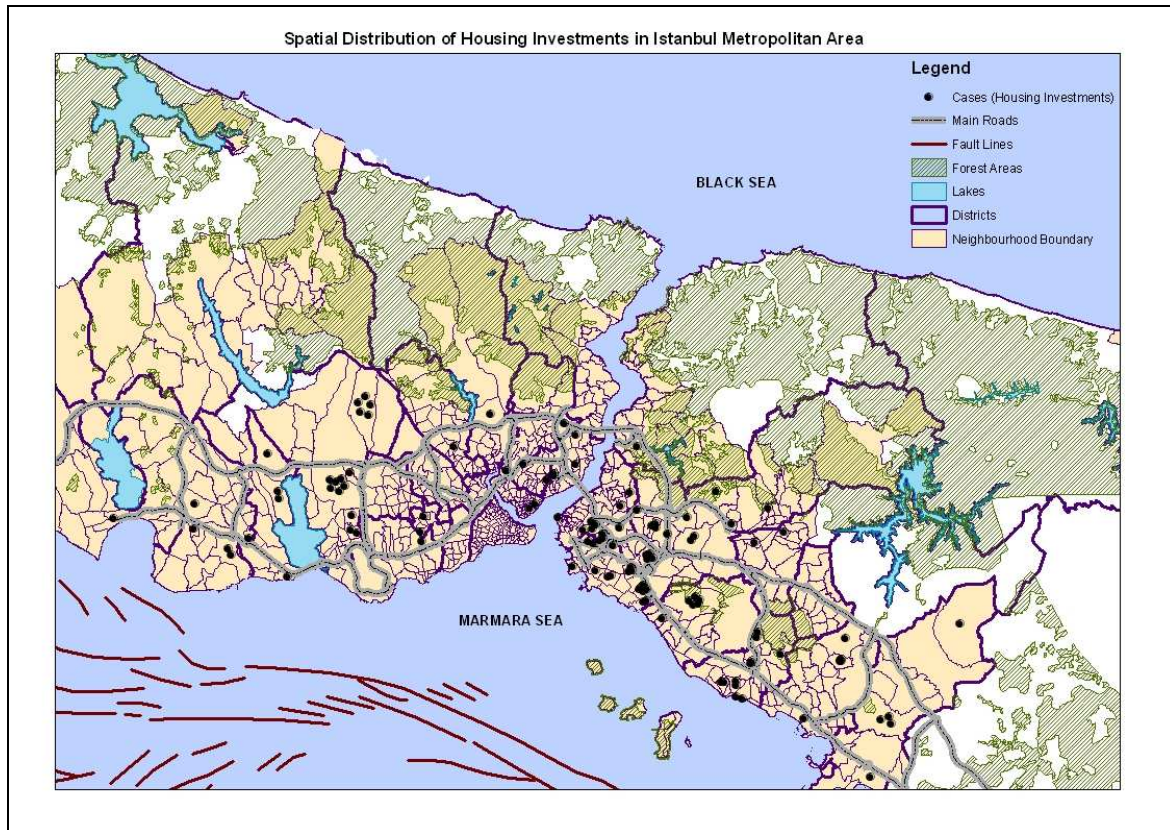


Figure.1: Spatial Distribution of Respondents' Investment Choices

IV. Spatial Distribution of Housing Investment According to Risk Perception in Istanbul Metropolitan Area

In order to determine the risk perceptions, participants were asked to rate their agreement on the statement “within the next 10 years, in Istanbul, an earthquake will occur which will cause serious life loss of and damage to property”. The red-colored circles in Figure 2 show the agreed participants with this statement. 49% of the participants indicated that they agree, while 16% of them indicated their disagreement. It is interesting to note that the participants who have a weak risk perception are located in the center of the metropolitan area and they are also located in the regions which are close to the Northern Anatolian Fault Line in the south of the city.

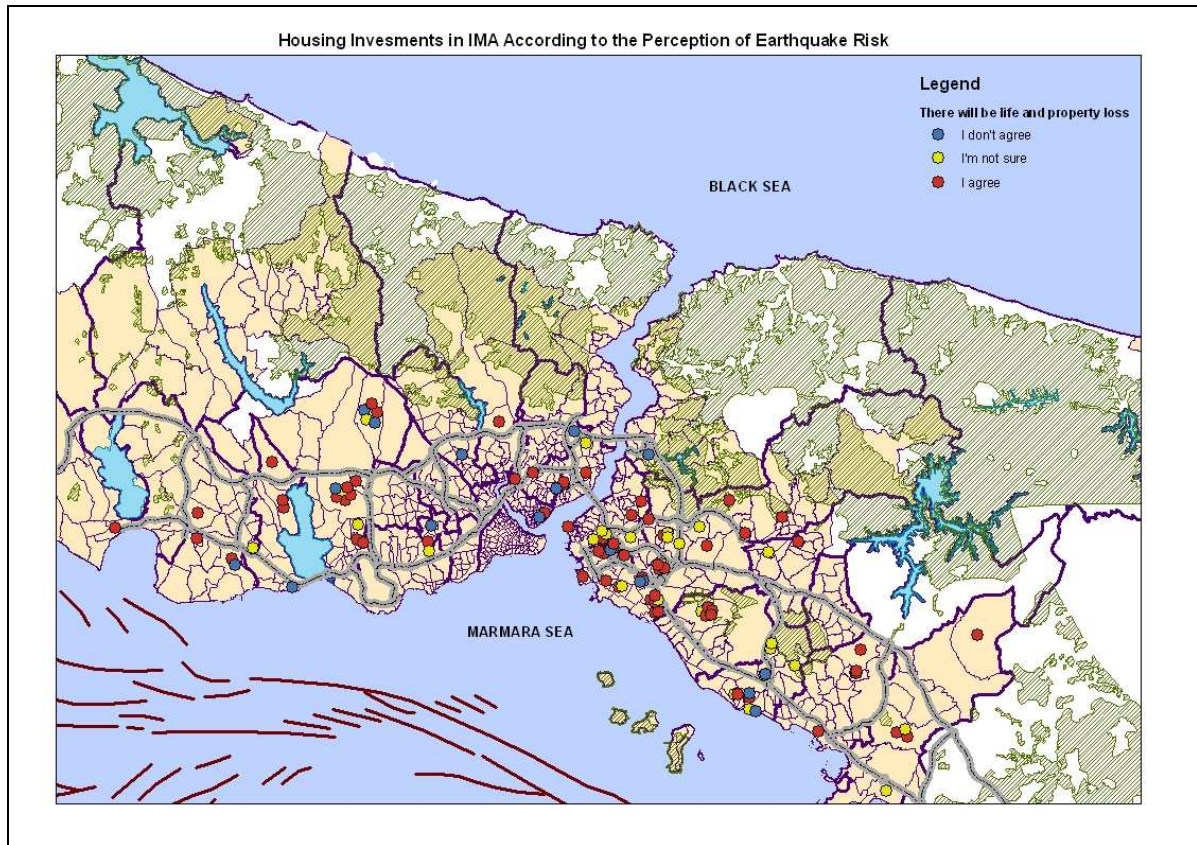


Figure.2: Perception of Earthquake Risk: There will be life and property loss

On the other hand, the participants were asked whether there will be injury to them or members of their family as a result of the possible earthquake which will occur in Istanbul. 36% of the participants indicated their disagreement with this statement. Besides, the number of participants is very high who indicated that they are not sure about this statement because they thought that it will depend on their location and the timing of the earthquake to be happened; as well as the characteristics of the housing unit that they invested in such as year of construction, construction technology ...etc (Figure 3). Therefore, it appears that they believe that there will be destruction due to earthquake in Istanbul but they do not think that they or members of their family will be injured. Here, the other factors that drive the housing choice gain importance.

Participants were also asked whether they agree or disagree with the statement to determine the impact of the earthquake; “the proximity to the fault line is a determining factor of the destructive strength of earthquakes”. It will be appropriate to imply that the maps which indicate lines regarding the location of the Northern Anatolian Fault line are widely common in media.

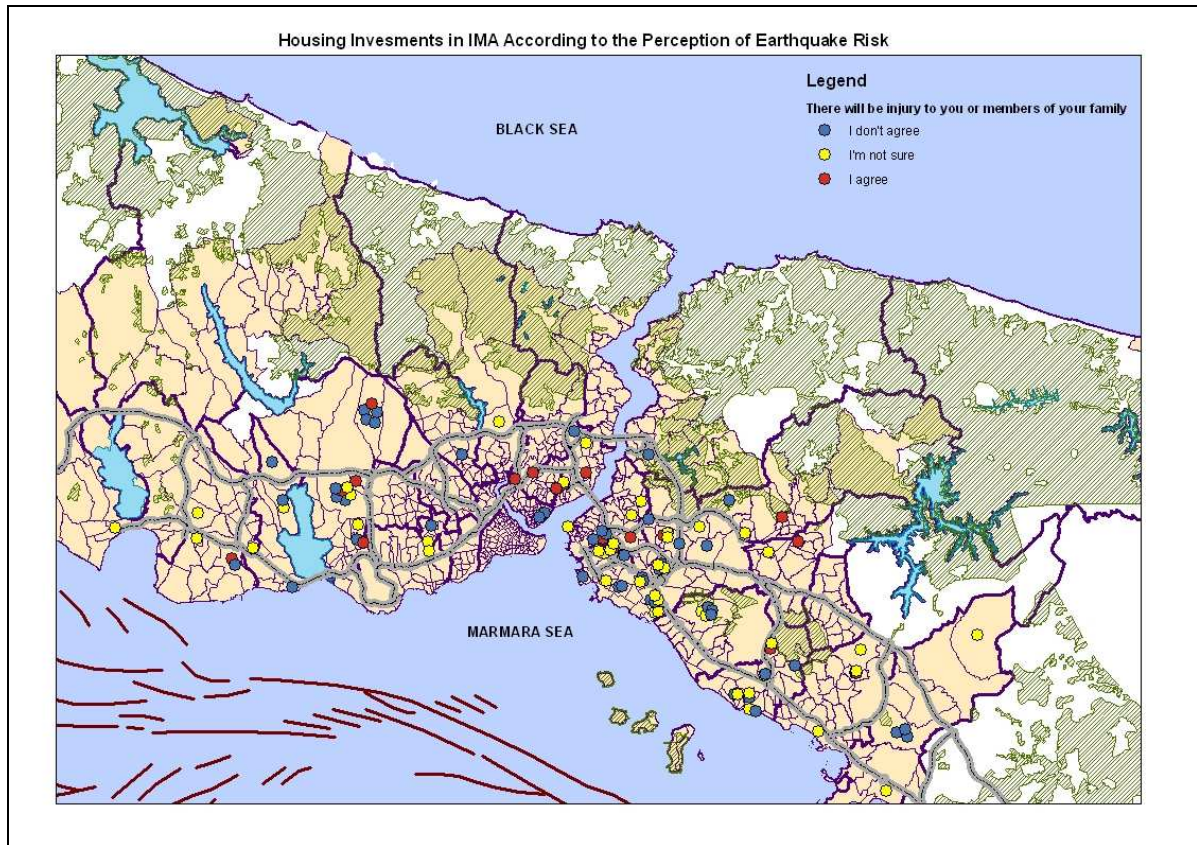


Figure.3: Perception of Earthquake Risk: There will be injury to you or members of your family

As is seen in Figure 4 the participants, who agree that the distance to the fault line is important, are marked with red. It has also been seen that some participants who invested in the southern parts of the city, in neighborhoods close to the shores of Marmara Sea and the fault line, also agree with this statement. 67 % of the participants who purchased residences far away from the fault line (north of E-5 motorway).

Given that the proximity to the fault line determines the destructiveness of the earthquake, 25% of the participants, who believe that a high magnitude earthquake will cause serious life loss and damage to property, invested in places located in the northern parts of the city away from the fault line (Figure 5). It becomes clear that actual seismic risk and perception of it influence the choices of respondents; however the characteristics of the housing unit and the environmental issues gain more importance than the proximity to the fault. Regarding the residential development in Istanbul Metropolitan Area some clues can be extracted from the fact that site selection on the areas close to the shores of Marmara Sea especially in the north of D100 motorway and urban fringes is dense.

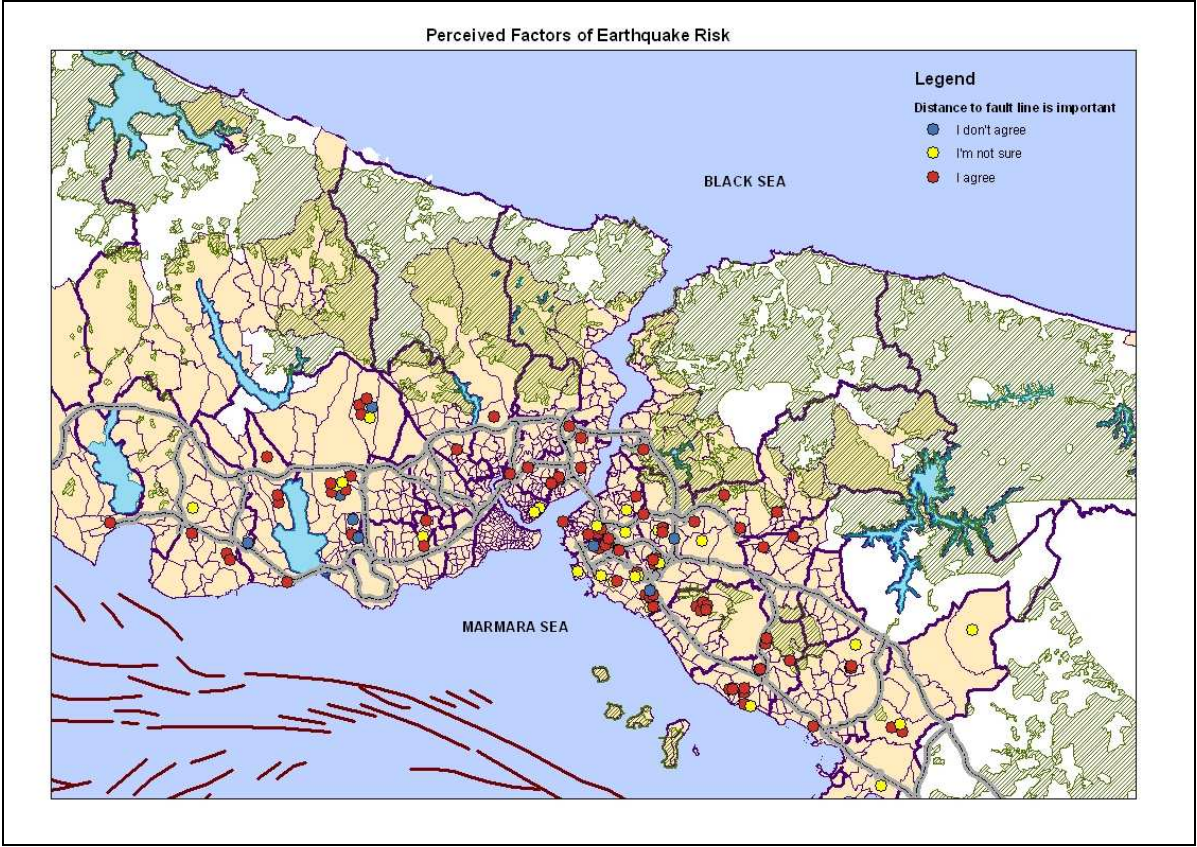


Figure 4: Perceived Factors of Earthquake Risk: Distance to Fault Line

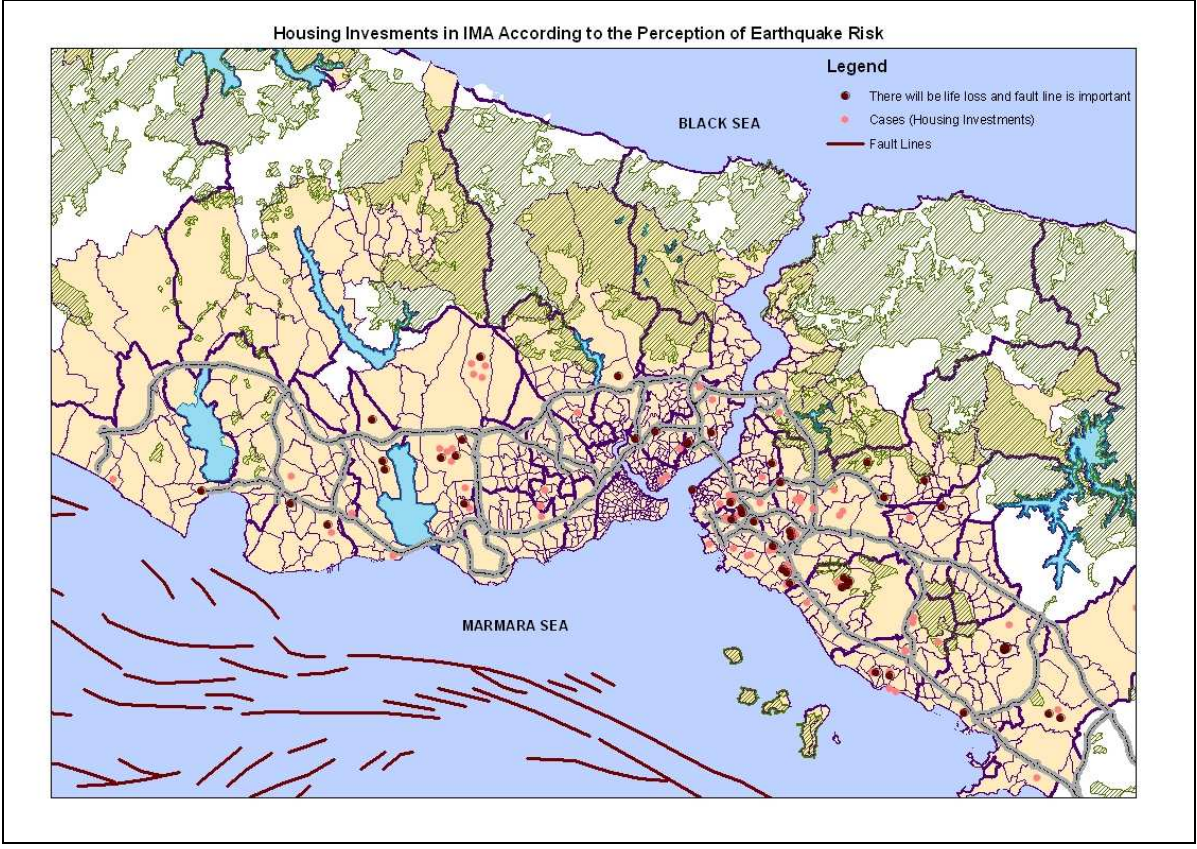


Figure 5: Real Earthquake Risk and Perception of Risk

V. Discussion

As a result, the risk perceptions of individuals and the actual risk are seen as the factors that drives the housing investment decisions. It can be monitored as a result of the analysis that the individuals with high perception of risk have a tendency towards the new residential buildings. It should be considered that; earthquake risk creates a demand for safer settlements, mostly on the northern areas and the thresholds (forest, water reservoirs) which have not been anticipated in the plans which have been made for Istanbul Metropolitan Area.

The fault line going through south shores of the Marmara Sea, the natural amenities that the northern part of the city offers and other factors that accelerate the process of escaping from the center of the city cause new demand for the housing projects towards urban fringe and the northern part of the Istanbul Metropolitan area. Particularly, in this process which increases the demand for the gated communities, issues such as social segregation, urban sprawl and automobile-dependent living...etc come into the agenda.

On the other hand, the density of the risky buildings in terms of earthquake safety in the center of the city is another factor which triggers this process. Scarce regeneration facilities bring with the dilapidation process in the city center and it is clear that the scenario of a possible destructive earthquake will cause serious problems in the center of Istanbul Metropolitan area.

Besides the factors affecting the housing investments, the other independent variables such as income level, the form of the family are also important in site selection of housing. At this point, spatial analysis of other independent parameters such as type of housing, the environment...etc that are queried with the questionnaire in context of the study, emerge as future work.

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