ISTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

"EVACUATION AND ACCESS" BASED CASUALTY REDUCTION PROPOSAL FOR HIGH DENSE SETTLEMENTS IN EARTHQUAKE – VULNERABLE AREAS.

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"DEPREM DAYANIMI YETERSİZ ŞEHİRLER İÇİN TAHLİYE VE ERİŞİM ÖNCELİKLİ CAN KAYBI AZALTIMI ÖNERİSİ"

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FOREWORD

I am grateful to many people, both in and out of the faculty, for the guidance, advice and tolerance over the past six years.
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Lastly, I wish to thank to my parents for their presence. Their beautiful outlook on life helps me to understand what things are the most important.

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ABBREVIATIONS

AEMG	: Australian Emergency Management Glossary
B	: Road Blockage Risk
BU	: Boğaziçi University
CBO	: Community Based Organizations
Ch	: Space Syntax Choice Value
DIE	: Devlet İstatistik Enstitüsü
DRO	: Disaster Relief Operation
EMPI	: EarthquakeMaster Plan for Istanbul
FEMA	: Federal Emergency Management Agency - USA
GDP	: Gross Domestic Product
GIS	: Geographic Information Systems
IIn	: Index of Intervention
IMM	: Istanbul Metropolitan Municipality
ITU	: Istanbul Technical University
JICA	: Japan International Cooperation Agency
MMS	: Moment Magnitude Scale (Denoted as MW)
NASA	: The National Aeronautics and Space Administration
NEO	: Non-combatant Evacuation Operation
NGO	: Non Governmental Organization
ODTU	: Middle East Technical University (Also abbreviated as METU)
PDC	: Pacific Disaster Center
PFS	: Petrol Filling Station
PGA	: Peak Ground Acceleration
PGV	: Peak Ground Velocity
PR	: Number of people living in a seismically vulnerable buildings
PS	: Seismic Performance Score
R	: Road Risk Value
RA	: Minimum radius of the road
RMS	: Risk Management Solutions Inc., Japan
SPSS	: Statistical Package for the Social Sciences – Computer Program
SPHM	: The State of California, Multi-Hazard Mitigation Plan
TMG	: Tokyo Metropolitan Government
UNDP	: United Nations Development Programme
USGS	: United States Geological Survey Agency
YTU	: Yıldız Technical University
ZPP	: Zeytinburnu Pilot Project

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"EVACUATION AND ACCESS" BASED CASUALTY REDUCTION PROPOSAL FOR HIGH DENSE SETTLEMENTS IN EARTHQUAKE – VULNERABLE AREAS"

SUMMARY

The earthquakes bring on two types of casualties. First, initial casualties which are generally due to collapsed buildings, shaking of the ground and damage on the urban land.

Secondary casualties are generally related with the physical conditions of durability of the urban structure. These also can reach to huge numbers especially for the poor settlements. People, who survive from the incident, may get trapped in the disaster core because of fires, collapsed buildings, fallen bridges, broken lifelines etc. These secondary effects also cause lack of resources which may lead long term casualties such as disease.

Depending on the vulnerability of the physical structure and community, all secondary impacts may reveal instantly. The challenging issue here is "**Can the casualties due to the weaknesses of the urban structure be higher than the initial casualties of earthquake itself?**"

This study is prepared in the aim of giving the priority to the buildings seismically vulnerable and with high probability of blocking roads after collapsing in rebuilding/retrofitting process. This will eventually allow the post earthquake services to be provided more easily, and allow much more people to be evacuated from the danger zone.

The study consists of 6 chapters;

Chapter 1 provides an overview of the background, purpose and research questions of this study.

Chapter 2 reviews the disaster management process and current & initial research works regarding the earthquake mitigation planning in the world. Mainly all studies/projects are not only based on securing public safety against to any disaster, but also avoiding the indirect effects of these disasters such as fire, flooding and soil erosion. Earthquake related casualties are evaluated and common approaches against these casualties are reviewed.

This chapter specifically underlines the need for this study, and gives an overview of the physical intervention techniques to any earthquake vulnerable settlement.

Chapter 3 includes the structure of the study and research design helping to create useful findings and outcomes of the dissertation.

Chapter 4 captures the approach of the model framework which will be used for improving safety for the settlements vulnerable to any disasters because of the irregular patterns, low building qualities and narrow connections. The aim is saving maximum life within shortest term and limited economic resources.

An earthquake would eventually cause an indirect impact such as fire. So risks in case of an earthquake and after an earthquake should be defined first in order to prevent additional life losses throughout an incident.

Mainly densely established areas with poor building quality will suffer building collapses and road blockages due to those collapses. Given the only evacuation and access routes are these roads, the street pattern after an earthquake would be crucial for saving lives stuck in a fire or collapse area.

Model, basically aims preventing building collapses on the main axes of any neighbourhood. It calculates the priorities of intervention (strengthening a building, demolishment of a vulnerable buildings etc.) to provide keeping the evacuation corridors are stay clear for people to get out/in the area.

The term priority means the index of corridors which will be cleared. The first corridor to secure is probably an important street which is on a major orientation route holding the highest proportion of people under risk.

The model first grabs the risk determination and orientation pattern analysis methods, than evaluates two important outputs: The Road risk value & The index of intervention.

The road risk value is pointing on the roads, holding significant numbers of people (or People under risk). These roads are clustered if they have any blockage risks in case of a disaster

The road risk value generally points out a scattered pattern on a map which is generally difficult to interpret. For this reason this value is combined with the "Choice" value which measures the "through movement" potential of a street segment, generated by Space Syntax Inc. Choice is simply predicts main natural movement axes within an urban fabric.

The index of intervention, which is the combination of the road risk value and Space Syntax's choice variable, gives a constant intervention index within a vulnerable urban pattern, consistent with an urban planners approach.

Chapter 5, demonstrates this model framework in two distinctive areas as case studies. Avcılar & Zeytinburnu areas, initially fringes of the spreading metropolitan area, recently announced as transformation areas due to high vulnerability and densely populated fragments of Istanbul. Given these areas has been evaluated by the Municipalities, local authorities and there are a number or transformation projects regarding the earthquake issue in these areas, model outputs are tested with the final intentions and next steps of these articulated studies.

Index of intervention value for Çırpıcı and Avcılar should be considered as starting point rather than another layer for disaster mitigation planning process. Although these outputs may scatter through the districts and there would be no consistency with the actual or proposed network, these lines should also be considered one by one as they have distinct risk factors and intervention possibilities.

Chapter 6 summarizes the main contributions of the study and discusses the needs for further extensions of this research. The outputs of the model proposal show that there are some significant consistencies between the evacuation routes that these plans propose and the index of intervention maps for the case areas. In addition, it is observed that more efficient road schemes can be provided with the help of the model output maps.

The key findings are showing that the approach can contribute to planning process as a layer with its applicable structure while it offers speeding up the mitigation process against the earthquakes.

“DEPREM DAYANIMI YETERSİZ ŞEHİRLER İÇİN TAHLİYE VE ERİŞİM ÖNCELİKLİ CAN KAYBI AZALTIMI ÖNERİSİ”

ÖZET

Depremin öncü etkileri, can kaybına yol açar ve fiziksel çevreye zarar verir. Depremin devam eden etkileri ise, yolların kapanması/bozulması ile oluşan kurtarma ve erişim problemleri, salgın hastalık ve yangın vb. sonuçlar olarak karşımıza çıkar. Bazı örneklerde depremin kendisinden daha fazla zarara yol açabilmektedirler.

Bu çalışma, kent parçalarının deprem sırasında yıkılan binalar yüzünden kapanma riskini en aza indirecek bir müdehale sırası geliştirmek amacı ile oluşturulmuştur. Depreme karşı zayıf bir kent dokusunda belirli ve limitli bir bütçe ile münferit binaları gelişigüzel yenilemek/yeniden yapmak yerine, kent parçasındaki oryantasyonu, doğal hareketlilik dokularını ortaya koyup, insanların tahliyesine imkan verecek tahliye eksenlerini belirleyip, bu eksenlerin tıkanmasını sağlayacak riskli binalara öncelik verilmesini öngörür. Bir kent dokusundaki risk altındaki nüfus büyüklüğünü asgariye indirebilmek için oluşturulacak bu riske dayalı müdehale sırası, önerilen simulasyon modeli ile birçok farklı örnekte kullanılabilecektir.

Buna bağlı olarak, **“Deprem dayanimi yetersiz yoğun yerleşik şehirler için tahliye ve erişim öncelikli bir can kaybi azaltimi önerisi”** isimli çalışma ortaya çıkmıştır. Çalışma altı bölümden oluşmaktadır;

Birinci bölüm, konu ile ilgili gözlemleri ortaya koyarak çalışmanın amacını irdeler. Çalışmanın başında sorulmuş olan, çalışmanın sonuçları ile birlikte açıklanması beklenen “Araştırma soruları” da bu bölümde listelenmiştir.

Afet yönetimi sürecini, deprem özelinde, dünyada günümüzde ve geçmişte uygulanmış olan çalışmalar ikinci bölümde açıklanmaktadır. Depremin etkilerini azaltmak adına yapılmış olan bu çalışmaların depremin birincil ve ikincil tüm etkileri göz önünde bulundurularak hazırlanmış olduğu görülmüştür. Depreme dayalı can kaybı türleri, nedenleri ve genel karakteristik yapıları ile incelenmiş ve anlatılmıştır. Yoğun yerleşik bölgelerde deprem sonrası yıkılan binaların yol açtığı tahliye ve erişim nedenleri üzerine yapılacak bu çalışmanın neden gerekli olduğu ifade edilmiştir.

Üçüncü bölümde, çalışmanın genel içeriği ve ilerlediği yöntem irdelenmiştir.

Dördüncü bölüm ise, depremin ikincil etkilerini, yıkılan binalar dolayısı ile kapanan yol sistemi nedeni ile oluşan tahliye ve erişim problemleri özelinde irdeler ve bu problemlerin etkin bir şekilde azaltılması adına önerilen model yapısını anlatır.

Yol sisteminin zarar görmesi ve yerleşimin her noktasına erişimin sağlanamamasının başlıca nedenleri o bölgedeki şehir geometrisi, yol sisteminin fiziksel kalitesi, yapı ve nüfus yoğunluğu, araç trafiğinin hacmi ve buna benzer birçok neden olduğu görülmüştür. Amaç, en yüksek sayıda insanı en kısa zaman içinde ve belirli finansal kaynaklar çerçevesinde güven altına almaktır.

Tahliye ve erişimi sağlaması beklenen yolların kapanmasına yol açacak deprem dayanımı az binaların güçlendirilmesi veya tekrar yapılması süreci özellikle ekonomik nedenler yüzünden çok hızlı bir şekilde gerçekleştirilemediği için, bu uygulamaların en çok insan hayatını kurtaracak bir şekilde sıraya konulması bu amaç dâhilindeki ana esastır.

Model, müdehale edilmesi gereken binaların öncelik sırasını "Müdehale Sırası"(Index of Intervention) değeri ile belirlemeye çalışmaktadır.

İlk olarak örnek bölgedeki risk değerlendirmeleri, nüfus yapısı, arazi kullanımı ve eğim değerleri kullanılarak fiziksel yapının zayıflığından kaynaklanacak muhtemel can kaybının oluşacağı yollar belirlenir. Bu süreci takip eden uygulama ise, kentsel alan kullanıcılarının oryantasyonu, kullandığı ana yollar ve işlevsel karakteristiklerin bu yollarla çakıştırılmasıdır. Kullanıcıların oryantasyonu, ulaşım için tercih edilen akslar ve rotalar gibi veriler şehirsel mekanlar ile binalar arasındaki ilişkileri inceleyen ve açıklayan Mekan Dizini (Space Syntax) yöntemi ile incelenip oluşturulmaktadır.

Bu yöntem mekan yapısının önemli özelliklerini yakalamakta, binaların, mimari planların ve şehir mekanlarının morfolojik analizini yapmakta kullanılan bir tekniktir. Kültür ve sosyal yapının fiziksel çevrenin yapılanma karakteristikleri ile ne tür ilişkileri olduğunu anlamamızı sağlayan birkaç yöntemden birisidir

Beşinci bölüm, önerilen model yapısının sınanması amacı ile Istanbul'da iki yerleşim üzerindeki etüt çalışmasını içerir. Avcılar ve Zeytinburnu, Istanbul Büyükşehir Belediyesi'nin de halen üzerinde depreme dayalı kentsel dönüşüm projeleri yürüttüğü, deprem dayanımı yetersiz ve yüksek yoğunluklu şehirsel dokusu ile ön plana çıkan iki ilçedir.

Oluşturulan model ile üretilen haritalar, belediyeler ve akademik birimler tarafından oluşturulmuş detaylı deprem öncelikli planlama projelerinin önerdiği yol sistemleri ile karşılaştırılmıştır. Öneri planlar ile model sonucu oluşan haritalar, tahliye ve erişim için güçlendirilmesi gereken ana eksenler konusunda büyük bir ölçüde örtüşmektedir.

Bununla beraber model haritalarının bazı eksenler için farklı alternatifler önerdiği de gözlemlenmiştir. Bu çıktıların bölgedeki riskleri detaylı bir şekilde incelediği ve ölçülebilir değerler üzerinden üretildiği göz önünde tutularak model önerisinin depreme yönelik planlama çalışmalarında bir altlık olarak kullanılmasının yarar sağlayacağı, plancı insiyatifinde yapılması gereken bu önerilerin oluşturulması sürecinde aydınlatıcı bir rol alacağı düşünülmektedir.

Son bölüm, önerilen ve örnek çalışma ile sınaması yapılan model çalışmasının genel sonuçlarını içerir. Çalışmanın başında sorulmuş olan araştırma sorularının cevaplarını ne ölçüde karşıladığını irdelemektedir. Afet yönetimi ve planlaması süreci içerisinde ne gibi alanlarda kullanılabileceğini, nasıl katkılarda bulunabileceğini ortaya koyar.

1. INTRODUCTION

1.1 Statement of the Problem

The 21st century is expected to witness not only sustained population growth, but also more urbanization. Within a generation, it has been estimated that the majority of the developing world's population will live in urban areas, and that the number of urban residents in developing countries will double, increasing by over 2 billion inhabitants (World Bank, 2000).

In 21st century, established urban fabric is significantly being affected by technological developments, new lifestyles/habits, diverse intentions of people and accelerated globalization in the world. Given the accessibility and the communication facilities are growing and also people have different needs in this information era, the nature of employment is changing rapidly. Basically, people need to be more qualified everyday in this competitive environment. Also people need to settle in the urban areas where the job opportunities are provided.

Thus, limited employment potentials causing immigration have been creating very dense cities unhealthy for the community. Some of these crowded cities are on an unstable geological formation which would eventually lead to catastrophic consequences.

Population shift is one of the main factors affecting urbanization. Less than 5 per cent of the world's population lived in cities a century ago. In 2008, for the first time in humanity, that figure exceeded 50 per cent. By 2050, it will have reached 70 per cent, representing 6.4 billion people. Most of this growth will be taking place in developing regions (UN-HABITAT, 2009).

Between 2007 and 2025, the annual rate of change in the urban population in developing countries is expected to be 2.27 per cent, and 0.49 per cent in developed regions. China's urban population is expected to double from about 40 per cent of its national population during 2006 to 2030 to more than 70 per cent by 2050.

In developed countries the level of urbanization reached the 50 per cent mark more than half a century ago; developing countries will only reach this level in 2019 (UN-HABITAT, 2009).

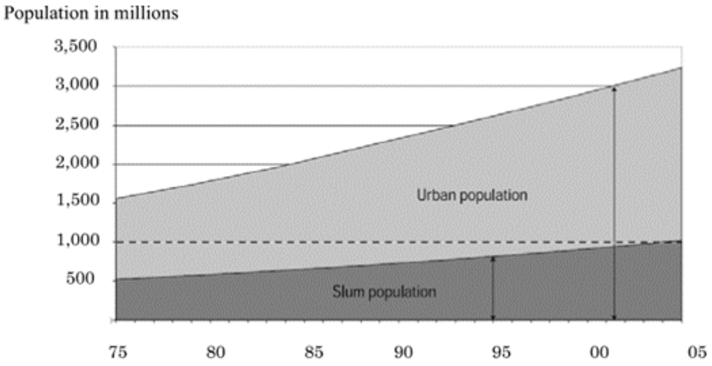


Figure 1.1: World Population Trend (Source – UN-HABITAT).

Although the world's population is still growing and people needs new planned residential areas day by day, currently significant proportion of population is living in established settlements with so many vulnerabilities against the nature.

Now, natural disasters like earthquakes, floods, fires etc. are causing huge casualties and extensive property damage due to lack of preparedness. The numbers of casualties are usually higher in developing countries and poor communities.

As seen in the Table 1.1, ten deadliest natural disasters of the past century mostly took place in poor or developing countries with high population density.

Table 1.1: Ten deadliest natural disasters in 20th century.

Rank	Event	Location	Date	Death toll
1.	1931 China floods	China	Nov. 1931	1m–2.5m
2.	1970 Bhola cyclone	Bangladesh	Nov. 1970	500,000
3.	2010 Haiti earthquake	Haiti	January 2010	300,000+
4.	1976 Tangshan earthquake	China	July 1976	300,000
5.	1920 Haiyuan earthquake	China	Dec. 1920	234,000
6.	2004 Indian Ocean Tsunami	Indonesia	Dec. 2004	230,000+
7.	1923 Great Kanto earthquake	Japan	Sept. 1923	142,000
8.	Cyclone Nargis	Myanmar	May 2008	138,000+
9.	1991 Bangladesh cyclone	Bangladesh	April 1991	138,000
10.	1948 Ashgabat earthquake	Turkmenistan	Oct. 1948	120,000

Although a wealth of scientific knowledge exists about the causes and effects of natural hazards, and technical methodology is well advanced for reducing their impacts, disasters continue to have devastating consequences, especially in developing countries. Between 1900 and 2004, 114 lethal earthquakes—1,000 or more deaths—resulted in a total of 2,071,253 officially reported deaths in at least 40 countries (USGS, 2004).

Theoretically, disaster prevention countermeasures should be implemented properly in order to maintain the urban life, minimizing losses of human life and property against any disasters. However, economical, political and social factors generally prevent the proper implementation processes.

Casualties in catastrophic earthquakes, especially in densely developed areas are inevitable. The purpose of reducing the casualty or to mitigate disaster effects can be listed as,

To protect human lives from the impact and

To provide post earthquake activities to be carried out well and to secure the state of ordinary living in order to sustain it.

The issue of amplification of casualties due to the vulnerability of physical structure has been successfully avoided in developed countries. Even in most devastating earthquake scenario in California, the minimum expected casualties don't get higher than 200 people while this number is 73,000 in Istanbul according to JICA report – Earthquake Model A (JICA, 2002).

For developing countries or poor communities under earthquake threat, the major factors against earthquake protection generally reveal as economy, population density and weak housing.

The earthquakes bring on two types of casualties. First, initial casualties, which are generally due to collapsed buildings, shaking of the ground and damage on the urban land.

Secondary casualties are generally related with the physical conditions of durability of the urban structure. These also can reach to huge numbers especially for the poor settlements.

People, who survive from the incident, may get trapped in the disaster core because of fires, collapsed buildings, fallen bridges, broken lifelines etc. These secondary effects also cause lack of resources which may lead long term casualties such as disease.

For example, after the Kashmir earthquake in 2005, 4,000 households were inaccessible by road due to landslides, 2.3 million people were without food for the winter and disease spread, sourced from people drinking the dirty, contaminated water.

This study focuses on the secondary impacts of the earthquakes to the established settlements in developing countries. The secondary impacts of an earthquake like road blockages, fires or combination of those are expected to cause as much casualties as the earthquake itself in such examples. Because of the accessibility difficulties in densely developed areas, evacuation and access facilities are unfortunately a major problem for the authorities.

1.2 Purpose of the Study

Casualties during and after the earthquakes are directly related with population, vulnerability and physical conditions inside the urban space. Areas with low income population or limited economic activities in developing or poor countries hold very densely populated settlement, weak against any disaster.

Depending on the vulnerability of the physical structure and community, all secondary impacts may reveal instantly. The challenging issue here is “Large numbers of people may be effected not because of the earthquake, rather because of the weaknesses of the urban infrastructure.”

Most of the developing countries have few metropolitan cities getting high values of immigrants. Eventually, informal settlements with high density reveal on the fringes of these cities. In this uncontrolled rapid growth period, authorities cannot provide the planned urban services and infrastructures as they are coming behind these developments.

This results in a planning environment that follows, rather than directs. These settlements are mostly become vulnerable to any disasters because of the insufficient urban services, irregular patterns, low building qualities and narrow connections.

In detail, the study focuses on the road blockages on the densely formed crowded settlements in the time of an earthquake. Basically, highly populated fragments with vulnerable buildings will suffer with road blockages due to building collapses. These road blockages may change the orientation of people and act as obstacles for the emergency tools such as ambulance and fire brigade. In order to avoid the evacuation difficulties and provide access to people, a precautionary simulation is used for Istanbul.

It is intended that in retrofitting/rebuilding process, giving the priority to the buildings seismically vulnerable and with high probability of blocking roads after collapsing, will eventually allow the post earthquake services to be provided more easily, and allow much more people to be evacuated from the danger zone.

In other words, this study is prepared to provide every single residential unit to be reached after an earthquake with the anticipated evacuation and access routes in the crucial patterns of Istanbul.

The purpose of this study is to develop a model that provides an index of intervention to; **save maximum life, within shortest term** with **limited economic resources** in the improvement process of the vulnerable urban structure.

As this index of intervention approach proposes the areas where the vulnerable buildings must be removed and infrastructure (inc. lifelines, roads etc.) must be secured first, the authorities will have guidance and starting point for securing the environment in most efficient way.

Focus areas are Avcılar and Zeytinburnu districts as such settlements in Istanbul needing immediate casualty reduction interventions in the case of an earthquake emergency.

1.2.1 Research questions

Based on the statement of the problem and the main purpose, this study sought to answer the following questions.

- Can the casualties due to the weaknesses of the urban structure be higher than the initial casualties of earthquake itself?

- Can rapid avoidance from the secondary effects of the earthquakes be achievable with poor qualities of the urban space and economic insufficiencies?
- Is there any possible way to organize or sort the actions should be taken regarding the people under risk?

1.3 Structure and the Context of the Study

This dissertation is composed of 4 main chapters surrounded by the introductory and concluding chapters as Figure 1.2 shows.

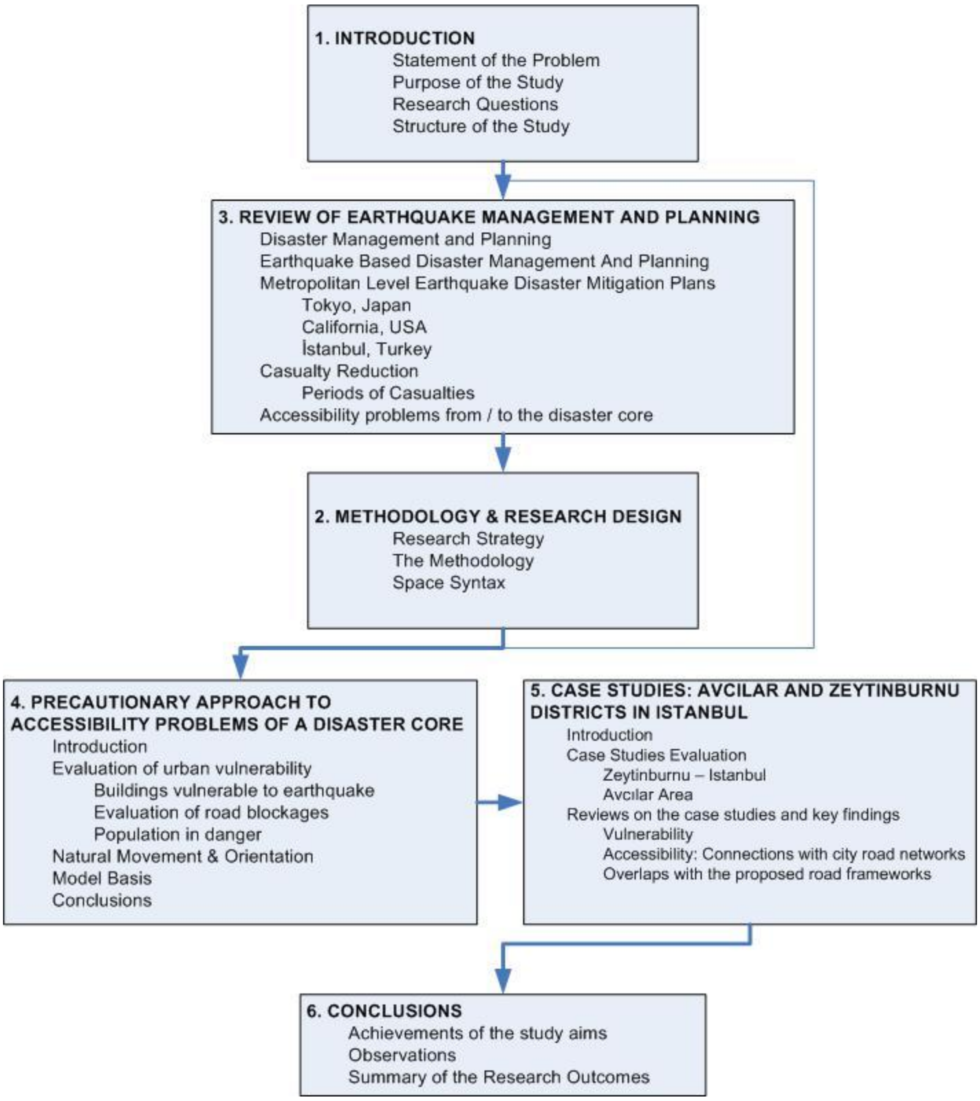


Figure 1.2: Structure of the study

Chapter 1 provides an overview of the background, purpose and structure of this study.

Chapter 2 reviews the disaster management process and current & initial research works regarding the earthquake mitigation planning in the world. Mainly all studies/projects are not only based on securing public safety against to any disaster, but also avoiding the indirect effects of these disasters such as fire, flooding and soil erosion. Earthquake related casualties are evaluated and common approaches against these casualties are reviewed.

This chapter specifically underlines the need for this study, and gives an overview of the physical intervention techniques to any earthquake vulnerable settlement.

Chapter 3 includes research design helping to create useful findings and outcomes of the dissertation.

Chapter 4 captures the approach of the model framework which will be used for improving safety for the settlements vulnerable to any disasters because of the irregular patterns, low building qualities and narrow connections. The aim is saving maximum life within shortest term and limited economic resources.

This chapter proposes an "Index of Intervention" variable as an output of the model. This variable is meant to express the priority of the roads in terms of minimizing the human casualties after the earthquake. For example, a road with a highest value needs to be secured and retrofitted first. By doing this, maximum possible number of people will be saved at the first stage. Given the time and economy are crucial aspects for the disaster mitigation, taking the most efficient steps one by one is proposed with this approach.

The chapter 5 includes practices and discussions of proposal on two settlements; Zeytinburnu and Avcılar districts in Istanbul / Turkey.

Summary of the key findings and general conclusions, expectations achieved are explained on the concluding chapter.

2. REVIEW OF EARTHQUAKE MANAGEMENT AND PLANNING

2.1 Disaster Management and Planning

A disaster is a serious disruption to community life which threatens or causes death or injury in that community, and damage to property which is beyond the day-to-day capacity of the prescribed statutory authorities. It requires special mobilisation and organisation of resources other than those normally available to those authorities (AEMG, 1998). These can be causing naturally, man made or mixture of both.

Disaster management is the management of risk so that societies can live with environmental and technical hazards and deal with disasters that they cause (Waugh, 2000). As the discipline of dealing with and avoiding risks, it seeks to promote safer, less vulnerable communities with the capacity to cope with hazards and disasters. It is a discipline that involves preparing for disaster before it occurs, disaster response (e.g., emergency evacuation, quarantine, mass decontamination, etc.), and supporting, and rebuilding society after natural or human-made disasters have occurred (Wisner et al, 2004).

Effective emergency management relies on thorough integration of emergency plans at all levels of government and non-government involvement. Activities at each level (individual, group, community) affect the other levels. It is common to place the responsibility for governmental emergency management with the institutions for civil defence or within the conventional structure of the emergency services.

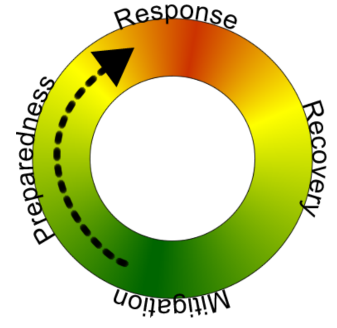


Figure 2.1: A graphic representation of the four phases in emergency management.

However, emergency management actually should start at the lowest level and only increase to the next higher organizational level after the current level's resources have been exhausted.

There are four types of activities depending on the stage of a disaster: mitigation and preparedness before disaster occur, response on the disaster, and recovery from the disaster. These activities of disaster management incorporate a wide array of constituents, including central and local government bodies, nongovernmental organizations (NGOs), chambers of professions, private and public organizations, community-based organizations (CBOs), and the citizens.

Mitigation

Mitigation means a sustained action taken or reduce ır eliminate the long term risk to human life and property from natural, human-caused, and technological hazards and their effects (SPHM, 2007).

Mitigation efforts attempt to prevent hazards from developing into disasters altogether, or to reduce the effects of disasters when they occur. The mitigation phase differs from the other phases because it focuses on long-term measures for reducing or eliminating risk.(Haddow, 2003) The implementation of mitigation strategies can be considered a part of the recovery process if applied after a disaster occurs. Mitigative measures can be structural or non-structural. Structural measures use technological solutions, like flood levees.

Non-structural measures include legislation, land-use planning (e.g. the designation of nonessential land like parks to be used as flood zones), and insurance (Wilson, 2009). Mitigation is the most cost-efficient method for reducing the impact of hazards, however it is not always suitable. Mitigation does include providing regulations regarding evacuation, sanctions against those who refuse to obey the regulations (such as mandatory evacuations), and communication of potential risks to the public (Lindell, 2006). Some structural mitigation measures may have adverse effects on the ecosystem.

A precursor activity to the mitigation is the identification of risks. Physical risk assessment refers to the process of identifying and evaluating hazards (Haddow, 2010). The higher the risk gets, the more urgent that the hazard specific vulnerabilities are targeted by mitigation and preparedness efforts.

Preparedness

Preparedness is a continuous cycle of planning, organizing, training, equipping, exercising, evaluation and improvem7ent activities to ensure effective coordination and the enhancement of capabilities to prevent, protect against, respond to, recover from, and mitigate the effects of natural disasters, acts of terrorism, and other man-made disasters (FEMA, 2007).

In the preparedness phase, emergency managers develop plans of action to manage and counter their risks and take action to build the necessary capabilities needed to implement such plans. Common preparedness measures include:

-Communication plans with easily understandable terminology and methods.

-Proper maintenance and training of emergency services, including mass human resources such as community emergency response teams.

-Development and exercise of emergency population warning methods combined with emergency shelters and evacuation plans.

-Stockpiling, inventory, and maintain disaster supplies and equipment (Maliszewski, 2008).

-Develop organizations of trained volunteers among civilian populations. Professional emergency workers are rapidly overwhelmed in mass emergencies so trained, organized, responsible volunteers are extremely valuable.

Another aspect of preparedness is casualty prediction, the study of how many deaths or injuries to expect for a given kind of event. This gives planners an idea of what resources need to be in place to respond to a particular kind of event.

Emergency Managers in the planning phase should be flexible, and all encompassing - carefully recognizing the risks and exposures of their respective regions and employing unconventional and atypical means of support. Depending on the region - municipal or private sector emergency services can rapidly be depleted and heavily taxed. Non-governmental organizations that offer desired resources, i.e., transportation of displaced homeowners to be conducted by local school district buses, evacuation of flood victims to be performed by mutual aide agreements between fire departments and rescue squads, should be identified early in planning stages, and practiced with regularity.

Response

The response phase includes the mobilization of the necessary emergency services and first responders in the disaster area. This is likely to include a first wave of core emergency services, such as fire fighters, police and ambulance crews. When conducted as a military operation, it is termed Disaster Relief Operation (DRO) and can be a follow-up to a Non-combatant evacuation operation (NEO). They may be supported by a number of secondary emergency services, such as specialist rescue teams.

A well rehearsed emergency plan developed as part of the preparedness phase enables efficient coordination of rescue. Where required, search and rescue efforts commence at an early stage. Depending on injuries sustained by the victim, outside temperature, and victim access to air and water, the vast majority of those affected by a disaster will die within 72 hours after impact (Walker, 1991).

There is a need for both discipline (structure, doctrine, process) and agility (creativity, improvisation, adaptability) in responding to a disaster (Harrald, 2006).

Recovery

The aim of the recovery phase is to restore the affected area to its previous state. It differs from the response phase in its focus; recovery efforts are concerned with issues and decisions that must be made after immediate needs are addressed. Recovery efforts are primarily concerned with actions that involve rebuilding destroyed property, re-employment, and the repair of other essential infrastructure. Efforts should be made to "build back better", aiming to reduce the pre-disaster risks inherent in the community and infrastructure (Haddow, 2003). An important aspect of effective recovery efforts is taking advantage of a ‘window of opportunity’ (Alexander, 2002) for the implementation of mitigative measures that might otherwise be unpopular. Citizens of the affected area are more likely to accept more mitigative changes when a recent disaster is in fresh memory.

For FEMA(Federal Emergency Management Agency); Disaster management principles are as follows;

1. Comprehensive – emergency managers consider and take into account all hazards, all phases, all stakeholders and all impacts relevant to disasters.

2. Progressive – emergency managers anticipate future disasters and take preventive and preparatory measures to build disaster-resistant and disaster-resilient communities.

3. Risk-driven – emergency managers use sound risk management principles (hazard identification, risk analysis, and impact analysis) in assigning priorities and resources.

4. Integrated – emergency managers ensure unity of effort among all levels of government and all elements of a community.

5. Collaborative – emergency managers create and sustain broad and sincere relationships among individuals and organizations to encourage trust, advocate a team atmosphere, build consensus, and facilitate communication.

6. Coordinated – emergency managers synchronize the activities of all relevant stakeholders to achieve a common purpose.

7. Flexible – emergency managers use creative and innovative approaches in solving disaster challenges.

8. Professional – emergency managers value a science and knowledge-based approach based on education, training, experience, ethical practice, public stewardship and continuous improvement.

2.2 Earthquakes

The Webster’s English dictionary defines Earthquake as, “Shaking and vibration at the surface of the earth resulting from underground movement along a fault plane of from volcanic activity”. Basically, an earthquake is the result of a sudden release of energy in the Earth's crust that creates seismic waves. The seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time.

Earthquakes occur in three ways; *Continental crush* - Two landmasses collide and climb one onto the other creating ranges like the Himalayas (which are still growing) and the Alps. *Continental slide* - Occurs when a landmass meet on the ocean floor, the heavier ocean floor slides beneath the landmass and a feature known as a trench is formed.

The deepest known trench is the Marianas Trench in the Western Pacific Ocean. *Continental transformation* - Finally, if two continents bypass each other and thus, the general location of a place changes as we know it to exist on the globe. Interestingly, in 16 million years, the North American continent will have moved so far south in relation to the Pacific Ocean, that Los Angeles will be north of San Francisco (UN-HABITAT).

An earthquake and its after-effects is the one of the most frightening and destructive phenomena of the nature. Thus, it is one of the most common and inevitable disasters in the world. Preliminary determination of the earthquake epicentres since 1963 is seen in the figure 3.2. This domain, created by the epicentres compasses most crowded country and regions like Europe, Middle East, Far East, Japan, Western America and China.

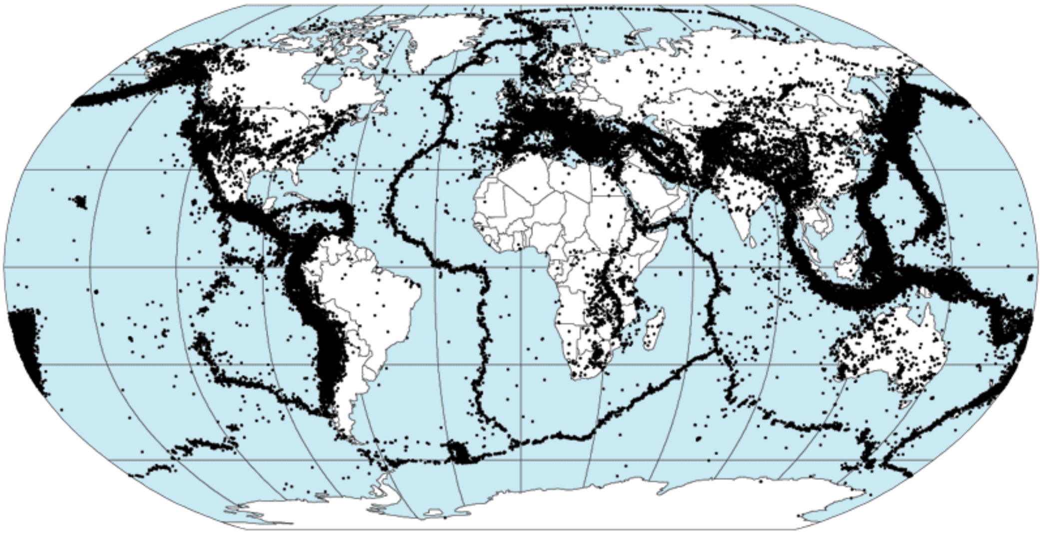


Figure 2.2: Preliminary determination of earthquake epicentres (NASA, 1998).

There have been a number of large mega geo events such as Sumatran earthquake of magnitude 9.3 in December 2004, and destructive earthquakes in India (Bhuj earthquake of magnitude 7.8 on 26 January 2001), Pakistan (Kashmir earthquake of magnitude 7.9 on 8 October 2005) and China (Sichuan earthquake of magnitude 8.0 on 12 May 2008). About half a million lives have been lost in these seismic disasters (Bapat, 2010).

Turkey, for example, has suffered from the 1999 İzmit earthquake (also known as the Kocaeli earthquake) with a 7.6 magnitude earthquake that struck north western part of the country on August 17, 1999.

According to official government estimates (as of October 19, 1999), it killed 17,127, and injured more than 43,953 people. Estimates of property losses (as of September 14, 1999) according to the World Bank range from $3 to $6.5 billion, which is equivalent to 1.5 to 3.3 percent of the Gross National Product of Turkey. It was the most devastating earthquake to strike Turkey since the 1939 Erzincan earthquake killed 30,000 people (USGS, 1999).

The country is located in the intersection of a complex tectonic and very active environment due to the interaction of several tectonic plates (Eurasian, African and Arabic plates).

Ninety-two percent of the country faces the threat of an earthquake. Primary and secondary risk zones cover 66% of the country, and are inhabited by 71% of the national population. The largest and most industrialised cities, including Bursa, Istanbul and Izmir, are located in these zones, mostly on the alluvial plain. The GDP of the primary and secondary risk zones accounts for 75% of national GDP. This geographical pattern intensifies the economic effects of earthquakes, as shown by the data on the 1992 and 1999 earthquakes (Şengezer, 2005).

North Anatolian Fault line compasses on the major industrial cities like İzmit, Istanbul which are the main economic centres of the country. It is responsible for a series of earthquakes in the last decade, particularly the 1999 one. In addition, the closeness of Istanbul to the fault line which continues across the Marmara Sea and which main alignment is capable to produce an earthquake of magnitude Mw=7.5, pose considerable threat to the city and the country in general (PDC, 2004).

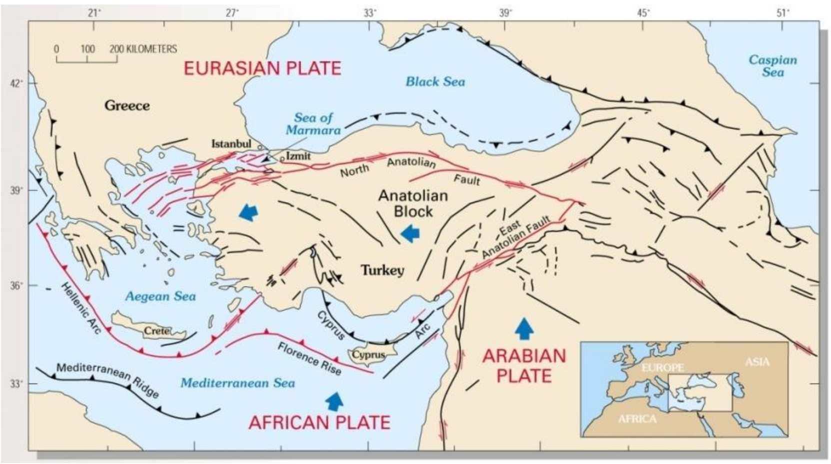


Figure 2.3: The tectonic map of Turkey includes the Northern Anatolian fault, East Anatolian fault, and Hellenic and Florence trenches (USGS, 1999).

Having the largest population in the country with (12,915,158 – DIE 2010), the economy of Istanbul remains solid since it dominates the trade at the national level and also has an important international significance; it counts on both, the most important airports and harbours in the country. Istanbul is identified as Turkey's economic capital. Main sector of the economy relates to provision of services and utilities (60%), manufacturing accounts for the 35% and the primary sector only for the 5% (PDC**,** 2004).

After the Kocaeli Earthquake in 1999, it is stated that this tremendous life loss is caused mainly by poor building quality, liquefaction, lifeline insufficiencies etc., but also after the initial casualty, insufficient evacuation and access services due to broken lifelines and road obstructions by building collapses caused deaths and gave significant damage to the area.

The public has realized that a probable major earthquake can have catastrophic damage on Istanbul. Authorities have been alarmed and risk-based strategy plans have been started to be prepared immediately. These recent studies regarding Istanbul include: The Study on A Disaster Prevention/Mitigation Basic Plan (JICA), Earthquake Master Plan for Istanbul (EMPI), Zeytinburnu Pilot Project (Sub Study of EMPI) and Urban Transformation Model for Vulnerable Zeytinburnu Area (A Model for Zeytinburnu Pilot Project). These plans, covering various scales and created by various public, academic and private institutions, focus on two major problems, namely prevention of the loss of life and reduction of the vulnerability of urban structure (Kubat et al, 2008).

2.2.1 Measurement scales of earthquakes

Earthquakes can be described by use of two distinctly different scales of measurement demonstrating magnitude and intensity. Earthquake magnitude or amount of energy released is determined by use of a seismograph, and instrument that continuously records ground vibrations.

A scale developed by a seismologist named Charles Richter mathematically adjusts the readings for the distance of the instrument from the epicentre. The Richter scale is logarithmic. An increase of one magnitude signifies a 10-fold increase in ground motion or roughly an increase of 30 times the energy.

Thus, an earthquake with a magnitude of 7.5 releases 30 times more energy than one with a 6.5 magnitude, and approximately 900 times that of a 5.5 magnitude earthquake. A quake of magnitude 3 is the smallest normally felt by humans. The largest earthquakes that have been recorded under this system are 9.25 (Alaska, 1969) and 9.5 (Chile, 1960) (UNDP, 1992).

A second type of scale, the earthquake intensity scale, measures the effects of an earthquake where it occurs. The most widely used scale of this type was developed in 1902 by Mercalli, an Italian seismologist. The scale was extended and modified to suit modern times. It quantifies the effects of an earthquake on the Earth's surface, humans, objects of nature, and man-made structures on a scale of 1 through 12, with 1 denoting not felt, and 12 total destruction. The values will differ based on the distance to the earthquake, with the highest intensities being around the epicentral area. Data is gathered from individuals who have experienced the quake, and an intensity value will be given to their location.

Table 2.1: Frequency of Occurrence of Earthquakes (USGS, 2004).

Descriptor	Magnitude	Average Annually
Great	8 and higher	1 [1]
Major	7 - 7.9	15 [1]
Strong	6 - 6.9	134 [2]
Moderate	5 - 5.9	1,319 [2]
Light	4 - 4.9	13
Minor	3 - 3.9	130
Very Minor	2 - 2.9	1,300,000

[1] Based on observations since 1900

[2] Based on observations since 1990.

2.2.2 Primary & secondary impacts of earthquakes

As this study focuses on reducing the casualties grow out afterwards the initial impacts, definition of primary and secondary impacts of this disaster type is necessary.

Earthquakes and their effects depend on a number of factors that change by time, location, urban configuration, buildings and the ground state.

Since the earthquake directly affects the land and all the rigid structure on it as well as the nature, the effects of an earthquake can be listed as; damage on the urban land, shaking and ground rupture, landslides and avalanches, fires, soil liquefaction, tsunamis, floods, and tidal forces.

The primary effects of the earthquakes mainly cause destruction of nature and property. Due to the shaking and rupturing of the ground from an earthquake, primary effects include buildings and surrounding nature being destroyed. Depending on the development of the affected area and the magnitude of the earthquake, the damage can be catastrophic. Buildings can fall, bridges can collapse, and fires can start along with avalanches and mudslides.

Physical effects occur to buildings; structures and infrastructure (i.e. transport network, bridges, highways, railways, water supply, water treatment facilities, pipelines, electrical infrastructure).

Also, initial casualties are a primary effect of earthquakes. People who are near to collapsing buildings, fires or mudslides can be killed instantly or become trapped under falling debris. Injured people may have a difficult time finding medical care because of the primary destruction (Url-1).

Casualty rates may be high when quakes occur at night because the preliminary tremors are not felt in sleep and people are not tuned in to media to receive warnings. In daytime, people are particularly vulnerable if in unsafe structures such as schools and offices and casualties may be very high too. Casualties generally decrease with distance from the epicentre. The proportion of dead may, however, be higher if there major landslides and other hazards, such as tsunamis. In areas where houses are of light-weight construction, especially with wood frames, casualties generally very much lower although fires may spread rapidly causing injuries and deaths.

Casualties can be very high especially when earthquakes occur in areas of high population density, particularly when streets between buildings are narrow and buildings themselves are not earthquake resistant, and/ the ground is sloping and unstable.

In addition, an earthquake can cause secondary impacts on the physical/social structure. For example, after the Kashmir earthquake in 2005, 4,000 households were inaccessible by road due to landslides.

In Kashmir earthquake, 2.3 million people were without food for the winter and disease spread, sourced from people drinking the dirty, contaminated water.

Secondary effects of the earthquakes are directly related with durability and strength of the urban infrastructure. These abilities should be considered as countermeasures against an earthquake in vulnerable cities.

These secondary effects cause lack of resources. Following the earthquake, water lines might be broken, people may be inaccessible in the disaster core, and fresh food might not be available nearby. Hospitals and homes may have been destroyed.

The after effects of an earthquake may be many homeless people in need of medical attention. Access roads could be blocked because of the damage, making it difficult for help and resources to arrive. These types of effects last far into the future.

Disease is a secondary effect of earthquakes. Because water lines may have been broken, fresh water might not be available and endemic diseases may become virulent if control measures break down and unsanitary conditions develop. Breakdown in sanitary conditions pose a threat and fear of epidemic due to large deaths. Other health threats may occur if there is secondary flooding or water supplies are disrupted and contaminated water is used or people are concentrated into high-density relief camps (Url – 1).

Also, multiple fracture injuries and number of severely and moderately injured is the most widespread problem. Injured people who cannot get immediate medical attention could find that their injuries have become infected. Corpses can infect the available water. Hospitals may not operate at full capacity, and the spread of disease from within the hospital can be a concern.

2.2.3 Earthquake based disaster management and planning

Unlike most natural disasters, there is usually no warning when an earthquake strikes. Earthquakes come out of nowhere and can cause untold damage. So, while most earthquakes are barely noticeable, some are deadly.

As each earthquake has a different signature, each earthquake teaches something new.

It is the duty of earthquake researchers and disaster managers that the lessons learnt from these seismic contingencies should be scientifically studied; analysed and significant inferences and conclusions should be taken to the common man with a view of increasing the seismic safety of the society in general and human lives in particular.

On one hand scientists have been coming forward with sufficient degree of confidence about reliable seismic precursors and on the other hand, the disaster management experts vehemently say that earthquakes still cannot be predicted (Bapat, 2010).

Everybody should learn and educate himself from the earthquake observations and it would be possible to mitigate the earthquake disaster. The ultimate aim of disaster management should be saving human lives. It is hoped that the lessons from various earthquakes would be useful in dealing with the pre-seismic and post-seismic situations suitable modifications in the disaster management plans may be incorporated and used.

If suitable actions are undertaken during the pre-seismic period and a watch is kept on several reliable seismic precursors, it would be possible to mitigate the earthquake disaster (Bapat, 2010).

As another approach; Coburn (1992) claims that: “Earthquake protection should be seen as an additional element of normal urban planning. It should not be a separate activity from other planning operations, but rather an integral part of the planning process.

Integrating natural hazard mitigation into land use planning can help a community become more resilient.

Land use planning involves gathering and analysing information on sustainability for developments in locations exposed to natural hazards, so that citizens, potential investors and government officials understand the limitations. Land use plans specify community goals, principles and actions. In preparing plans, local governments must engage in a consensus-building process so that crucial issues regarding the use of hazardous areas can be resolved (Burby et al., 2000).

For Mekvichai (2008), mitigation measures include city planning, legal infrastructure and building codes, insurance, and coordination of these, detailed as follows.

City planning help providing safe and secure urban space in long term, to assure any development will be done to reduce risk of disaster, and to make sure that rescue operations can easily reach all parts of the city.

Building codes can reduce the risks of disasters, physically. To reduce collapsing, fires and avoiding obstruction water or flood damage. Such as designs for buildings to tolerate certain magnitudes of earthquakes.

Insurance – both public and private – for provision of the financial resources for rebuilding after a disaster.

Laws and regulations to help prevent man-made disasters, to reduce the risk of natural disasters, and to protect citizens from the effects of these disasters.

-The creation and maintenance of disaster rescue units.

-The development of coordinated disaster management.

Preparedness:

-Installing warning systems so people can avoid or take shelter from the impending disaster.

-Structural adjustments to buildings and to public works that are found to be vulnerable.

-Stockpiling supplies, such as food and other materials that would be needed if disaster strikes.

-Resource inventory, to make sure sufficient supplies and materials are available for an adequate response

-Enforcing laws and regulations, in particular by means of; building and land use permits – building and land use inspections.

-Monitoring conditions: whether it is monitoring the potential disasters (such as pending floods in Bangkok) or monitoring the levels of preparedness.

-Emergency drills, so the rescue units are well prepared and city residents are aware of what they need to do.

-Public education to help the city residents understand what might occur when various types of disasters strike and what they should do to reduce the risks to their person and property.

Disaster response:

-Immediate and effective rescue operations

-Provision of resources to residents affected by the disaster.

Recovery efforts:

Restoration of facilities and services,

-Reconstruction of the community if it was damaged or destroyed by the disaster.

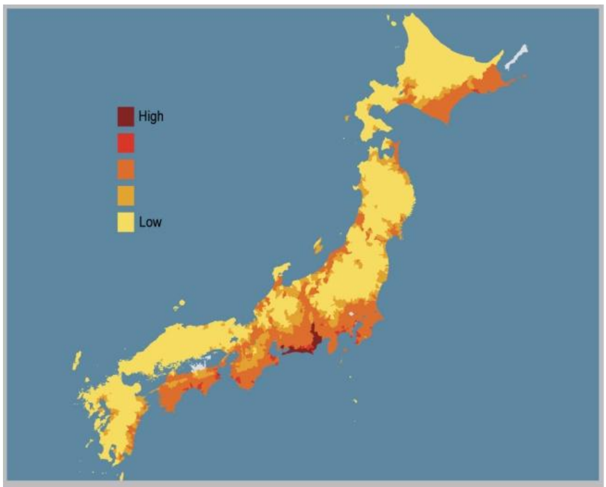
All these phases of earthquake based emergency management progress reveal with distinct articulated and detailed outlines in the various examples throughout the world. Risk definitions, priorities and actions may be very distinctive one example to another. In some examples, all measurements and phases are contained in regional/national level emergency plans. But as stated before, the experiences showed that these efforts must take place in the bottom-line of the community in a participatory way in order to achieve successful risk management through the urban areas.

2.3 Metropolitan Level Earthquake Disaster Mitigation Plans

2.3.1 Tokyo, Japan (35°40'60N, 139°46'0E)

Japan has a high earthquake hazard. Building collapse is the primary cause of casualties from Japanese earthquakes. In most of the earthquakes occurring in Japan during the 20th century, there was an average of 1 person killed for every 10 buildings that collapsed, or a 'lethality ratio' of 0.1. This average figure varies considerably – one in 10 earthquakes has a lethality ratio of 0.25 (i.e., kills 1 person for every 4 buildings that collapse) (RMS, 2007).

In the national level, the Central Disaster Management Council chaired by the Prime Minister formulates and executes disaster management plan. Prefectural Governments and Municipalities also have their own Disaster Management Councils and formulate and promote disaster management local plans. However, at the 1995 Great Hanshin Awaji Earthquake Disaster, the central government failed to capture the damage situation correctly and delayed making right actions. The disaster caused more than 6,000 casualties.



Casualty patterns expected from earthquakes are highly regional

Figure 2.4: Earthquake Casualty Pattern of Japan according to RMS(2007).

Most of them were killed by the collapse of old wooden houses. Since this disaster, many voluntary disaster management organizations have been established in the community level and voluntary activities for disaster mitigation have been conducted widely. Also, the central government issued regulations for promoting seismic retrofit of old buildings and many local governments provide free seismic evaluation to the citizens and prepare subsidy for retrofit of old wooden houses (Saito, 2007).

So, safety, risk management and disaster preparedness become very important aspects of city management in Japan. In the wake of accelerated urban growth and emergence of strong market forces, local area needs and priorities in Japan changed and so was the perception of day to day risks and security from disasters (Misra, 2004).

The 1995 Kobe Earthquake destroyed many houses and buildings. In addition, over 6,000 human lives were lost by the earthquake. Fires broke out in numerous areas at the same time. However, fire-fighting performance was insufficient to prevent the areas from fire extending.

On the other hand, thanks to wide roads, parks, and a series of incombustible buildings called “fire prevention zones”, the spread of fire was limited.

However, many houses and buildings in areas that surrounded by the fire prevention zones were completely burned out, indicating the importance of implementing measures not only at an urban level but also at an district level.

There are three significant characteristics of this earthquake:

The first characteristic is that it was the first urban disaster in which damage from collapsed houses dominated. It had been assumed until thet that the typical pattern of urban earthquake disaster in a mega-city would be like the 1923 Kanto Earthquake, in which the dominant damage in was not collapsed houses but rather damage bu urban fire-spread. The second is that building collapse was even more than estimates before the earthquake. The buildings which met the present building code had no damage, or little damage. It was mail reason that many inadequate buildings existed. Furthermore, a more fundamental problem was that non renewable built-up areas existed. In fact, most damage was concentrated in densely built-up areas. The third is that urban fire-spread damage made a large social impact and the reaction of the public was very serious, although fire damage in Hanshin-Awaji Earthquake was not extensive, and in fact was rather small, because it was not windy (Kato, 2008).

Japan continues to improve the design and construction quality of its building stock to make it more earthquake resistant and safer for occupants. The 1995 Kobe Earthquake illustrated several shortcomings of the building code, and several new laws and key code amendments were quickly introduced, including design requirements to prevent ‘soft story’ failures that cause collapse. In recent years, Japan’s engineering community has moved away from safety-based design guidelines in favor of performance based design guidelines, which assess the design standard in relation of the performance expected of the structure.

International engineers estimate that design code requirements make modern buildings in Japan some of the worlds most earthquake-resistant. The Japanese population is generally becoming safer as older, timber buildings are being replaced by multi-story, high-occupancy engineered structures.

As a result, there is now the threat of massive casualties from collapses of high-occupancy engineered buildings (RMS, 2007).

As the largest city and the capital of Japan, Tokyo, should be taken into consideration here. The city has been the largest urban agglomeration in the world, started to expand its urbanized areas in the 1920s, led by suburban rapid railway developments. The population of the city region grew from 7.5 million in 1920 to 32 million in 2005.

The city has two kinds of countermeasure aspect from urban planning. One is the evacuation plan to guard citizens' lives from heat radiation of urban spread fire. Another is the promotion plan to construct a disaster resistant city.

Evacuation plan in Tokyo prepares some safe refuge sites from urban fire-spread for all citizens. TMG assigns 170 sites as safe refuge at the present. The area of these sites is said to be approximately more than 10 ha. Safety of all the sites from heat radiation was assured with calculations based on an engineering model. Firstly, flammable zones around a candidate refuge site are calculated. Moreover, maximum capacity for evacuees is calculated from area which will be less than heat radiation intensity for human to endure. The sphere of evacuees is decided corresponding to the capacity. If all citizens were to evacuate to the specified evacuation site, in theory their lives would be guarded from urban fire spread (Kato, 2008).

Another plan at the city level is the promotion plan to construct a disaster-resistant city. This plan has two major points. One is to partition the entire urbanized area to urban fire compartments, which is an area of approximately 80 ha. Another is to mitigate vulnerability inside urban fire compartments (Kato, 2008).

All boundaries of each urban fire compartment are formed by a belt consisting of a wide road and fire-proof buildings by the roadside which will stop urban fire spread. Inside each compartment, community based improvements are implemented, such as small open spaces known as pocket parks, collaborative housing renewal, and road improvement to widen roads with less than 4 m with to 6 m. according to the Tokyo fire department, approximately 80% of urban belts to stop fire-spread have been built up at the present; however, they are unevenly distributed. Development has made little progress in the west area in Tokyo. As a main reason, it is pointed out that some roads authorized in city planning have not been constructed yet (Kato, 2008).

Inside compartments there are also many districts with high vulnerability.

2.3.2 California, (34° 3'8.04"N, 118°14'37.27"W) – Earthquake Loss Reduction Plan

Including the highly populated urban agglomerations like San Francisco and Los Angeles, California State in United States of America, is one of the regions which have the highest hazard potentials in Northern America. The region is located to the western edge of the continent parallel to the Pacific coast of USA.

California has three primary impact disaster sources: earthquakes, floods, and wildfires. However, the state is relatively more resistant to earthquakes in terms of casualty and property damage compared to other settlements facing with earthquakes.

As seen in Table 2.2, even devastating earthquake scenarios estimate lower than 200 minimum life losses in the state currently. Compared to any other vulnerable settlements throughout the world, this is a relatively successful picture in terms of mitigation and loss reduction.

Table 2.2: Earthquake Scenario Losses, California, USA (SHMP, 2007).

Potential Earthquake Scenarios Northern California	Mw	Projected Building Damage in Millions	Projected Range of Deaths	Projected Range of Injuries
San Andreas Fault: Repeat of the 1906 San Francisco1 Earthquake	8	$94,000	800-1,600	22,000-32,000
San Andreas Fault: Santa Cruz + Peninsula + North1 Coast segments	8	$122,000	1,800-3,400	39,000-59,000
San Andreas Fault: Santa Cruz + Peninsula segments2	7	$30,000	2,1	105
San Andreas Fault: Santa Cruz segment2	7	$5,900	N/A	N/A
San Andreas Fault: Peninsula segment2	7	$24,000	1,3	66
Southern Hayward: Repeat of the 1868 Earthquake2	6,7	$15,000	800	42
Northern Hayward2	6,5	$9,000	200	12
Southern Hayward + Northern Hayward2	7	$23,000	400	20
Rodgers Creek2	7	$8,000	150	10
Southern Calaveras + Central Calaveras2	6	$3,200	N/A	N/A
Northern Calaveras2	7	$10,000	200	15
Southern + Central + Northern Calaveras2	7	$13,000	N/A	N/A
Concord2	6	$2,800	200	9
Green Valley2	7	$3,200	N/A	N/A
Concord + Green Valley2	6,7	$6,800	N/A	N/A
San Gregorio2	7	$15,000	350	19
Mount Diablo2	6,7	$7,000	40	3

Given the earthquake risk has been one of the major concerns for authorities, the planning process has been continuing for a noteworthy time:

1969: Santa Rosa Earthquake Strikes (5.7Mw)

1970: Joint Legislative Committee on Seismic Safety has established.

1974 “The Final Report”, prepared by this committee is published.

1975: The Seismic Safety Commission was established.

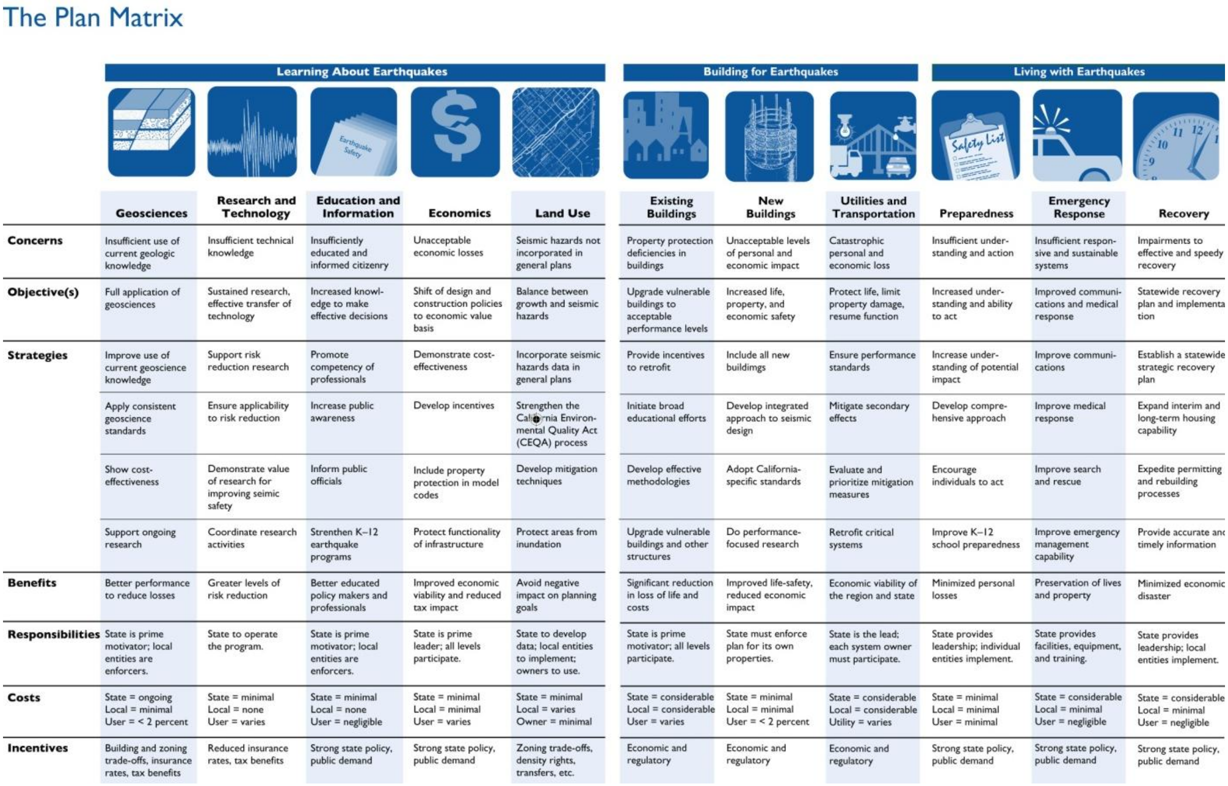
1979: “Goals and Policies for Earthquake Safety in California” report was published.
1982: Earthquake Hazards Management: An Action Plan for California is published.
1986: California Earthquake Hazard Reduction Act – Legislation established.
1987 – 1992: The Commission published California at Risk (State’s official earthquake hazard reduction plan)
1992 – 1997: Second Edition was published.
2002 – 2007: Third Edition was published
2007 - 2011: Last edition of the plan, in progress. This has three basic goals, learning about the earthquakes, building to resist earthquakes, living with earthquakes.

Although formats, styles, priorities and other elements have changed over time, the strategic planning approach has produced several long term accomplishments like legislative background, articulated and practicable strategic planning.

Mitigation of seismic shaking hazards has always been the main concern for the authorities in California. Because, significant proportion of losses has been caused by this effect (e.g. 98% of losses in the Loma Prieta Earthquake). Current California building codes include provisions for considering the potential shaking from earthquakes, including stronger shaking near faults and amplification by soft soils. The building ode has been the main mitigation tool for seismic shaking in most buildings (SHMP, 2007).

The California Earthquake Loss Reduction Plan sets forth basic government policy and direction in pursuit of the vision for a safer California. It contains 11 elements, each addressing a distinct but interrelated area of concern. Plan is prepared as a matrix, with each element supporting and being supported by others.

The purpose of the SHMP is to significantly reduce deaths, injuries, and other disaster losses caused by natural and human-caused hazards in California. It describes past and current hazard mitigation activities and outlines future disaster loss reduction goals, strategies, and actions. The plan provides guidance for hazard mitigation activities while cementing partnerships among local, state, and federal agencies as well as the private sector in a formal written document. It is intended to be a “living document” that will be modified periodically (every 5 years) to reflect future changes in hazards and societal conditions.



The Plan Matrix

	Learning About Earthquakes				
	Geosciences	**Research and Technology**	**Education and Information**	**Economics**	**Land Use**
Concerns	Insufficient use of current geologic knowledge	Insufficient technical knowledge	Insufficiently educated and informed citizenry	Unacceptable economic losses	Seismic hazards not incorporated in general plans
Objective(s)	Full application of geosciences	Sustained research, effective transfer of technology	Increased knowl-edge to make effective decisions	Shift of design and construction policies to economic value basis	Balance between growth and seismic hazards
Strategies	Improve use of current geoscience knowledge	Support risk reduction research	Promote competency of professionals	Demonstrate cost-effectiveness	Incorporate seismic hazards data in general plans
	Apply consistent geoscience standards	Ensure applicability to risk reduction	Increase public awareness	Develop incentives	Strengthen the California Environ-mental Quality Act (CEQA) process
	Show cost-effectiveness	Demonstrate value of research for improving seimic safety	Inform public officials	Include property protection in model codes	Develop mitigation techniques
	Support ongoing research	Coordinate research activities	Strenthen K–12 earthquake programs	Protect functionality of infrastructure	Protect areas from inundation
Benefits	Better performance to reduce losses	Greater levels of risk reduction	Better educated policy makers and professionals	Improved economic viability and reduced tax impact	Avoid negative impact on planning goals
Responsibilities	State is prime motivator; local entities are enforcers.	State to operate the program.	State is prime motivator; local entities are enforcers.	State is prime leader; all levels participate.	State to develop data; local entities to implement; owners to use.
Costs	State = ongoing Local = minimal User = < 2 percent	State = minimal Local = none User = varies	State = minimal Local = none User = negligible	State = minimal Local = minimal User = varies	State = minimal Local = varies Owner = minimal
Incentives	Building and zoning trade-offs, insurance rates, tax benefits	Reduced insurance rates, tax benefits	Strong state policy, public demand	Strong state policy, public demand	Zoning trade-offs, density rights, transfers, etc.

	Building for Earthquakes			Living with Earthquakes		
	Existing Buildings	**New Buildings**	**Utilities and Transportation**	**Preparedness**	**Emergency Response**	**Recovery**
Concerns	Property protection deficiencies in buildings	Unacceptable levels of personal and economic impact	Catastrophic personal and economic loss	Insufficient under-standing and action	Insufficient respon-sive and sustainable systems	Impairments to effective and speedy recovery
Objective(s)	Upgrade vulnerable buildings to acceptable performance levels	Increased life, property, and economic safety	Protect life, limit property damage, resume function	Increased under-standing and ability to act	Improved communi-cations and medical response	Statewide recovery plan and implementa tion
Strategies	Provide incentives to retrofit	Include all new buildimgs	Ensure performance standards	Increase under-standing of potential impact	Improve communi-cations	Establish a statewide strategic recovery plan
	Initiate broad educational efforts	Develop integrated approach to seismic design	Mitigate secondary effects	Develop compre-hensive approach	Improve medical response	Expand interim and long-term housing capability
	Develop effective methodologies	Adopt California-specific standards	Evaluate and prioritize mitigation measures	Encourage individuals to act	Improve search and rescue	Expedite permitting and rebuilding processes
	Upgrade vulnerable buildings and other structures	Do performance-focused research	Retrofit critical systems	Improve K–12 school preparedness	Improve emergency management capability	Provide accurate and timely information
Benefits	Significant reduction in loss of life and costs	Improved life-safety, reduced economic impact	Economic viability of the region and state	Minimized personal losses	Preservation of lives and property	Minimized economic disaster
Responsibilities	State is prime motivator; all levels participate.	State must enforce plan for its own properties.	State is the lead; each system owner must participate.	State provides leadership; individual entities implement.	State provides facilities, equipment, and training.	State provides leadership; local entities implement.
Costs	State = considerable Local = considerable User = varies	State = minimal Local = minimal User = < 2 percent	State = considerable Local = considerable Utility = varies	State = minimal Local = minimal User = minimal	State = considerable Local = minimal User = negligible	State = considerable Local = minimal User = negligible
Incentives	Economic and regulatory	Economic and regulatory	Economic and regulatory	Strong state policy, public demand	Strong state policy, public demand	Strong state policy, public demand

Figure 2.5: The California Earthquake Loss Reduction Plan - Main Elements.

The State of California is required to have a Federal Emergency Management Agency (FEMA)-approved multi-hazard mitigation plan to be eligible for disaster recovery assistance and mitigation funding in USA.

Therefore, The State of California, Multi-Hazard Mitigation Plan(SHMP) is prepared and published in 2007. The plan reflects California's cultural, societal, economic, and environmental values and acknowledges numerous regulatory and compliance issues facing the state. It is intended to set the tone for the implementation of hazard mitigation practices that will build a safe and resilient California and perform the following functions:

1. Document state-wide hazard mitigation systems implemented in California

2. Describe strategies and priorities for future mitigation activities

3. Facilitate integration of local, state, tribal, and private sector hazard mitigation activities into a comprehensive state-wide effort

4. Meet state and federal statutory and regulatory requirements for an Enhanced Plan

Strict legislative decisions and compulsory planning process in each stage seem to help the urban security of California State in terms of earthquake casualties.

2.3.3 Istanbul, Turkey (41°1'7N, 28°57'5E) – Earthquake Master Plan for Istanbul

Following the disastrous earthquakes that struck Turkey in 1999 and realizing the high probability of occurrence of a large earthquake that may impact once again important urban areas of the country (65% during the next 30 years)(PDC, 2005), the authorities decided to put in place a comprehensive disaster risk management system that incorporates preparedness, mitigation and emergency response procedures, as means to reducing future potential losses and overall risk in the city of Istanbul.

EMPI is a collective study prepared with participation of Turkey's leading Universities, ITU, METU, YTU and BU, aimed to make the city become safe for a possible earthquake. It is intended to make every single procedure brief and clear, such as planning, creating programs, defining authorities etc. Most important issues for the success of the plan are introduced as; the **public participation** and **Constitutional (Legal) Framework**. Thus, Master Plan is accepted as a social contract, defining responsibilities, decisions and methods among the Government, municipalities, professions, NGO s and the community.

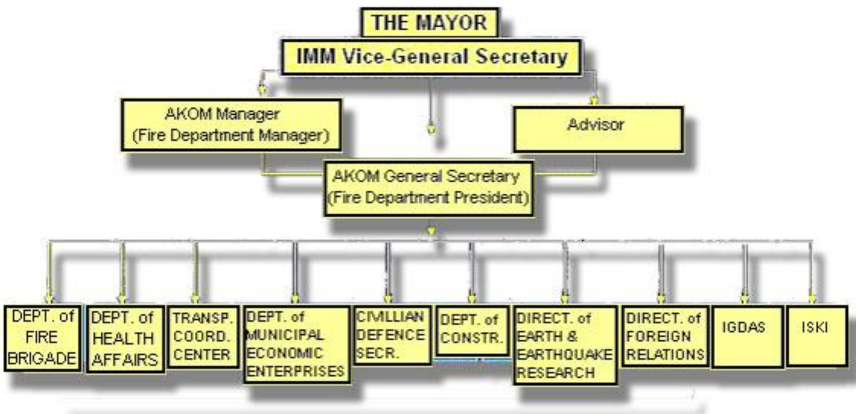


Figure 2.6: AKOM – Disaster Coordination Center (IMM, 2003).

EMPI was based on three fundamental principles:

- Plans and projects must not be imposed, but must be determined in a process to generate a medium for collective effort and a total mobilization throughout the city;

- Risk sectors must be determined as basic city-level clusters of interrelated risks; Specific projects within a sector are to be determined by the related 'stake-holders', based on an analysis of 'risk factors' in each sector;

- ‘High-risk areas’ must be identified for immediate special action planning and investment programs.

An important aspect to be covered by the Master Plan is decided to be the assessment of seismic vulnerability of existing building stock in Istanbul, the development of seismic retrofitting methods and the determination of technical, social, administrative, legal and financial measures to be taken in order to be able to implement such methods. In the Master Plan the works to be done in these fields are examined and the recommendations about the measures to be taken are given.

The scope of Earthquake Master Plan for Istanbul comprised of works to be done in the following areas:

1. Assessment of current situation

2. Seismic assessment and rehabilitation of existing buildings

3. Urban planning issues

4. Legal issues

5. Financial issues

6. Educational issues

7. Social issues

8. Risk and disaster management issues

In other words, the purpose of EMPI is not to retrofit all buildings but to enhance safety and total quality of life in Istanbul. It is pretended as an endless process; yet has its short and medium-term targets. EMPI not only aims to reduce risks in existing environment but to avoid vulnerabilities in the formation of new urban environment.

Besides the mitigation of earthquake risk, this plan’s secondary goal is the improvement of urban life quality. The approach to the earthquake problem is holistic in nature, i.e. comprising economic, political, social and cultural visions, and strategic in application, i.e. flexible and relying on the effective participation of various actors.

EMPI stresses that risk management relates mostly to legal, social and political issues, and its realization requires support and commitment of governmental institutions at all levels as well as active participations of civil society .

Besides Earthquake Safety, EMPI promotes: Improvements in infrastructure, Eradicating unauthorized constructions, protecting historical and cultural values, facilitating public participation and enhancing total quality of life and urban environment (PDC, 2005).

-Through the development of EMPI and the whole participative process that it triggered, common agreement and stakeholder commitment was developed. The city would like to see it as a social contract among all the different organizations and persons that participated, with a clear understanding of their roles in the new scheme, including clear mechanisms for accountability.

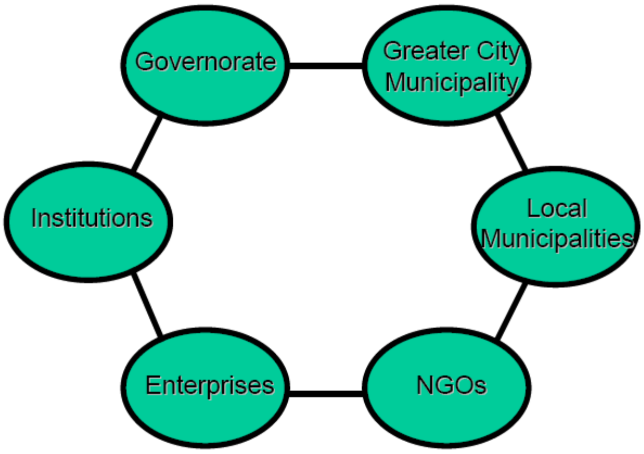


Figure 2.7: Key Players Proposed by EMPI (IMM, 2003).

Implementation of the earthquake master plan, since it addresses the reduction of current physical and social vulnerabilities in the city and it looks for improving the safety and living conditions of the community in general. Istanbul but also set priorities for specific districts depending on their level of vulnerability, availability of resources and cost effectiveness of the intervention. Pilot study of the Earthquake Master Plan for Istanbul, has been started in Zeytinburnu, simultaneously with the master plan and aimed to spread all over the urban totality.

2.3.3.1 Zeytinburnu Pilot Project

According to Earthquake Master Plan for Istanbul (EMPI) and Japan International Corporation Agency (JICA) researches, within the regeneration, rehabilitation and reinforcement programs which should be implemented in the areas under the probable earthquake threat, Zeytinburnu selected as a pilot project area.

The project aims to generate the "Applicable Urban Transformation Project Model" to provide the existing urban structure become continuously safer (Kubat Et al, 2008).

The settlement is located near to the historical peninsula of Istanbul. However, there are some remarkable differences between these two settlements, divided by old city walls. Zeytinburnu, unlike any urbanized area, has developed spontaneously, unplanned and illegally. At first, people migrating to Istanbul were selecting this area to settle because property of land was Government's and with the help of loopholes these people were able to get their house licensed.

Thus, settlement grown rapidly and vulnerability rating increased dramatically in terms of poor building quality, density of population, evacuation threats and open space deficiencies. JICA's (2002) indicators show that %16,6 of the buildings in Zeytinburnu will be Seriously Damaged in case of an earthquake with the magnitude of 7.5. This ratio, turned out to be %20 for the first step of the detailed engineering studies. According to these studies, in Zeytinburnu there are 11.859 dwellings, holding about 45.000 people, are under risk.

In Zeytinburnu, quite a number of people are living and working in limited spaces. In some quarters, average population density increases to 921 people for a hectare. High building density, on the other hand, originates the probable earthquake evacuation problems and accessibility issues in residential areas. There are not enough open spaces except roads and parking lots.

General aim of Zeytinburnu Pilot Project (ZPP) was to concentrate on minimising earthquake risks at first. In order to do this, project developers decided to evaluate risky regions first, to have safe urban residence against all the disasters and to take precautions for urgent interference, rescue operations, evacuations in a short time after disaster. The Alternative Plan Scenarios are produced through evaluating current plans, classic planning approaches and the zoning studies for action plan.

Project Stages and Aims: Action Plan consists of 3 main stages including 20 year-action process. In the first and second stage, in a five-year period, urgent interventions to prevent and minimize the loss estimation caused by probable earthquake are suggested. In the third stage, to increase the quality of urban life and to bring the identity in the vision of Zeytinburnu, a planning model is created.

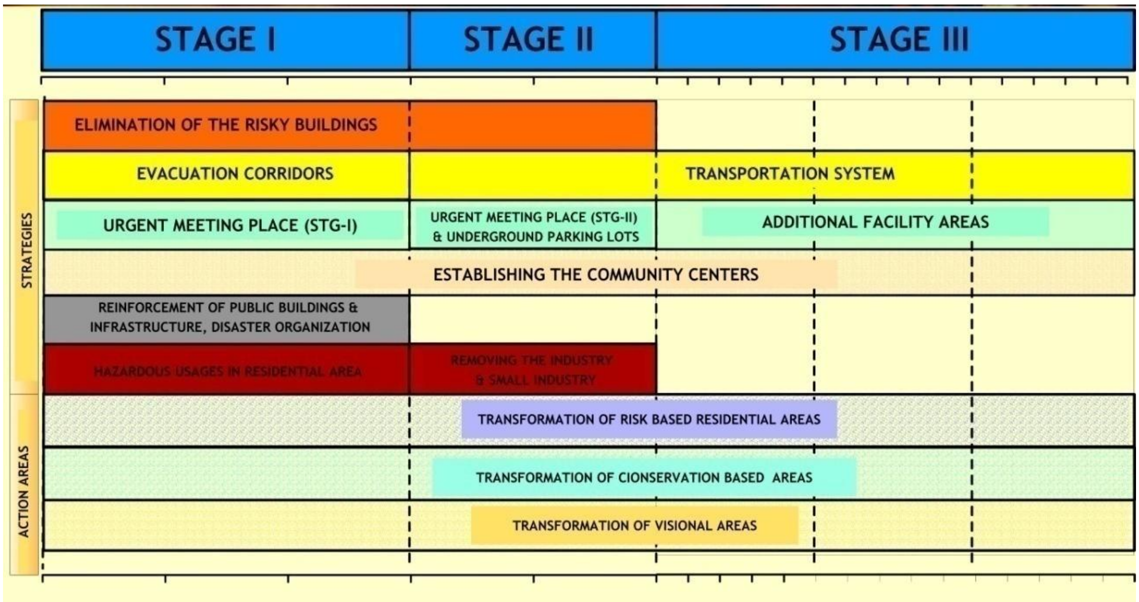


Figure 2.8: Main Stages of ZPP (IMM, 2005).

As shown in figure 2.8; there are three main stages: a) Elimination of risky buildings, b) creating evacuation corridors and, c) proposal of urgent meeting places to be completed as soon as possible in order to mitigate current risks.

About 2000 risky buildings identified by the project engineering team will be demolished and rebuilt if necessary.

Evacuation corridors are planned to respond to the needs of sheltering and rescue after an earthquake, addressing whole Zeytinburnu, supporting the transportation system integrated with peripheral road network.

Open Spaces for urgent gatherings and for people to be evacuated and cared, are selected from the building islands that contain risky buildings. After these buildings are purchased from their owners and demolished, proper open spaces would be created.

Community Centres: The deficiency in the social dimensions of urban transformation projects complicates the operation of projects and credit supply.

Thus, establishing community centres are meant to provide face to face contact among the community and the NGO’s and Government, municipalities.

In the short-term, establishing the community centres and initiating their operation is very important in order to:

-Ensure the co-ordination and communication between community and stakeholders,

-Provide that the action plans (projects) are made by community and stakeholders together,

-Upgrade the skills of all citizens; introduce education programs to strengthen social and economical structure,

-Arrange education programs about evacuation, rescue, sheltering, etc. in case of a probable disaster.

It is also intended to strengthen the public buildings to prevent and minimize the estimated loss due to a probable earthquake. Gathering the directors of these facilities such as active parks, fire brigades, medical, religious, security buildings around the issue of disaster organization is accepted as a vital issue for the maintenance of the project as well as ensuring that the schools and their gardens could be used as rehabilitation, storage and delivery centres. The appropriate facilities, in terms of sufficient capacity, are selected to place the essential equipment of urgent interventions. It is recommended to use the community centres' infrastructure to organize and educate the employee of urgent condition.

During the planning process, not only current and proposal configurations, but also models, strategies, progresses, financial issues, timelines, constitutional background and multi-disciplinary procedures are evaluated in order to make the model for Zeytinburnu become flexible and applicable for other settlements.

Urban design principles for Zeytinburnu are adopted from disaster risks and risk based planning issues. These principles also based on the historical structure of Zeytinburnu. Sector based or spatial changes and development strategies are created and balanced with social and demographic dynamics. Services proposed are major economic sector rather than Industry.

Social infrastructure and urban networks are designed from the point of fair social services distribution (Kubat Et al, 2008).

Finally, all progresses are evaluated with the overall prediction of sustainable and economic structure and Zeytinburnu Pilot Project Planning Process' which include articulated research, evaluation, processing and finalization processes. This makes the project a multi-disciplinary team work. But, typically, success of such a project and sub-models including finance, transformation and strategies, depend on the negotiation and participation of the parties involved.

2.4 Casualty Reduction

Since the earthquakes are either inevitable and timing is unpredictable, also, all of those who live in a seismic area are exposed to earthquake threats, all physical and social elements structures of urban fabric must be well designed, planned, deployed, coordinated against any disaster constantly.

Earthquake related casualty is the loss of human life or the decrease of health status of people throughout the earthquake periods including shaking, emergency, recovery and reconstruction.

In other words, casualties are explained as a result of vulnerability of an urban system provoked by an earthquake, and evaluated by combining vulnerabilities of physical, social, economical systems.

2.5 Periods of Casualties

As all disasters do, earthquakes affect the settlements in different timescales. In addition to the initial impact, casualties continue to emerge due to vulnerability of the system in emergency and even recovery periods. These periods are first impact, during the emergency and throughout the recovery process.

- The shaking and immediately after earthquake periods indicate a duration from the beginning of ground shaking to following few minutes, during which causes of casualty are mainly due to physical and personal reactions.

- During the emergency period, evacuation, search and rescue, transportation of injured people, emergency relief goods and first aid service for injured people are implemented. This period depends on the combination between functional and systemic performance of physical damage and social abilities of controlling, management and organization.

- The recovery and reconstruction periods, can be simply understood in terms of locations of residents’ livings, because it mostly affects their lifestyles.

The location of homeless people generally moves from emergency shelters, to temporary shelters, to newly constructed areas, through a political strategy (Kuwata, 2004).

2.6 Accessibility problems from / to the disaster core

The major implementations in the emergency period like evacuation, rescue, and transportation of injured people require constant connections between the city main road network and the disaster core. In most cases, studies offer considerable solutions as securing evacuation corridors, green belts, gathering spaces for vulnerable urban areas. Even though these are all accepted and useful implementations, costs usually come up as the major issue against these solutions. Given the earthquake vulnerable settlements today are mostly located in developing or poor countries, economic factors reveal as another obstacle against these implementations.

In these poor or developing countries, limited employment opportunities are concentrated on the industrial major cities with high property values. This evokes the densely developed and highly populated urban areas with lack of safety, poor building and infrastructure quality. In other words, for the migrants and urban poor, unplanned areas with foot access to facilities, services and jobs become most affordable locations.

However, in such areas, planning and maintenance of urban infrastructure remain very poor while the population in these settlements over time lead to significant numbers.

For example, Istanbul, with a population of 13 million people, have started to grow dramatically from 1950's the industrial leap of the country. This growth caused by immigration, and eventually many squatter settlements have revealed on the fringes with narrow and irregular shaped roads, lack of infrastructure and poor building quality.

In the case of an earthquake, as well as the initial casualties, these conditions create secondary casualties by accessibility problems to the disaster core. In such cases, the topology of the disaster area almost completely changes.

Then, accessibility between the disaster site and outside world gets on a poor level. In other words, roads to dispatch rescue personnel from outside to disaster area and to transfer victims from disaster area to outside cannot be accessed due to debris obstacles. These obstacles can be listed as collapsed buildings, large volumes of concrete, deformation on roads and fire.

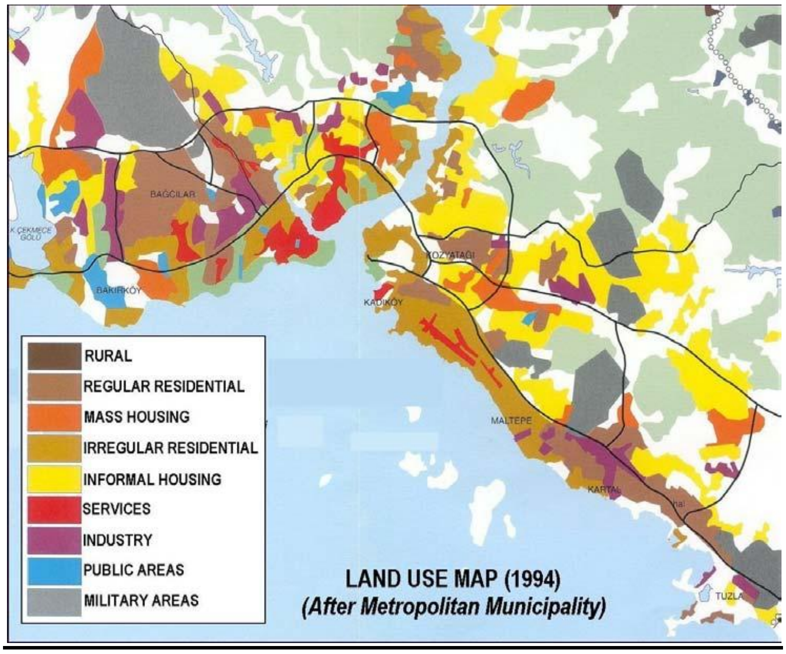


Figure 2.9: Istanbul - Informal Settlements (IMM, 2003).

Casualties in catastrophic earthquakes, especially in densely developed areas are inevitable. The purpose of reducing the casualty or to mitigate disaster effect can be listed as,

To protect human lives from the impact and

To provide post earthquake activities to be carried out well and to secure the state of ordinary living in order to sustain it.

3. METHODOLOGY AND RESEARCH DESIGN

3.1 The Methodology

The main depiction on the observation phase is “In addition to initial impacts, an earthquake would eventually cause secondary impacts such as accessibility problems to the disaster core”. For avoiding these on a sensible base, firstly, it is intended to understand the distinctive properties of the urban space related with these types of possible casualties.

The purpose of this study is to develop a model that provides an index of intervention to; **save maximum life, within shortest term** with **limited economic resources** in the improvement process of the vulnerable urban structure.

As this index of intervention approach proposes the areas where the vulnerable buildings must be removed and infrastructure (inc. lifelines, roads etc.) must be secured first, the authorities will have guidance and starting point for securing the environment in most efficient way.

The following data sources are collected for the basis of the model design:

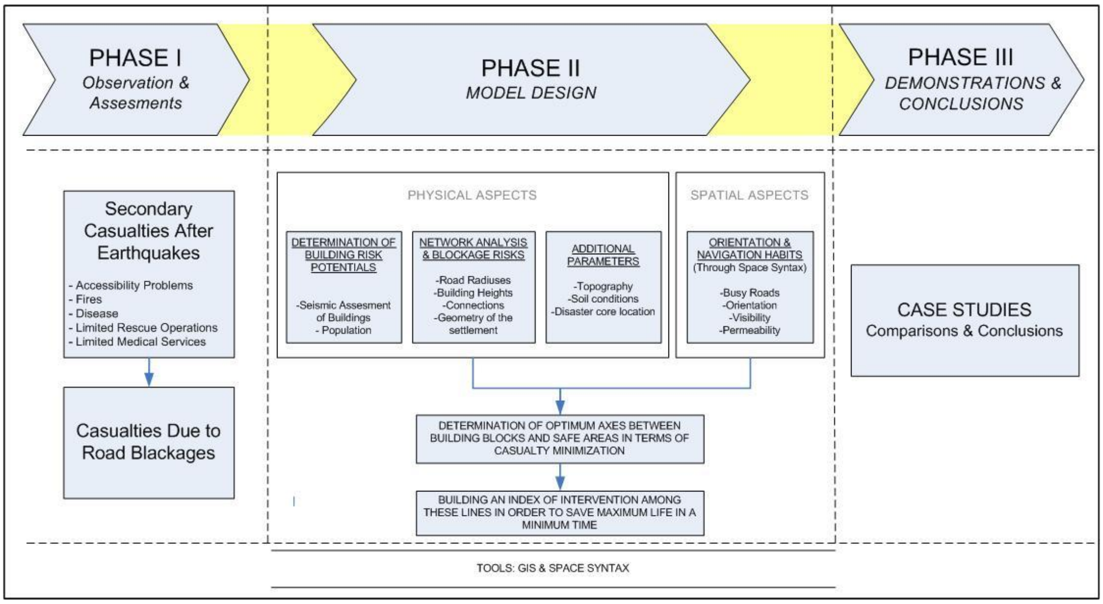


Figure 3.1: Research Process

Physical aspects: In order to avoid the earthquake risks, understanding the vulnerability of the physical structure is important. For this case; Seismic vulnerability of Buildings, ground conditions, road blockage possibilities and related data, topography, location type and settlement geometries and subcategories of these headings are collected.

Spatial Aspects: Since the risk is directly related with human casualties, spatial aspects such as road network hierarchy, orientation, visibility, permeability of urban spaces, functional distributions are also collected within the study.

Combination of these aspects in a sensible base would give significant outcomes for the earthquake management planning process in terms of definition of priorities, evacuation routes design and intervention possibilities.

The main techniques used are GIS (Geographic Information Systems) and Space Syntax theory and techniques. GIS allows the collected data to be reviewed, combined and simulated in spatial and tabular environments.

For the prediction of people's movement in urban environments, Space Syntax is used as a valuable tool. In order to grab the common routes people will eventually use, the physical characteristics of urban pattern should be evaluated first. Main pedestrian uses, potential destinations and through-movement patterns should be defined. With Space Syntax approach, these characteristics can simply be explained using the physical properties of the urban space.

The study proposes an innovative approach appending the Space Syntax measures into the risk assessments to evaluate the possibilities of intervention in most applicable approach.

3.1.1 Space Syntax

"Space syntax" is a theory and a method for the description of built space, is created by Prof. Bill Hillier in "The Unit for Architectural Studies, University College London", has been used to treat spatial configuration as a variable in a variety of studies of the social functions, cultural significance and behavioural implications of layouts.

Method is describing and analyzing the relationships between spaces of urban areas and buildings.

Professionals normally refer to these relationships as “the layout”. In Space Syntax, the spaces are understood as voids (streets, squares, rooms, fields, etc.) between walls, fences and other impediments or obstructions that pedestrian traffic and/or the visual field (Klarqvist, 1993).

One of the most consistent findings of Space Syntax analysis is that patterns of pedestrian movement, vehicular movement, land use and residential crime in urban areas are directly and significantly affected by urban form and spatial layout.

The basic of the technique is the relationship between human spatial behaviour and the urban morphological structure, i.e. how people’s movement is affected by spatial perception. Basically, people have a preference for easy journeys. Establishing the accessibility of a public space means that the way this area will be used can be mathematically predicted (Jiang, 1999).

3.1.1.1 Representation of urban space in Space Syntax: Axial maps

Space Syntax could provide a new vision of space for the representation of urban systems within GIS, and more generally for systems dealing with spatial configurations.

Figure 3.2: Axial Map of London (Hillier, 1999).

To apply Space Syntax it is necessary to construct a graphical representation of an urban area. The ‘axial map’ is the input for the computer modelling technique, which movement potentials, land use patterns and vulnerability can be quantitatively estimated.

It is constructed on the basis of an accurate scale map, by drawing the longest and fewest straight lines, or ‘lines of sight’, that pass through all the accessible space in an urban area or building.

The resulting pattern of intersecting lines leads the process of an understanding of the essentially spatial structure and features of an area or building is built up. In other words, the axial map contains the least set of the longest straight lines that can be drawn in the open space so that every convex space is crossed by at least one such line.

Figure 3.3: The axial representation of Istanbul's historic core.

In addition to space syntax findings, these lines will be holding the data such as, vulnerable building count, population, incline, blockage risk, that is necessary for the model and outputs are represented with these lines.

3.1.1.2 Destination potential of a space - Integration

The central concept of Space Syntax is “Integration”. It is supposed that the distribution of integration across an urban area correlates with the movement pattern in that area. Urban areas can be distinguished by, and compared in terms of different levels of integration. So, it is used as a measure of quality for urban areas.

In Natural movement, (Hillier et al., 1993), it was shown that the structure of the urban grid has systematic and independent effects on movement patterns, which could be captured by integration analysis of the axial map.

In Cities as movement economies (Hillier, 1996) it was shown that natural movement and so ultimately the urban grid itself impacted on land use patterns by attracting movement seeking uses such as retail to locations with high natural movement, and sending non-movement seeking uses such as residence to low natural movement locations. The attracted uses then attract more movement to the high movement locations, and this in turn attract further uses, creating a spiral of multiplier effects and resulting in an urban pattern of dense mixed use areas set against a background of more homogeneous, mainly residential development (Greene, 2003).

In order to define integration, two simple measures should be identified first: Syntactic step and depth. Syntactic step is defined as the direct connection or permeable relation between a space and its immediate neighbours. In an axial map a syntactic step may be understood as the change direction from one line to another (Klarqvist, 1993).

On the other hand, depth between two spaces is defined as number of syntactic steps in a graph is needed to reach one from the other. When this calculation is made for each line in the map it turns out that some lines require fewer changes of direction than others in order to cover the rest of the axial map.

Figure 3.4: Integration map and locations of centres in Istanbul.

Integration measures how close each segment is to all others within the radius, using the least angle measure of distance, so it is a measure of how accessible each segment is from all the others, and so how much potential it has as a destination for movement. People make many short trips and few long trips, so the closer a segment is to all others the more promise it offers as a destination. Integration measures the destination potential for a segment at that radius.

In Istanbul case above map, main destination centre reveal at the western part of the city in European continent. The core, showed with bright colours, geographically overlap with the current central business and commercial district. Also some sub centres distinctively reveal in the evaluation.

3.1.1.3 Through movement potentials - Choice

Choice value is used for prediction of main roads to be used just for passing, not for a destination, rather as a through movement lines. This measures the degree to which each segment lies on least angle routes between all other pairs of segments within the radius, so it measure the through-movement potential of each segment within that radius.

Evaluation of choice in urban areas show that the major axes for transportation, high speed roads or the roads with passing trade potentials usually have a higher choice value than the other segments. For example, the choice values on Istanbul metropolitan area axial maps almost compasses on the main highways.

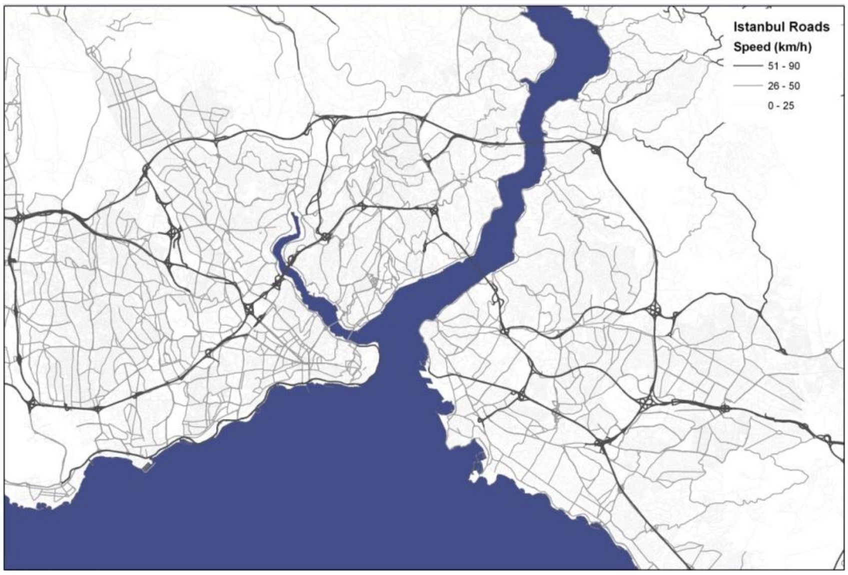


Figure 3.5: Istanbul average vehicle speeds on highways (Data source, IMM).

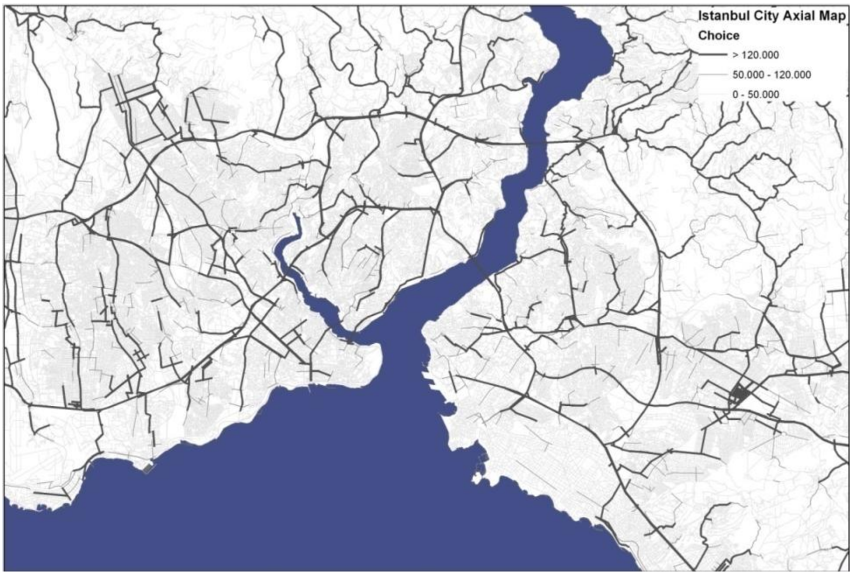


Figure 3.6: Istanbul Choice Map.

In order to find out choice value efficiency, Istanbul map is also used. For this case, the roads with higher choice values mostly overlap with the highways or speed roads around the city.

3.1.1.4 Additional parameters - Connectivity

Connectivity measures the number of immediate neighbours that are directly connected to a space. This is a static local measure. The roads with higher number of immediate neighbours, or high connectivity values, accordingly, have more advantages of evacuation possibilities in a disaster region.

3.2 Conclusions

The model first grabs the risk determination and orientation pattern analysis methods, than evaluates two important outputs: The Road risk value & the index of intervention.

Definition of road risk value helps to depict the risk assessment spatially. Also it would be used as a layer through the land use planning exercises in vulnerable areas. But given the limited time consideration in some extremely vulnerable settlements, sorting the risk intervention areas due to the efficiency of the process is crucial. In that sense, index of intervention value is proposed to provide this sorting in an appropriate way. With the help of this value, securing the highest number of people within a short time and can be provided.

Each line has an intervention degree, related with risk assessment and natural movement. Securing one the red lines in here doesn't mean only securing people living in that street, also creating a evacuation preference for other residents through the settlement.

The index of intervention, which is the combination of the road risk value and Space Syntax's choice variable, gives a constant intervention index within a vulnerable urban pattern, consistent with an urban planners approach.

Demonstration of this model framework takes place in two distinctive areas as case studies. Avcılar & Zeytinburnu areas, initially fringes of the spreading metropolitan area, recently announced as transformation areas due to high vulnerability and densely populated fragments of Istanbul. Given these areas has been evaluated by the Municipalities, local authorities and there are a number or transformation projects regarding the earthquake issue in these areas, model outputs are tested with the final intentions and next steps of these articulated studies.

4. PRECAUTIONARY APPROACH TO ACCESSIBILITY PROBLEMS OF A DISASTER CORE.

4.1 Introduction

This chapter mainly provides the framework of the model that ensures the order of interventions for securing as much lives as possible at the earliest agenda with the limited economic resources for the earthquake vulnerable settlements.

The main techniques used are GIS (Geographic Information Systems) and Space Syntax theory and techniques. GIS allows the collected data to be reviewed, combined and simulated in spatial and tabular environments.

The essential outputs of the study are lines, representing the road connections in the urban environment, as they are defining most immediate response axes to save maximum life within shortest term and limited economic resources. They also propose the areas where the vulnerable buildings must be removed and infrastructure (inc. Lifelines, roads etc.) must be secured first.

The map returns are plotted in a Geographical Information System (GIS) which enables detailed analysis of the many variables of the study. In addition, such a system provided the opportunity to describe the results in a coloured graphical representation, which allows for identification of routes and locations where there are high levels of movement.

In the first phase of the model, definition of the vulnerability and calculations of the number and locations of people insecure are provided. Evaluation of the blockage risks of the roads within a network due to the collapsed buildings is the second phase of the process.

After, predictions of the major routes that people use frequently to reach the city main road network and major destinations in the urban configuration will be estimated with the help of the theory Space Syntax and its techniques are indicated.

In addition, some physical characteristics of the urban space such as incline is also evaluated through the model. After the combination of all these inputs, determination of the roads to be intervened first is predicted in order to secure provision of post-earthquake activities to be carried out.

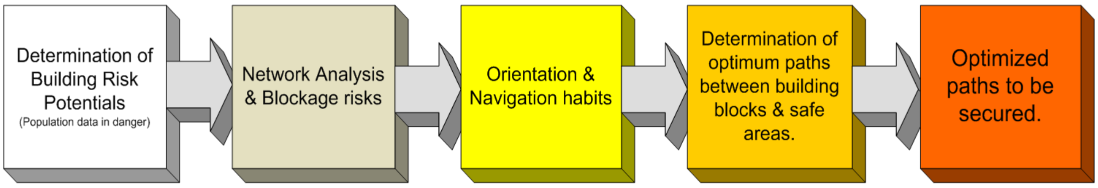


Figure 4.1: Basic framework of the model proposal.

Istanbul represents a proper case for this model proposal as it holds a significant size of population in danger and valuable assets. Also, the vulnerability of the urban physical structure is typical to other examples of developing countries.

Causalities also depend on some additional factors which are extending on a very wide range of possibilities. These additional factors can be described as the time of the event, assumed magnitude and epicentre of the earthquake and also the direction of the earthquake. These additional factors are included in the risk assessment phase particularly in determination of the building risk potentials.

As 2010, it seems a rapid intervention to a physical and social structure of the city hasn’t been achieved yet. Within these 11 years, a number of studies, researches and projects with different scales on various aspects have been produced by the authorities, NGO’s and academic institutions. Implementation process on any of these has given no outputs yet.

4.2 Evaluation of Urban Vulnerability

4.2.1 Buildings vulnerable to earthquake

Many reinforced concrete framed houses and apartment blocks in Turkey are highly vulnerable. When they collapse, they are considerably more lethal and kill a higher percentage of occupants than other types of buildings. Some other factors, such as soft soil, high density and a greater number of floors, increase the vulnerability of buildings by as much as two or three times (Şengezer, 2005).

In the evaluation of the seismic safety of buildings, the technique used in EMPI is adopted in the intermediate level. Originally it includes three stages, each requiring more detailed works after the previous stage. The first stage inspection/evaluation works are also referred as “street survey” and correspond to preliminary assessment. In this study, the seismic vulnerability evaluation will be used in this level and outputs of this stage will be used in the model.

The goal of these works is to make a preliminary grading of all buildings in Istanbul with respect to their seismic performance, and therefore to collect limited data on buildings by visual inspection from outside which can be processed in a rational manner for seismic assessment (EMPI, 2003).

This visual inspection method uses 8 variables: these are; Number of stories, soft story presence, heavy overhangs, apparent building quality, short columns, pounding effect, topography and incline, and local ground conditions.

Number of Stories: Field observations after the 1999 Kocaeli and Düzce earthquakes revealed that there is a very significant correlation between the number of stories and the severity of building damage. Accordingly with the observations, damage increases almost linearly with the number of stories.

Soft Story: This usually exists in a building when the ground story has less stiffness and strength compared to the upper stories. This situation mostly arises in buildings located along the side of a main street.

The ground floors, which have an access from the street, are used are store or a commercial space. This commercial space at the bottom is mostly left open between the frame members for customer circulation.

Besides, the ground stories may have taller clearances and a different axis system causing irregularity. Many buildings with soft stories were observed to collapse due to a pancaked soft story in the past earthquakes all over the world.

Heavy Overhangs: Heavy balconies and overhanging floors in multi-story reinforced concrete buildings shift the mass centre upwards; accordingly increase seismic lateral forces and overturning moments during earthquakes. Since this building feature can easily be observed during a walk-down survey, it is included in the parameter set.

Apparent Building Quality: The material and workmanship quality, and the care given to its maintenance reflect the apparent quality of a building. A well-trained observer can classify a buildings apparent quality roughly as good, moderate or poor.
Short Columns: Semi-unfilled frames, band windows at the semi-buried basements or mid-story beams around stairway shafts lead to the formation of short columns in concrete buildings. These columns usually sustain heavy damage during strong earthquakes since they are not originally designed to receive the high shear forces relevant to their shortened lengths.

Pounding Effect: When there is no sufficient clearance between adjacent buildings, they pound each other during an earthquake as a result of different vibration periods and consequent non-synchronized vibration amplitudes. Uneven floor levels aggravate the effect of pounding. Buildings subjected to pounding receive heavier damages at the higher stories.

Topographic Effects: Topographic amplification is another factor that may increase the ground motion intensity on top of hills. Besides, buildings located on steep slopes (steeper than 30 degrees) usually have stopped foundations, which are incapable of distributing the ground distortions evenly to structural members above.

Local Soil Conditions: Site amplification is one of the major factors that increase the intensity of ground motions. In urban environments, geotechnical data provided by local authorities is a reliable source for classifying the local soil conditions. The intensity of ground motion under a building during an earthquake predominantly depends on the distance of the building to the causative fault, and the local soil conditions.

Mapping of seismic hazard at micro scale considers both variables. Seismic hazard, or ground motion intensity is mapped in terms of PGA and PGV in the JICA report.

PGV usually reflects the effect of soil conditions very well during a large magnitude earthquake (Wald et al., 1999).

Accordingly, PGV is selected to represent the ground motion. The PGV map in the JICA report has contour increments of 20 cm/s2. The intensity zones in Istanbul are expressed accordingly, in terms of the associated PGV ranges.

Zone I: 60<PGV<80 cm/s2

Zone II: 40<PGV<60 cm/s2

Zone III: 20<PGV<40 cm/s2

Building Seismic Performance: Once the vulnerability parameters of a building are obtained from walk-down surveys and its location is determined, the seismic performance score is calculated by using Table 4.1. In this table, an initial score is given first with respect to the number of stories and the intensity zone.

Then, the initial score is reduced for every vulnerability parameter that is observed or calculated. A general equation for calculating the seismic performance score (PS) can be formulated as follows.

PS = (Initial Score) - Σ(Vulnerability parameter) × (Vulnerability Score)

The weight of each building vulnerability parameter is evaluated by statistical procedures, based on the Düzce database. Statistical analysis is conducted by the program package SPSS Version 11, using the "Multivariable Stepwise Linear Regression Analysis" procedure. The results are then smoothed, and the weights of the parameters for which there was no available data (soft story, pounding, topography) are assigned by using engineering judgment.

Table 4.1: Initial and Vulnerability Scores for Concrete Buildings, 2003).

Story #	Zone I 60<PGV<80	Zone II 40<PGV<60	Zone III 20<PGV<40	Soft Story	Heavy Overhang	Apparent Quality	Short Column	Pounding	Topographic Effects
1 - 2	90	125	160	0	-5	-5	-5	0	0
3	90	125	160	-10	-10	-10	-5	-2	0
4	80	100	130	-15	-10	-10	-5	-3	-2
5	80	90	115	-15	-15	-15	-5	-3	-2
6-7	70	80	95	-20	-15	-15	-5	-3	-2

Vulnerability Parameters

Soft story : No (0); Yes (1)

Heavy overhangs : No (0); Yes (1)

Apparent quality : Good (0); Moderate (1); Poor (2)

Short columns : No (0); Yes (1)

Pounding effect : No (0); Yes (1)

Topography effect : No (0); Yes (1)

Second and third stages of this assessment requires more detailed works, briefly, in the second stage assessment, starting with the high priority buildings and regions, more detailed investigation/evaluation works will be executed for seismic assessment of buildings. The goal of this phase of investigations will be to make reliable performance evaluations which will enable to reach final decisions.

The third stage involves an almost through analysis of the building and decision on its earthquake worthiness and economic feasibility of retrofit. This stage of evaluation works will comprise especially high rise buildings and socially essential buildings. It will be carried out by registered expert engineering firms in accordance with specified methods and performance criteria (EMPI, 2003).

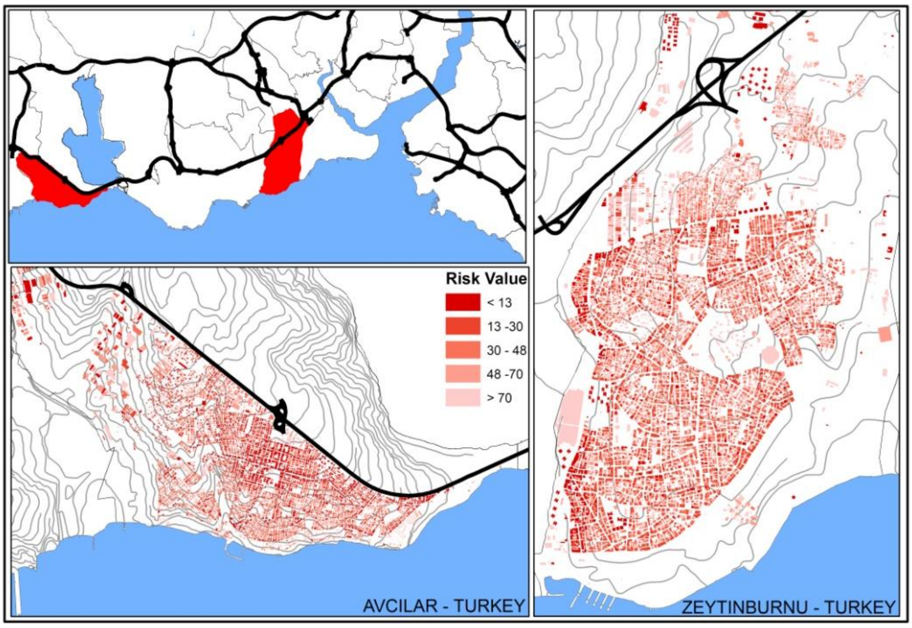


Figure 4.2 Avcılar and Zeytinburnu. Vulnerability Scores (GIS Data source, IMM).

4.2.2 Evaluation of road blockages

The JICA report, published in 2002, includes a road blockage estimation study with the evaluation of earthquake scenario and the current road radiuses. In the report, the blockage of roads caused by collapsed buildings was estimated and evaluated based on the results of assumed building damage derived from a Model C earthquake. The road blockages refer to the situation in which a road width of 3 m (which would allow for the smallest of vehicles to drive through the road) cannot be secured due to debris from a buildings collapse (Figure 4.3).

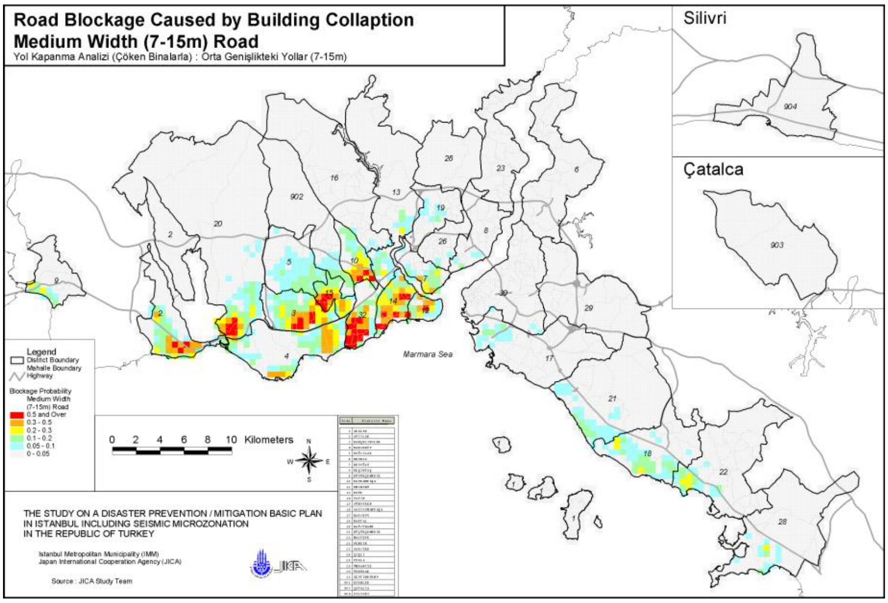


Figure 4.3: Estimated road blockages in Istanbul (JICA, 2002).

The estimation of road blockage was carried out for three cases: 1) roads 2 to 6 m in width; 2) roads 7 to 15 m in width; and 3) roads 16 m or greater in width.

Using the estimation, the evaluation found four stages where areas would be expected to be isolated due to road blockages. According to the estimation, many isolated segment areas will be located in the southern part of the city on the European side.

These isolated segment areas could significantly hamper evacuation and rescue activities, the removal of collapsed buildings, and the transportation of relief goods. Accordingly, in those segment areas highly expected to become isolated, necessary improvements should be made, such as the construction of additional roads and the use of roadside lands to reduce the possibility of isolation (JICA, 2002).

Figure 4.4: A Street scene showing narrowness in Çırpıcı – Zeytinburnu.

Main factors amplifying the road blockage risks are the vulnerability of the buildings on the street, efficient radius (there may be roads wide enough for providing access and evacuation but due to road side parking or other obstacles, very minor part is available), function of the street, junction qualities and population dependent to the road.

As stated before, this study uses lines as outputs, representing the roads. Every data will be appended into these lines in order to combine and evaluate them spatially. After the evaluation of seismically vulnerable buildings in the urban environments, a calculation method is proposed to create an index of blockage risks. This method is using; **mean number of floors through the road**, **minimum road radius** (in metres) and **a number of people living in a seismically vulnerable buildings** to achieve the findings. Calculation is as follows;

$$B = \frac{meanF}{Ra} \times \mathrm{Pr}$$

B: Blockage Risk

F: Mean number of floors

Ra: Minimum Radius of the road

Pr: Number of people living in seismically vulnerable buildings.

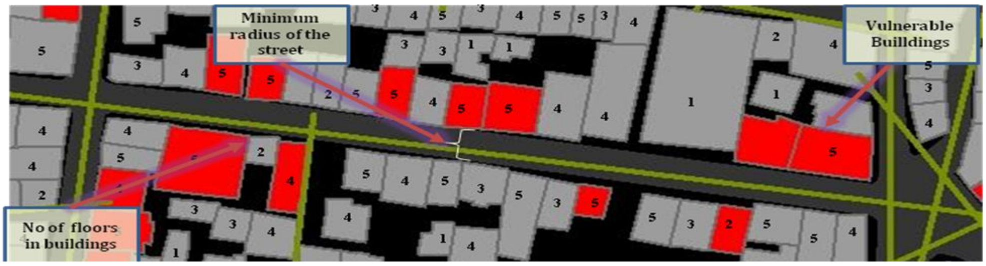


Figure 4.5: Road blockage variables.

4.2.3 Population in danger

Definition of seismically vulnerable buildings in urban environment doesn't completely reveals the risk factor as an outcome. But, it is possible to calculate the number of people living in danger with several tools like GIS. Population in danger term not only expresses these people in vulnerable buildings, but also a number of people will be inaccessible in between collapsed buildings or any kind of debris.

Even if they live in safer buildings, fire, smoke or other after effects of the earthquake will affect these people too.

This study uses the roads in order to calculate people in danger and evaluate risk in urban areas accordingly. The number of people living in vulnerable buildings is generally provided by local municipalities or authorities. If these are not available, figures can be calculated with the available number of residential units multiplied by the assumed average household size.

4.3 Natural Movement & Orientation

In the growth of cities, spatial factors first influence movement patterns, and these then affect land use distributions, then this produces multiplier effects on movement, which then attract a great concentration of movement-dependent land uses. Density of population in the most of the cities is directly regarded with the distance to the core (Greene, 2003). Transportation of people in the large cities, especially in the urgent periods becomes very crucial from this point of view.

In emergency evacuation process, people escape to a safe place; they use accessible routes for evacuation, whether from inside the building or outside it. These routes should be visually accessible and permeable, or otherwise they cannot get away from the hazard situation (Mohareb, 2009). In order to grab these common routes people will eventually use, the physical characteristics of urban pattern should be evaluated first. Main pedestrian uses, potential destinations and through-movement patterns should be defined.

Pedestrian or vehicle counting survey may provide efficient information for a model work in this phase. However, the result of these surveys may also be misleading given the density of pedestrian or vehicle usage varies on time and can give misleading information about the total potential or characteristics of an urban space.

In this case, a valuable tool for the prediction of people’s movement in urban environments, Space Syntax is used. With this approach the characteristics mentioned above can simply explained using the physical properties of the space. In order to make efficient contribution to the model process regarding the definition of possible movement patterns in an urban space, **integration, choice** and **connectivity** measures are adapted to the calculations as explained in the following section.

4.4 Model Basis

The outputs of this model proposal can be used as guides for intervention actions in the urban transformation process. The beginning of the process requires good and appropriate data collection phase. The variables will be used in the model as follows;

- Vulnerable Buildings (20% of lowest scored in the cluster).

- Population and number of people living in a vulnerable buildings.

- Estimated blockage risks.

- Space syntax integration value: Integration measures how close each segment is to all others within the radius, using the least angle measure of distance, so it is a measure of how accessible each segment is from all the others, and so how much potential it has as a destination for movement. People make many short trips and few long trips, so the closer a segment is to all others the more promise it offers as a destination. Integration measures the destination potential for a segment at that radius.

People will be using the specific roads for evacuation during the earthquake. Integration value is added to the model for the definition of permeable roads, main destinations, which will be one of the most important arguments in this phase.

- Space syntax connectivity value: The main reason to add this parameter to model basis is to define roads which have more directions to turn or escape. The roads with higher number of immediate neighbours, or high connectivity values, accordingly, have more advantages of evacuation possibilities in a disaster region.

- Topography (% incline of the roads): The incline of the land effects the orientation in the urban space. The greater a grade, the more power a person or a machine requires climbing it; therefore routes with lower grades are preferred, so long as they do not have other disadvantages, such as causing significantly increased overall travel distance. In other words, it is a general assumption that people change or lengthen their routes when their direct passage to destination has a significant incline.

- Space Syntax choice value: Evaluation of choice in urban areas show that the major axes for transportation, high speed roads or the roads with passing trade potentials usually have a higher choice value than the other segments.

The model principally is proposed with two outputs: Road risk value and Index of Intervention values. Each value is proposing distinct outcomes providing information for total risk assessment and intervention priorities against the earthquake risk.

4.4.1 Road risk value

Basically superposition of the outcomes of risk assessment, space syntax outputs and additional data involving the physical characteristics of an area like incline%, provide the road risk value.

These values will be collected for each road and appended to a table. Also within a range, each value will have clusters from good to bad.

Table 4.2: Road risk value, variables table(Zeytinburnu –Istanbul).

Integration		Connectivity		Vulnerable buildings(%)		Population		Population in vulnerable buildings		Incline %		Blockage Risk	
Coeff.	Range	Coeff.	Range	Coeff.	Range	Coeff.	Range	Coeff.	Range	Coeff.	Range	Coeff.	Range
1	2,05	0,2	33	1	100	1	7,5	1	2,3	1	14	1	1500
0,8	1,58	0,4	5	0,8	80	0,8	560	0,8	220	0,8	12	0,8	110
0,6	1,441	0,6	3	0,6	60	0,6	360	0,6	110	0,6	9	0,6	50
0,4	1,331	0,8	2	0,4	40	0,4	200	0,4	50	0,4	6	0,4	22
0,2	1,21	1	1	0,2	20	0,2	110	0,2	10	0,2	4	0,2	1

Calculation of the road risk value is applied with the assistance of the sampling table (Table 4.2.) including ranges of equal intervals (20% each) for each variable and assigned coefficients for these variables.

Multiplication of all coefficients for a line gives the risk value as the output.

The entire risk assessment variables outcome as the risk values for each road segment on the case areas. When spatially represented, output maps could be used as tools in intervention strategy definitions or more articulated emergency processes by the professionals. However, depiction of these outcomes is crucial as they may not always give spatially consistent maps. In this case the choice value of Space Syntax is used in model process in order to better combine the risk assessment and movement potentials in a disaster core as it is a measure that demonstrates the existence of alternative routes from one space to another or the degree of choice that each space represents for its immediate neighbours as a space to move to.

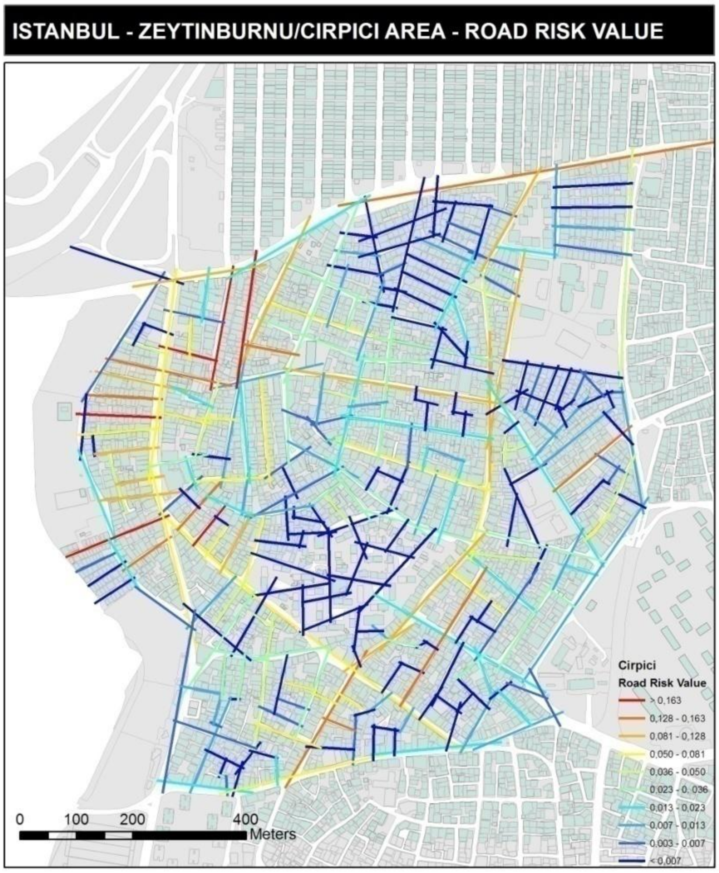


Figure 4.6: Çırpıcı - Istanbul - Road Risk Values.

Choice may also be a better predictor of movement for inhabitants with better knowledge of the layout than strangers who rely on reading the layout in order to move.

4.4.2 Index of intervention value

Definition of risk value helps to depict the risk assessment spatially. Also it would be used as a layer through the land use planning exercises in such areas. But given the limited time consideration in these types of extremely vulnerable settlements, sorting the risk intervention areas due to the efficiency of the process is crucial. In that sense, index of intervention value is proposed to provide this sorting in an appropriate way. With the help of this value, securing the highest number of people within a short time and can be provided.

Index of intervention value is simply calculated with multiplying the normalized Space Syntax choice value with the risk value.

IIn. = Risk Value * Choice(Log(Ch+2))

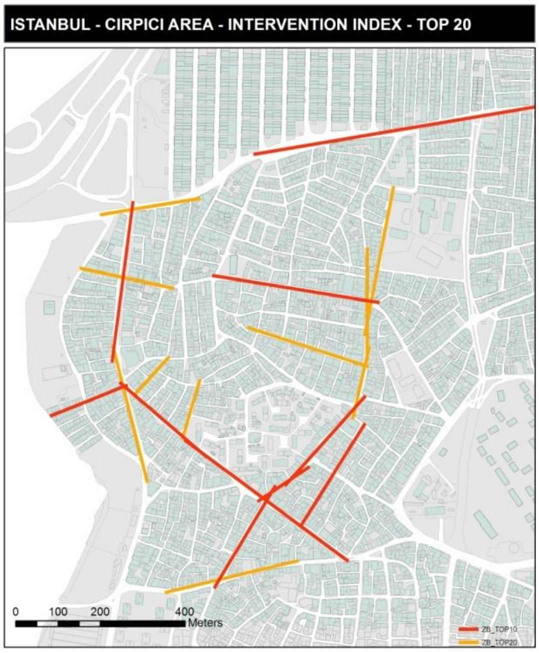


Figure 4.7: Index of intervention values (Highest 20) for Çırpıcı / Istanbul.

Index of intervention value should be considered as starting point rather than another layer for disaster mitigation planning process. Although the outputs can be scattered around the examples and there may be no consistency with the actual or proposed network, these lines should also be considered one by one as they have distinct risk factors and intervention possibilities.

Outputs of the assessments proposed in the model framework are spatially examined in the cases of Zeytinburnu and Avcılar settlements in Istanbul. The details, observations and general comments are provided in the Chapter 5.

4.5 Conclusions

The proposed risk reduction, land use and disaster management plans in such areas propose “Evacuation corridors”, “Green Cores” and accessibility organizations within an appropriate planning sense. Also these works already intended on social cooperation in addition to physical interventions.

Nevertheless, this study is prepared in the aim of contributing this planning process, providing better evaluation techniques and selecting the most appropriate agenda.

The model proposal and its techniques are empirical and can be manipulated due to the conditions of an urban space and vulnerability.

Thus, the outcomes are only proposing the small range of settlements vulnerable to earthquakes but the most urgent ones as distinctively holding dense population in an urban totality.

In the design process of the model, it is intended to use most basic data / tools in order to provide faster outputs rather than the time consuming detailed analysis processes. These dataset needed in the model process can be available in any municipality. Though, model outputs can be created with a basic desktop working with a proper GIS tool.

Especially, workings on the movement patterns of the people needs long site surveys and observations. Space Syntax methodology helps to understand the current orientation and movement patterns as well as it can be used as a valuable tool to predict the efficiency of the design proposals. Of course, further evaluation and analysis would be needed for more precise outputs.

5. CASE STUDIES: AVCILAR AND ZEYTINBURNU DISTRICTS IN ISTANBUL

5.1 Introduction

Given the earthquake risk almost compasses the densely populated areas of Istanbul, an efficient intervention plan is needed for immediate respond to that risk. The model will be used for securing as high population as possible by defining risks, evacuation possibilities, population density etc.

Model basically uses building risks, population, integration, topography, blockage risk and road radius values in order to define most immediate response roads to save maximum life within shortest term and limited economic resources.

Istanbul provides the two areas for the case studies are already holding a significant number of people in vulnerable settlements as well as these case areas. These proposals provide a starting point of this process.

5.2 Case Studies

5.2.1 Zeytinburnu – Istanbul (40°59'55N, 28°54'11E)

The Earthquake Master Plan for Istanbul has been motivated by a request by the Metropolitan Municipality (IMM) to a consortium involving four leading Turkish universities: Boğaziçi, Istanbul Technical, Middle East Technical and Yıldız Technical Universities. These efforts are the pioneering examples of Urban Development Projects and Local Transformation Programs, or total “Action Planning” for Turkey.

Zeytinburnu, with its extremely vulnerable urban structure, vital economic importance and with other threats and opportunities, is selected as a pilot study area for the EMPI (Earthquake Master Plan for Istanbul).

Figure 5.1: Zeytinburnu - Location in Istanbul

JICA’s indicators show that %16.6 of the buildings in Zeytinburnu will be seriously damaged in case of an earthquake. This ratio turns out to be %20 with the further seismic safety evaluations, proposed by EMPI.

In Zeytinburnu, %23.8 of the urban areas is residential. Residence becomes dense in Sümer, Veliefendi, Telsiz, Beştelsiz, Gökalp, Yenidoğan, Nuripaşa, Yeşiltepe and Çırpıcı quarters. Total population of the district is 290.147 in 2009, with the net average density of 921 person/hectare.

Figure 5.2: Zeytinburnu - Poor quality concrete building stock.

This high density ratio shows open spaces’ deficiency and the need of urban social infrastructure for sustainable urban life. According to recent engineering studies, in Zeytinburnu there are 11,859 dwellings that are under risk and have a population of 45,000.

These values, in the further evaluation with a detailed working, increased to 13,694 dwellings and have 52,000 people under risk.

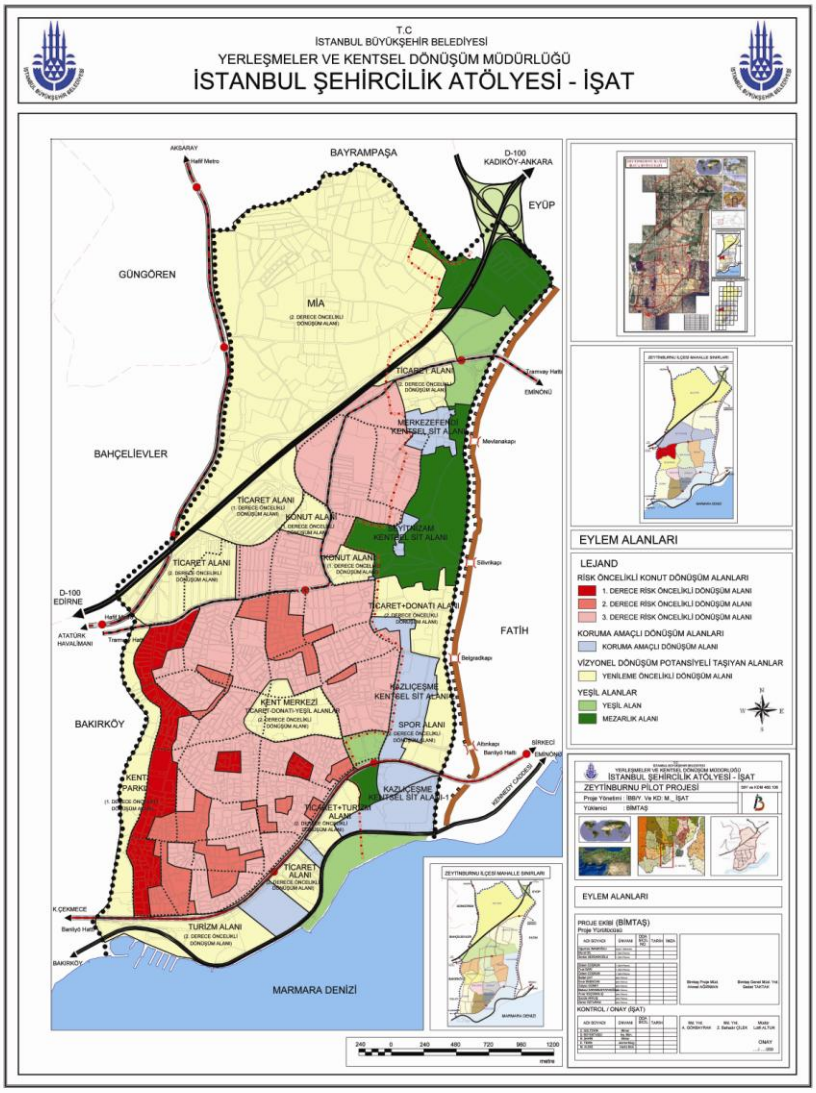


Figure 5.3: Zeytinburnu - Action areas, defined accordingly to risk assessments (IMM, 2005).

Risk zoning map, prepared by the Urban Planning Department of the IMM, in the figure 5.3 shows that western parts of the settlement has higher vulnerability against an earthquake due to soil conditions, population density and building quality.

As a case study, Çırpıcı quarter and its surroundings is selected as the first area.

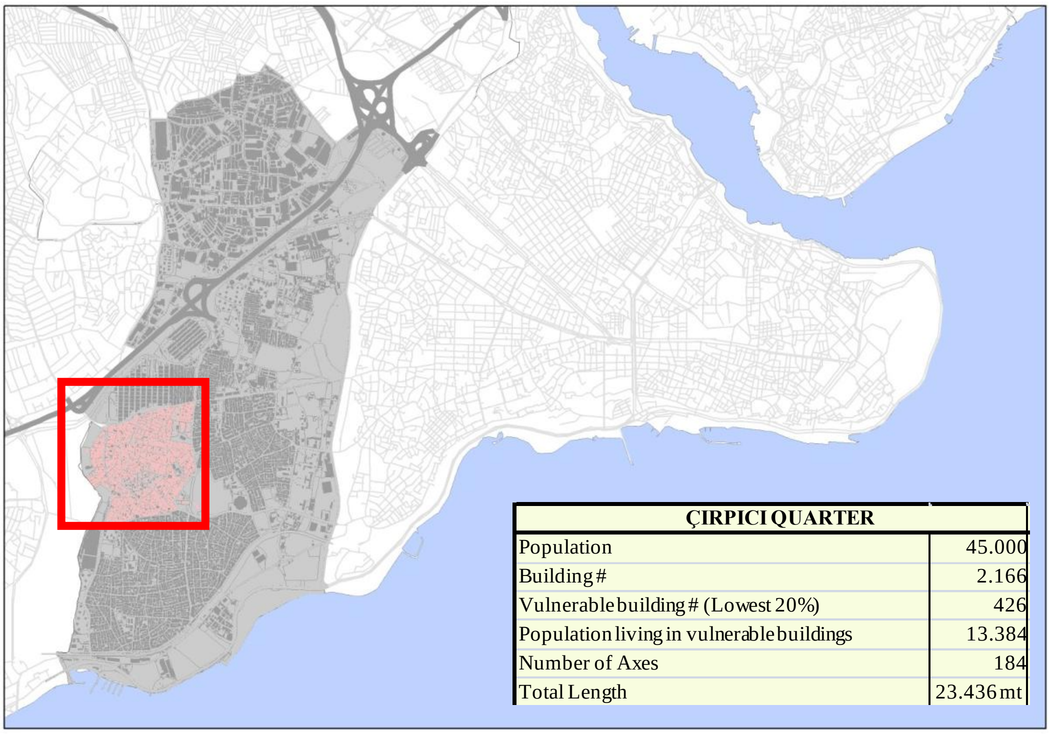
5.2.1.1 Çırpıcı area - Zeytinburnu

In 1960's, Zeytinburnu district is initially established as an informal settlement, beyond the old city walls. Therefore, the physical pattern is developed in organic or irregular shape – very deformed grid- similar to Turkish traditional settlements.

Mainly, southern part of the main D100 highway is established as residential. However, there are significant number of informal shops and textile production facilities in these residential areas. In addition, given the district centre is located in this part, the majority of the population of Zeytinburnu stays in this vulnerable urban space throughout the day.

Income levels are lower than the average, causing the urban transformation process slower. In addition, since this area has informally developed, local dwellers usually don't support any interventions to the settlement.

The area is located to the north-western part of the district, and actually well connected to the city main road network with the surrounding roads. However, inner roads are generally narrow while the most of these roads are being used as side car parking. In the case of an emergency, evacuation or access with any vehicle would become almost impossible due to this poor qualities and possible road congestion.



ÇIRPICI QUARTER	
Population	45.000
Building #	2.166
Vulnerable building # (Lowest 20%)	426
Population living in vulnerable buildings	13.384
Number of Axes	184
Total Length	23.436 mt

Figure 5.4: Zeytinburnu - Building stock.

The basement floors of the majority of the buildings are occupied by informal textile production facilities. Although the social life takes place outside the buildings, an important number of people do not get outside from these workplaces in the daytime. Seismic vulnerability exercises generally show that the basement floors are one of the most dangerous parts of the buildings in the case of an earthquake. In addition, main roads are occupied by retail shops too.

There are 2,166 buildings in the settlement. Average number of storeys has increased to 4.12 with the help of immigration. First, people had built 1 or 2 story buildings. With the help of immigration due to the job opportunities in Istanbul, these people built additional storeys on to these buildings, rather than paying rent for a new apartment or purchasing one. Now, significant number of buildings is built in this ecclesiastic way. Now, the population of the Çırpıcı case study area is 45.000.

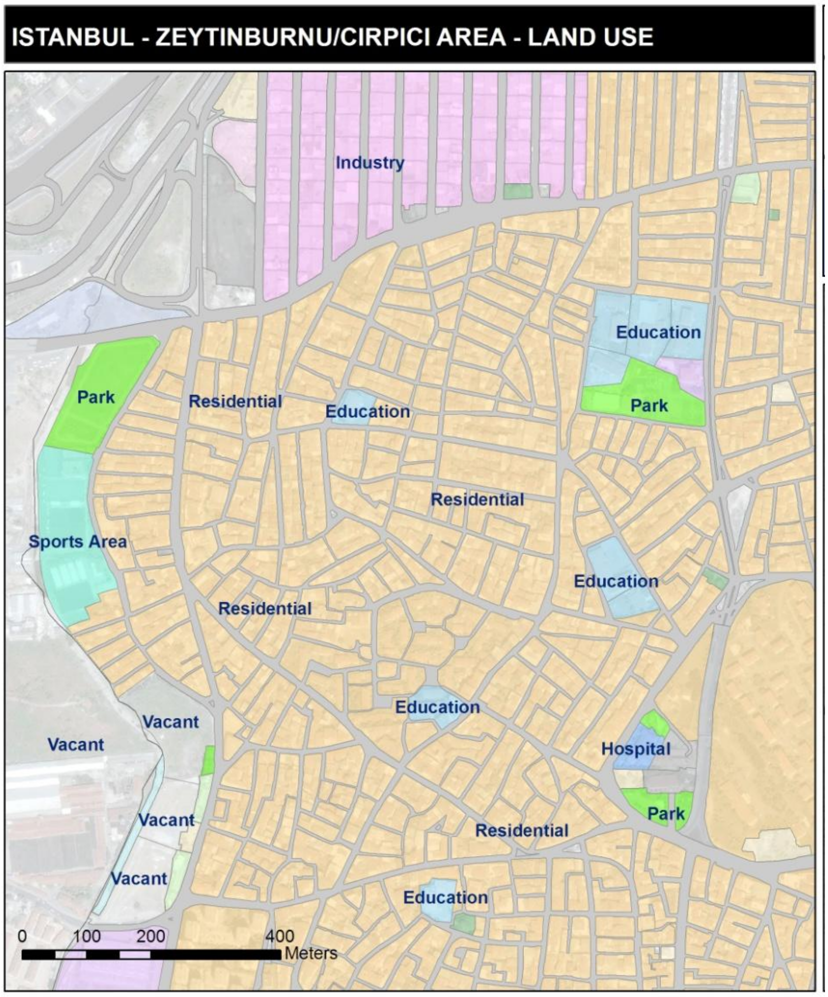


Figure 5.5: Çırpıcı - Zeytinburnu - Land Uses

The area is bounded by the industrial estate to the north, vacant areas to the west, residential areas to the south and retail centre of the district to the east. It mainly consists of residential buildings. The open spaces to the west, already reserved as gathering spaces by the local authorities.

There are no significant dangerous usages in the area like PFS of industrial activities.

5.2.1.2 Seismic vulnerability

Seismic vulnerability evaluation outputs (figure 5.6) show that the seismic risk distinctive among zones inside Çırpıcı. Risk is mainly concentrated North West and also along the main arteries of the settlement. To the west, the dried river basin, which affects the ground conditions, is located. This zone also has some steepness, amplifying the vulnerability of the buildings. There are about 426 buildings evaluated as vulnerable and there are about 13.386 people directly under danger.

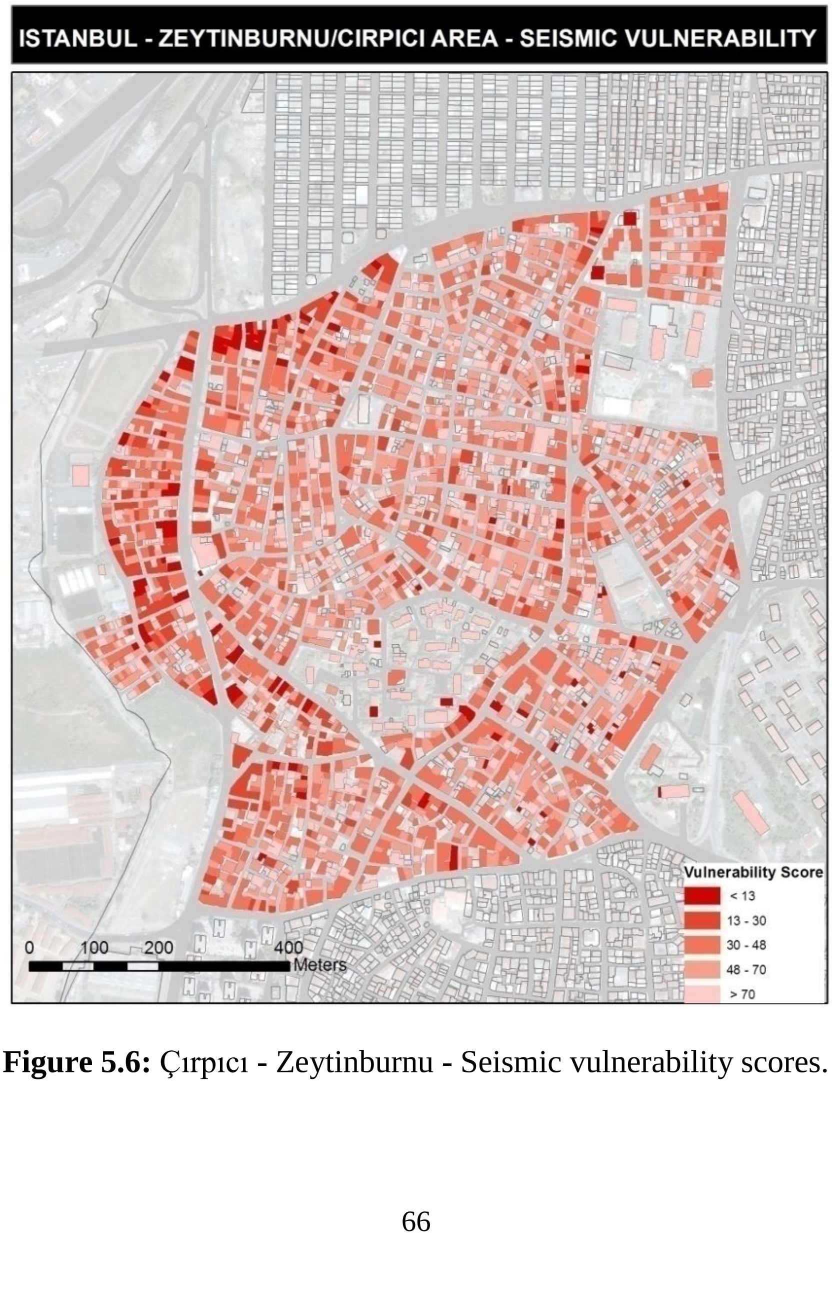


Figure 5.6: Çırpıcı - Zeytinburnu - Seismic vulnerability scores.

Given the building density is very high and most of the building islands consist of adjacent building blocks, the vulnerable building would eventually provide a threat for the other safer buildings. In addition, with the average road radius of 6.77 metres, the buildings which collapse would fall off the road side and probably hit on the buildings on the opposite side of the roads. This will create additional damage and blockage of the roads.

As seen in figure 5.6, having the most vulnerable buildings to the western edge of the building stock, actually creates additional threat to the area given the only evacuation space is to that direction. This means, closure of the evacuation routes to the west reveal as a total threat to the Çırpıcı area in total.

5.2.1.3 Road blockages

In the case area of Çırpıcı, there are 293 lines of sight and around 250 streets, mostly open to the vehicle traffic. Given the building plots are very small and there are no additional spaces for car parking inside these plots, almost all of these roads are occupied by side car parking. The average road radius in the area is 6.77 metres.

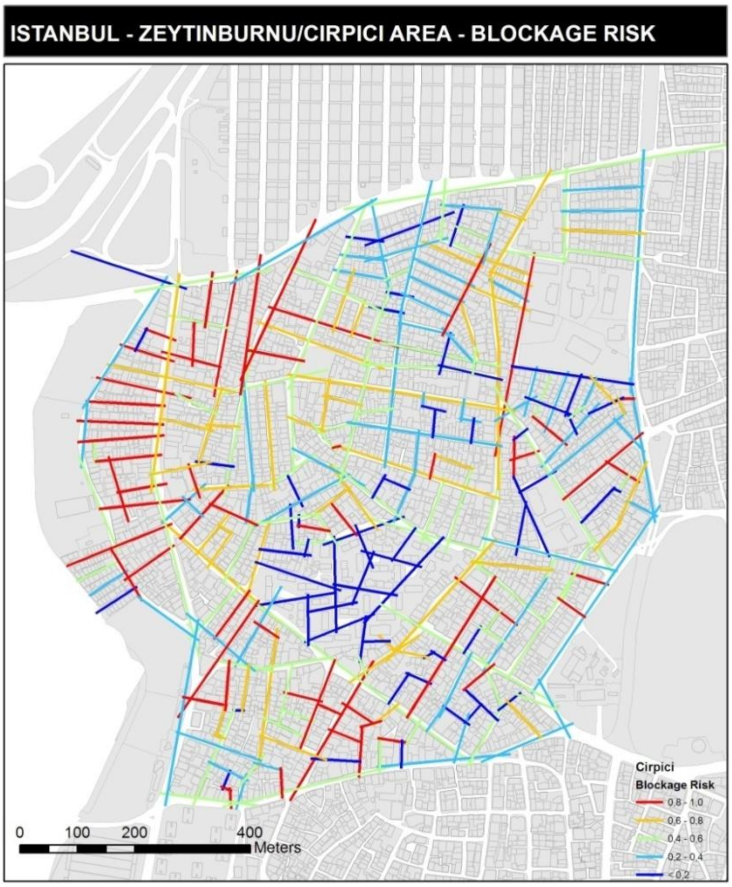


Figure 5.7: Çırpıcı - Zeytinburnu - Road blockage risks.

With the additional car parking, this number decrease to 4.5 metres. Eventually most of these roads will be inaccessible by huge vehicles like standard fire brigade and ambulance.

Even though this settlement look like a grid with minor deformations, dead ends and closed roads for car parking through the area enhancing the threat for the blockage.

As seen in figure 5.7, the road blockage risks are scattered unevenly, but the highest 10 line hold about 4,400 people (9.78%).

Another important variable increasing blockage risk is usage. Especially for this area, textile production facilities and industrial zone to the north requires a large proportion of goods being transported to/from the area. This is currently provided by large minibuses and trucks, inconvenient for narrow streets.

5.2.1.4 Population under risk

In Çırpıcı, there are 13,384 people living in buildings which are considered as vulnerable to an earthquake.

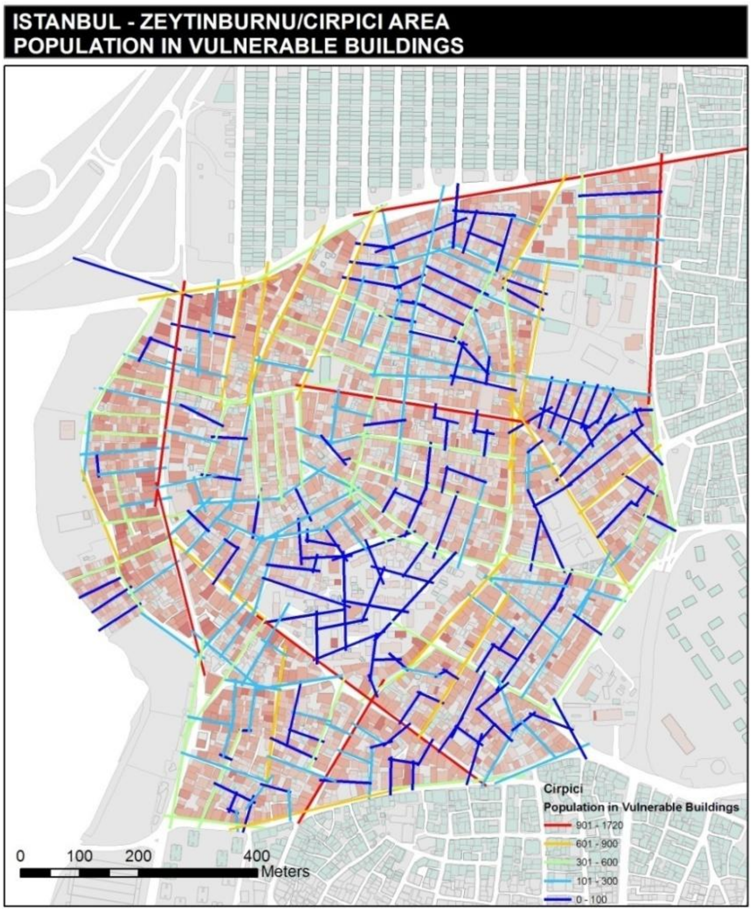


Figure 5.8: Çırpıcı - Zeytinburnu - Population in vulnerable buildings.

This number can be misleading due to there are secondary impacts of earthquakes leading more casualties in such settlements, as stated before. The main infrastructural problem the area has is lack of integrity of the urban network and reliability of the roads in Çırpıcı. Main obstacles for the integrity of network are; Grid is already deformed, roads are narrow and occupied by parked cars, building quality is poor and the road quality is insufficient.

From this point of view, “population under risk” term is not only a number, but a fact that is generally dependent on the quality and integrity of this urban fragmentation.

The figure 5.8 shows that the central lines throughout the quarter has generally high number of population under risk even though these can be considered as wider and straight streets easy to access and evacuate. Conversely, these are most crucial connection to be secured in order to start provision of the security of the people in the area.

5.2.1.5 Incline

As stated before, it is a general assumption that people change or lengthen their routes when their direct passage to destination has a significant incline.

Çırpıcı area is located on a generally plain land. There are few points that the slope is higher than 10%. These streets are expected to be more segregated than the others given the higher grades weaken the spatial perception. In the Çırpıcı case there are few roads in this cluster, seen in figure 5.9. But this part of the settlement have generally high traffic volume during the daytime given the commercial facilities are concentrated in Turan Güneş Blv. and this axis is connecting not only Çırpıcı, also southern parts of Zeytinburnu to the city main road network. In the case of an emergency, this would eventually lead to the more congestion on this road because of the possible decrease on the evacuation alternatives and least numbers of streets will be left open to this boulevard.

Regarding the incline also effects the seismic vulnerability of the buildings, the combined risk assessment outputs is already expected to indicate these parts of the settlement as a focusing area.

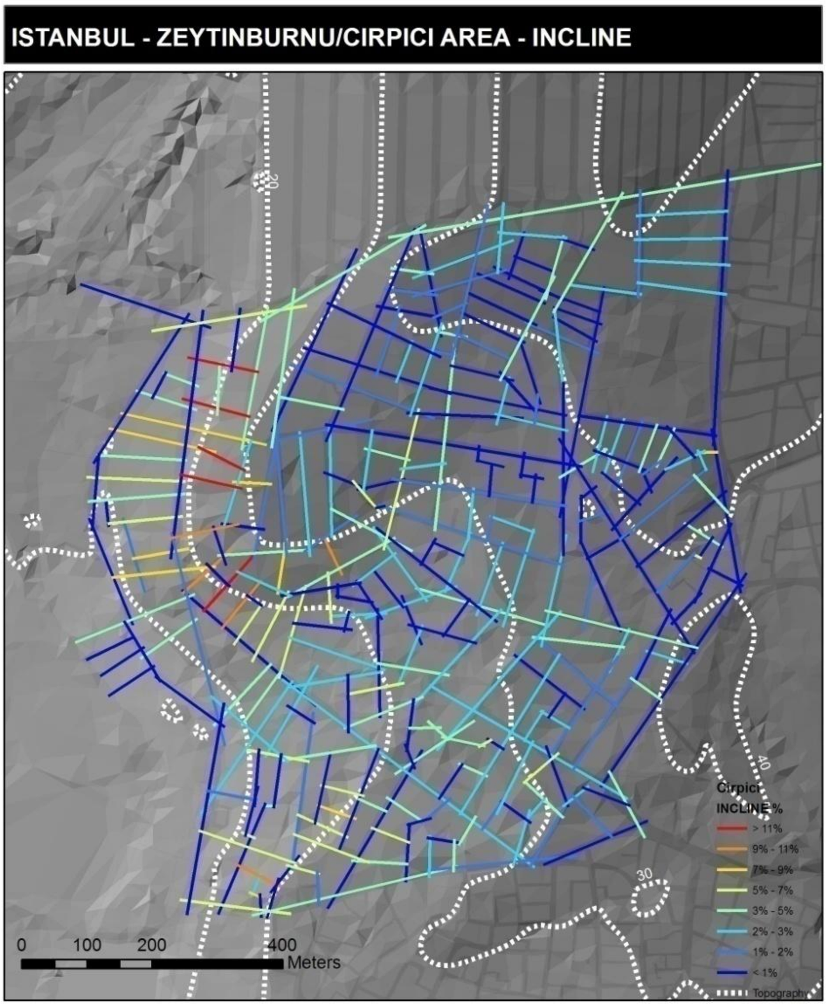


Figure 5.9: Çırpıcı - Zeytinburnu - Incline percentage.

5.2.1.6 Integration and land use

Çırpıcı area generally consists of high dense residential areas and some educational facilities like primary & secondary schools. Main axes in the settlement consist of retail facilities too.

These facilities create additional traffic volume and temporary congestions during the working hours. Space Syntax Integration pattern and these main axes overlap.

The buildings coloured red in figure 5.10 already have commercial or retail activities on the ground floors. This shows the importance of the main axes in emergency period.

The lines with higher integration values and dense usage for daily activities mean that these streets are most knowledgeable, permeable and convenient ones in the whole system.

In the figure 5.10, the integration value and the seismic vulnerability thematic representations are intentionally overlapped in order to provide the super-positioning of the risk assessment. In general, integration estimates the density of pedestrian usage in such settlements.

As the Space Syntax methodology suggests that central red lines are supposed to be socially integrated ones, the map reveals the risk fact of the settlement since most of the integrated lines are occupied with seismically vulnerable buildings.

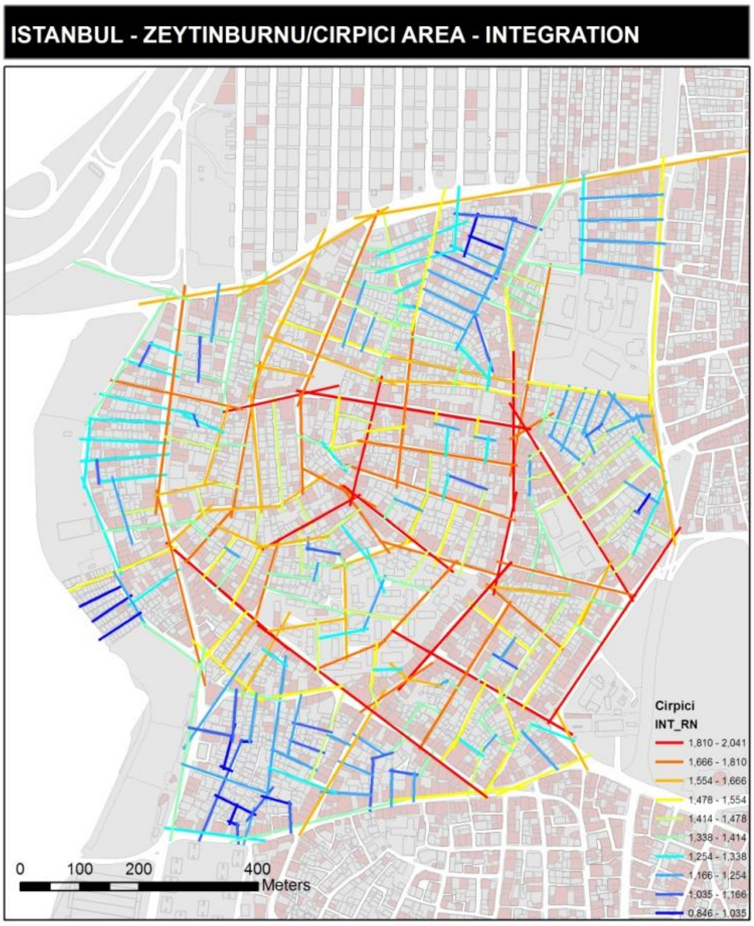


Figure 5.10: Çırpıcı - Zeytinburnu - Space Syntax integration value

On upper scale, integration map of Zeytinburnu (Right) in figure 5.10, the assessment assumes the usage is supposed to be through the D-100 highway for Zeytinburnu district.

As the integration value doesn’t propose efficient orientation or through movement potential of an urban space, space syntax. Choice value is also evaluated for Çırpıcı area.

5.2.1.7 Choice

The upper scale - district level choice analysis would show the thresholds of the Çırpıcı area are defined as the main movement axes as the actual conditions indicate. Moreover, the neighbourhood scale – local analysis (Figure 5.11) shows the higher choice levels indicate that the inner arteries of the quarter in addition to the ones on the edges.

These least angled lines are mostly included as the evacuation corridors by the local authorities in the transformation plans.

But, in urban areas with more undeformed grid patterns, higher choice levels would be scattered randomly within the cluster. In order to evaluate the efficiency of the proposed networks, outcomes of the risk assessments; calculated as the Risk Values, should be overlapped with these lines.

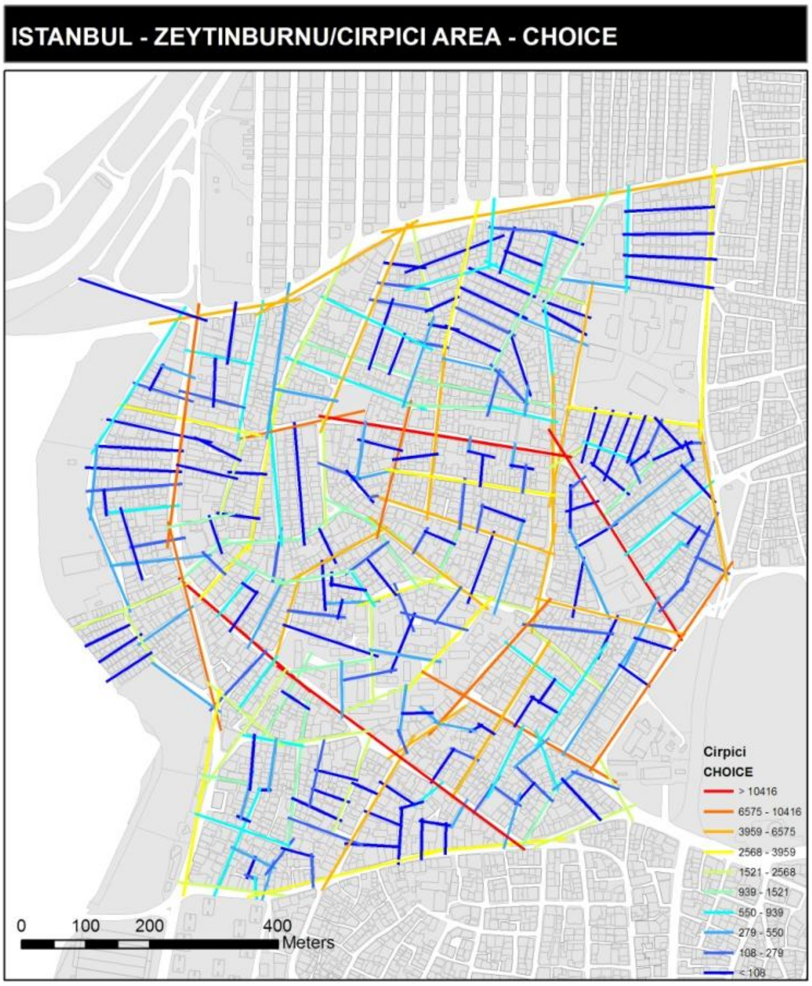


Figure 5.11: Çırpıcı - Zeytinburnu - Space Syntax choice value

5.2.1.8 Connectivity

Space syntax connectivity value is used in an unusual context in this model proposal. It assumes that a street with higher numbers of openings to other spaces have more alternatives to evacuate or to be reached. In this context, for especially deformed grids like organic shaped settlements or existence of Islamic cul de sacs reveal, as threats against the evacuation and access.

For Çırpıcı case, we may say that this settlement is a deformed grid and there are no significant numbers of dead ends which decreases the risk value for each segment and secures the streets.

In the figure 5.12, colder colours show the least possibility to escape or to be reached. 9 of 25 building with highest blockage risks have only 2 connections in the area. This figure can be depicted as 36% of these streets or connections will eventually block while these don't have any alternative escaping openings but entrances and exits.

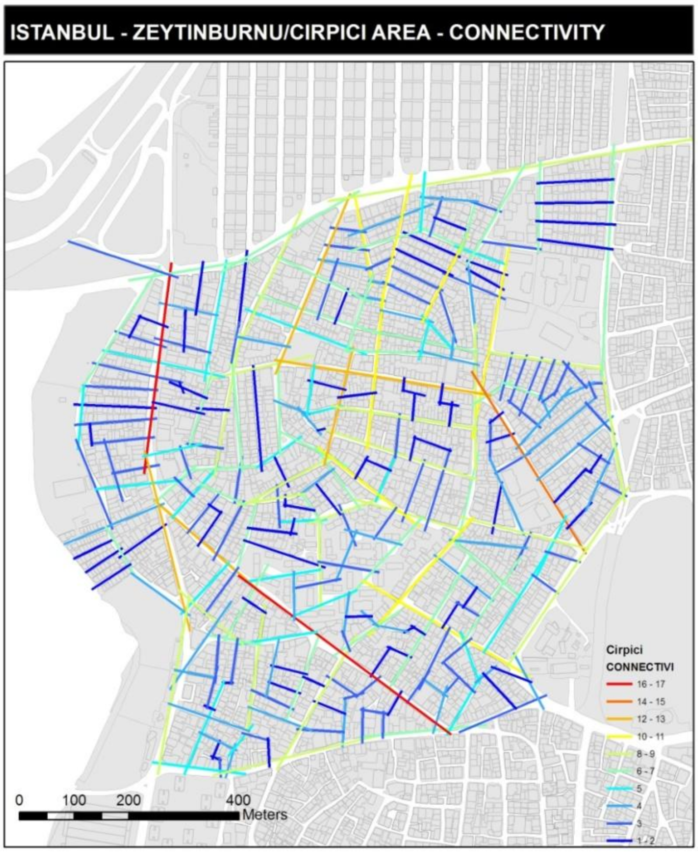


Figure 5.12: Çırpıcı - Zeytinburnu – Connectivity.

5.2.1.9 Road risk value

The entire risk assessment variables outcome as the risk values for each road segment on the case areas. When spatially represented, output maps could be used as tools in intervention strategy definitions or more articulated emergency processes by the professionals. However, depiction of these outcomes is crucial as they may not always give spatially consistent maps.

For instance, in Zeytinburnu, Çırpıcı area, the outputs in figure 5.13 show that the risk is concentrated to the NW of the settlement and also scattered around it. So the articulated definition of the risk may not be the efficient tool for an emergency planning process given this process is mainly based on the sustainability of the physical structure and accessibility in case of a disaster.

In order to achieve the provision of the base for an emergency planning process, it is significantly necessary to merge the risk evaluation and the combined physical & social interrelations on the same level.

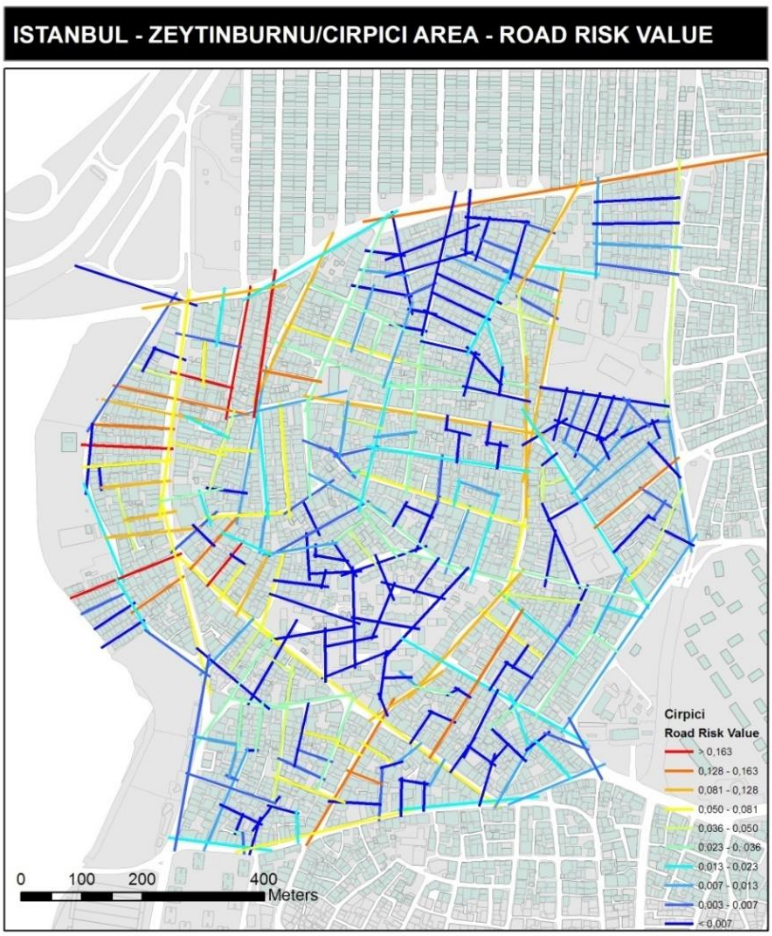


Figure 5.13: Çırpıcı - Zeytinburnu - Road risk values.

5.2.1.10 Index of intervention

The Index of Intervention map for Çırpıcı area give more consistent findings overlapping with both the road hierarchy and the proposed risk assessment.

Study show that Prof. Turan Güneş Bld., Hoca Ahmet Yesevi street, Seyit Nizam Road, 75/2 street, Rüstem Balkan Roads have more urgent intervention needs for both local and upper scale earthquake security throughout the settlement.

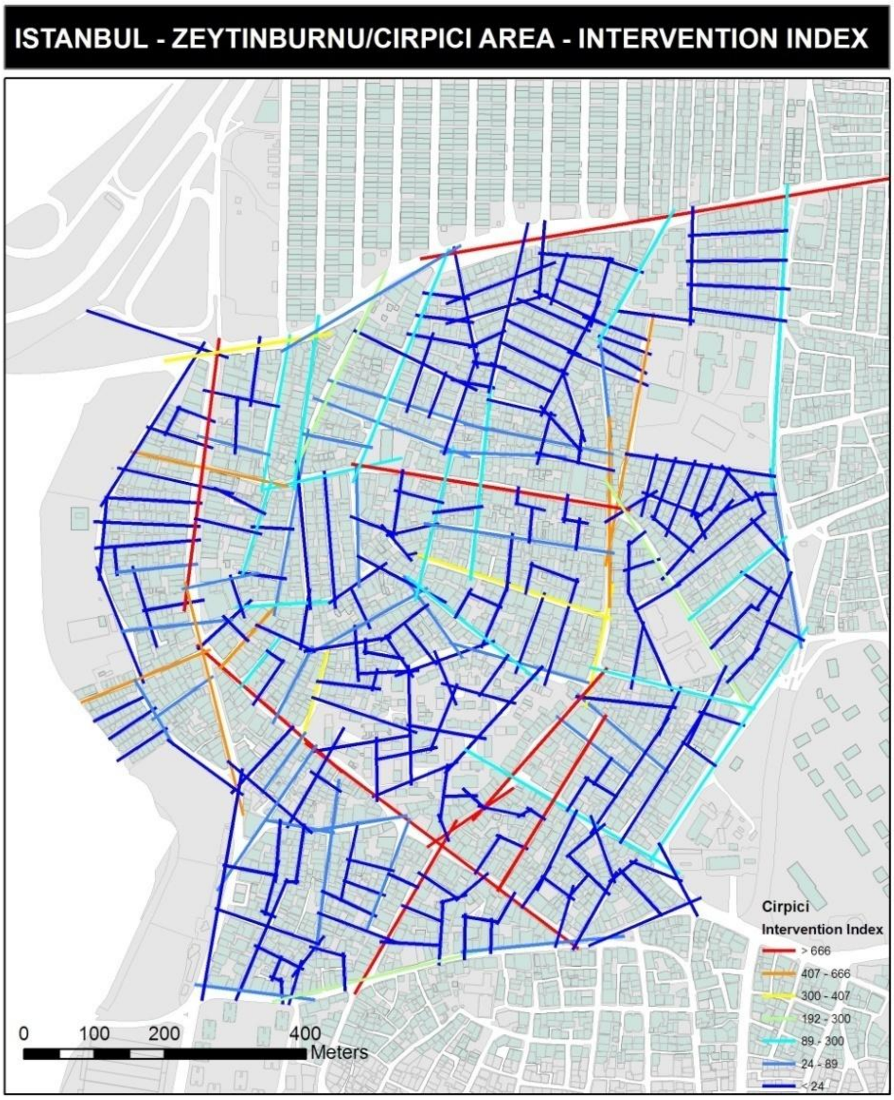


Figure 5.14: Çırpıcı - Zeytinburnu - Index of intervention.

Given there are already evacuation and risk management plans being implemented for Çırpıcı and Avcılar regions, the findings are discussed and compared mutually. The proposed role of the findings of this study in emergency planning is also given with headlines in conclusions.

5.2.2 Avcılar area (40°58'43N, 28°43'25E)

Avcılar is a modern residential and industrial district with 348,635 residents, located 22 km to the west of Istanbul historic core. The settlement initially had been used as the countryside for the residents of Istanbul. Since the beginning of the 1960s, settlement started to growth and become a part of the urbanized Istanbul.

Industrial development commenced in Avcılar following the construction in 1959 of a fuel-storage facility and a thermoelectric power plant. The number of industries in Avcılar increased to 350 in 1990 from nine in 1970. The completion of the Avcılar campus of Istanbul University by the end of 1980 also stimulated urban activity (Şengezer, 2005).

District is divided into parts by the D100 highway, one of the main highways passing throughout the whole urban area of Istanbul.

The case area with 161,144 people (DIE, 2009) located in the southern part of this road. Within the Istanbul city borders, this area is the most damaged area during the 1999 Kocaeli Earthquake with 261 deaths, 40 collapsed buildings and 86 heavily damaged structures.

The main economic activity is industry with both small and larger sizes (501 units in total), particularly concentrated on the western part of the settlement. In addition to industrial facilities, there are also a Thermal power plant and a petrol distribution port which are considered as risky functions very close to the residential areas.

Figure 5.15: Avcılar - Location in Istanbul.

The population density is not high as Zeytinburnu Çıpıcı area but still considered as high with 535 person / hectare with an average number of floors of 4.4. There are 6,977 buildings in this case area consisting of 51,250 residential units.

JICA report indicates that, including a significant number of vulnerable buildings compared to other parts of Istanbul, the area compassing on Zeytinburnu, Bakırköy and Avcılar districts will be highly impacted by an earthquake according to the different disaster scenarios (figure 5.16).

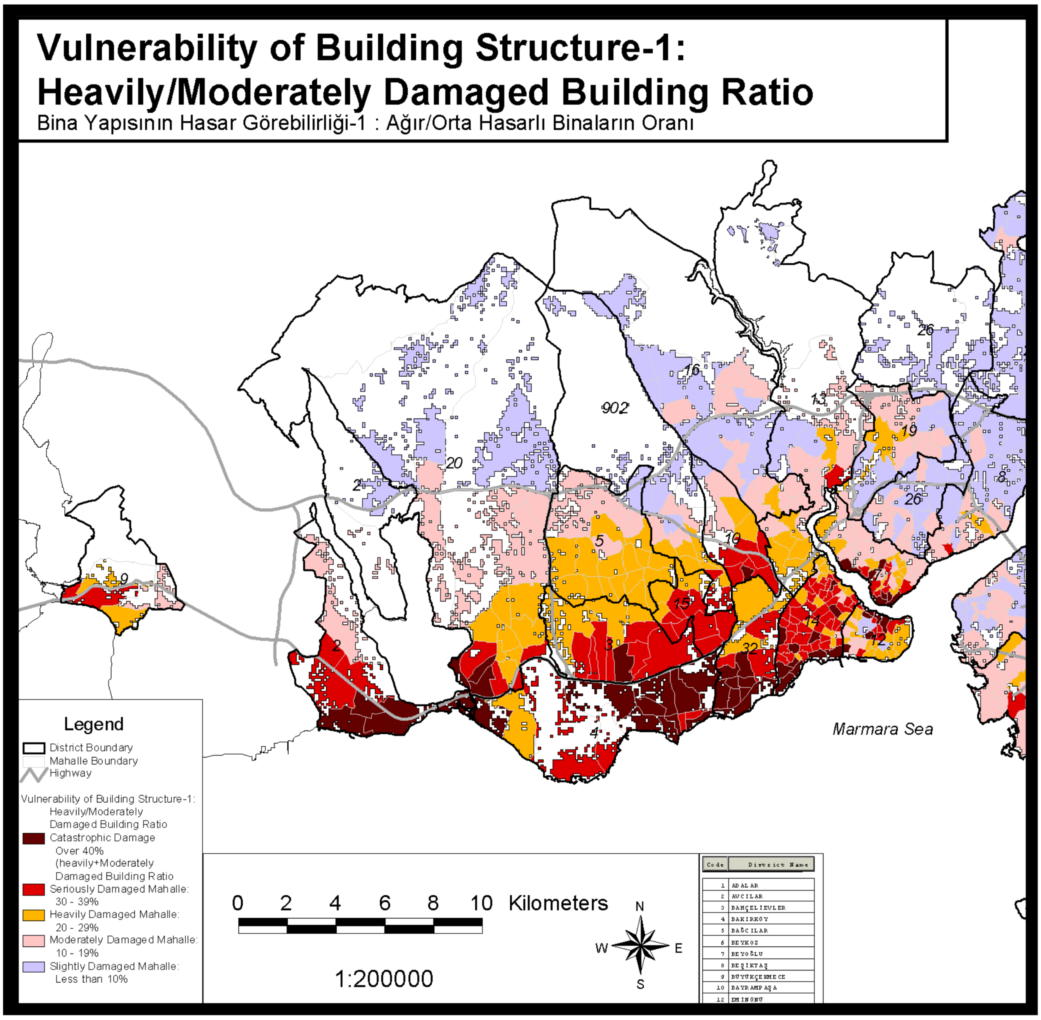


Figure 5.16: Western Istanbul, vulnerability of building structure (JICA, 2002).

Given the Avcılar area has a dynamic economy with the industrial and commercial facilities, the affluence level of the residents are higher than the Zeytinburnu district. Also, property values to the coastal area including promenades are very high compared to other parts of the settlement. However, this coastal part also holds the vulnerability.

Nearly most of the buildings are made of concrete, as Şengezer states; When concrete framed houses collapse, they are considerably more lethal and kill a higher percentage of occupants than other types of buildings.

Some other factors, such as soft soil, high density and a greater number of floors, increase the vulnerability of buildings by as much as two or three times (Şengezer, 2005). Regrettably, Avcılar area holds most of these risky characteristics. 2,681 of the total buildings are scored under 35 points with the Seismic vulnerability evaluation.

Figure 5.17: Avcılar coast (left) and D100 Highway (right).

Urban configuration is mainly developed in grid iron pattern on the settlement. This means the possible routes for evacuation and access is more diverse and delivering people from the disaster core would be less difficult than any other example with a deformed grid pattern.

However, most of the buildings are made of concrete and high. In addition day time traffic and pedestrian density is much more than Çırpıcı area since this case includes the district centre as the main destination for all residents of the whole district. Highway passing through Avcılar, connections and openings on these junctions are often get congested during the day time.

Additional loads of traffic should be considered as another obstacle for the intervention actors in the event of a disaster.

The north Anatolian fault line passes 10 km to the south of the Avcılar area under the sea. In addition to the building damage and possible physical impacts to the built environment, tsunami is also a threat for the coastal residential parts.

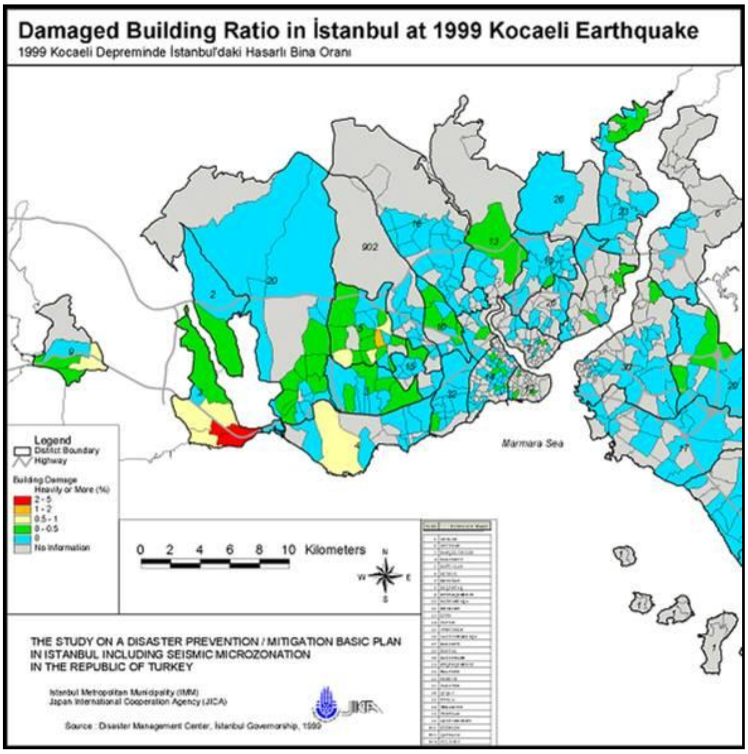


Figure 5.18: Western Istanbul – Damaged building ratio in Istanbul at 1999 Kocaeli Earthquake (JICA, 2002).

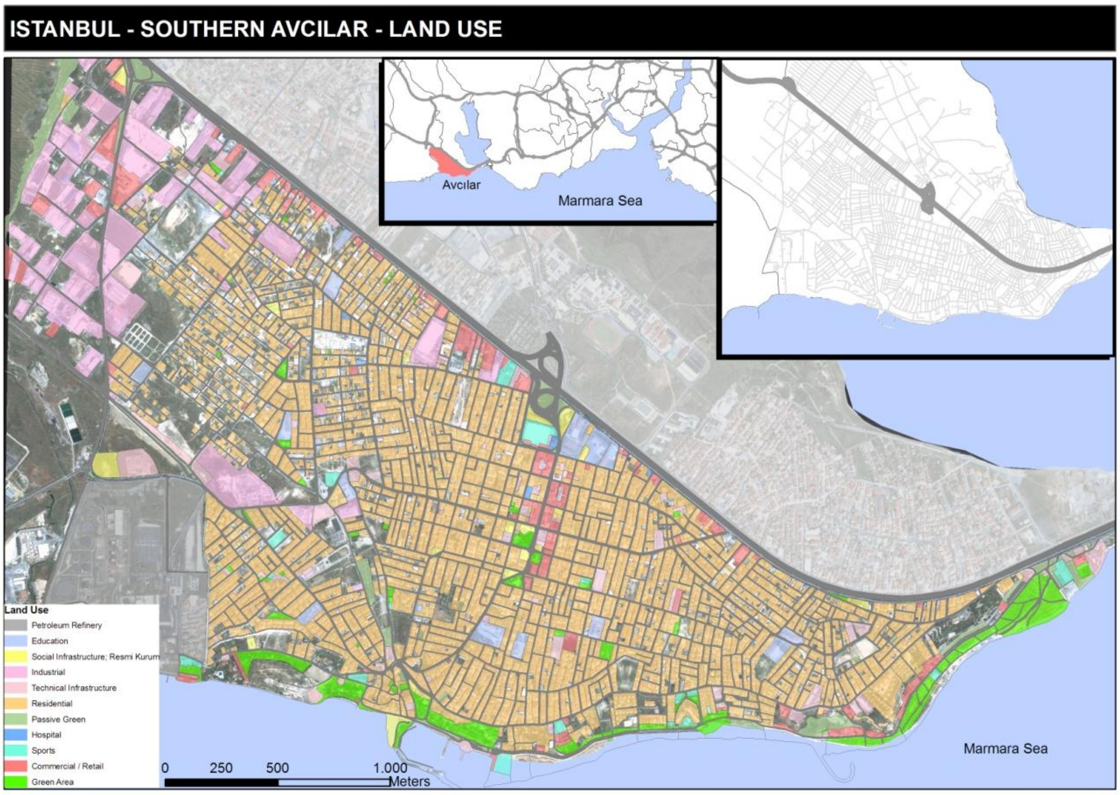


Figure 5.19: Avcılar - Land use.

In detail,

-The case area compasses on 1,119 hectares with 51,250 residential, 7,197 commercial and 501 industrial units with 161,144 people in 6977 buildings.

-The geometric centre of the area is overlapping with the Avcılar district centre with service, retail and commercial land uses. It is very busy in the day time since it is taking loads of people with the gravity of the centre.

-Industrial area to the west and Port area to the SW adds extra truck traffic to the south-north axis of this part.

-University campus to the north is taking extra population from outside the district.

-Finally lack of active green spaces in the settlement (1,18 sq m per person) rises the earthquake risk accordingly.

5.2.2.11 Seismic vulnerability

2,681 of 6,977 buildings took the score under 35 with the seismic vulnerability assessment in Avcılar. Around 79,000 people are currently living in these building.

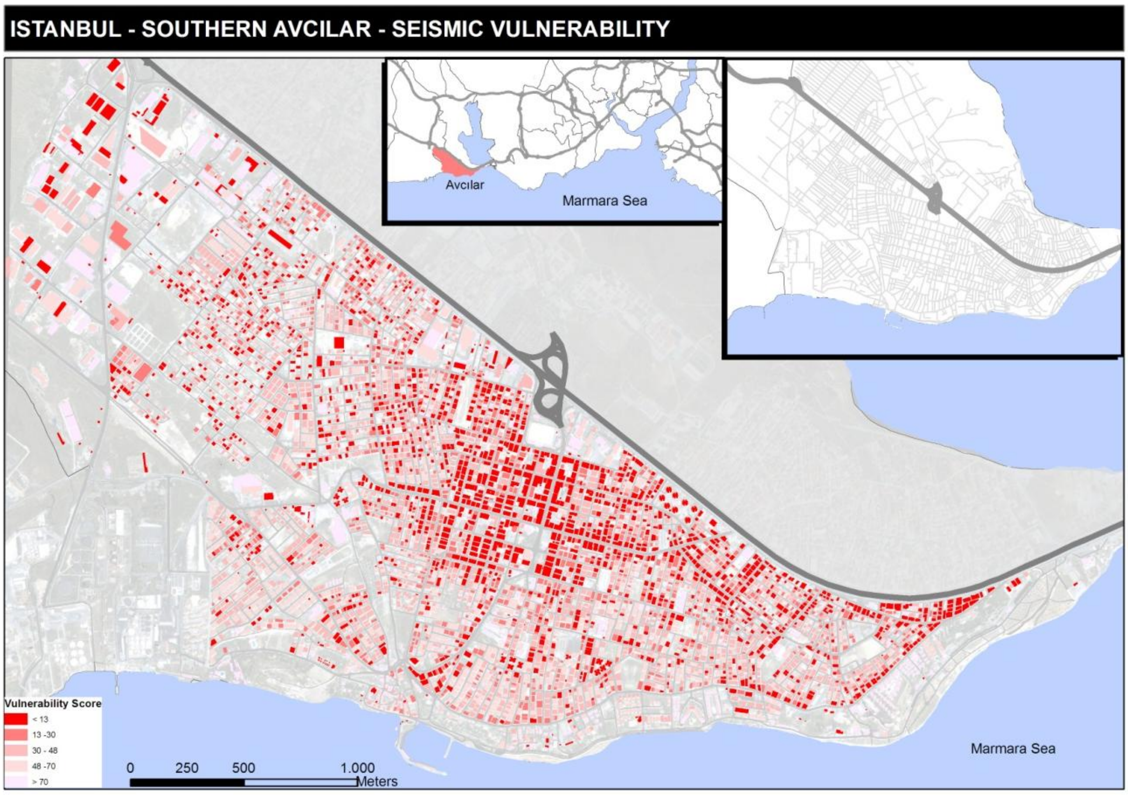


Figure 5.20: Avcılar - Seismic vulnerability of the buildings.

As seen in figure 5.20, the vulnerability reveals on the core of the settlement probably with the direct proportion of number of floors.

This case show that the earthquake would regrettably make more impact on the people than the resident population given the day time population is very high compared with other parts. In addition central parts of any settlement generally have high property values which can reveal as another obstacle against the planning progress.

Also, in 10 km radius, there is no access or egress junction to the settlement but the central junction, which is fully surrounded by the vulnerable buildings (Figure 5.20).

5.2.2.12 Road blockages

Without giving any details on the traffic volume or the pedestrian density on the core, the simple road blockage calculation regarding the road radiuses and risk assessment reveal that the most of the possible evacuation axes are going to be broken in this urgent cluster.

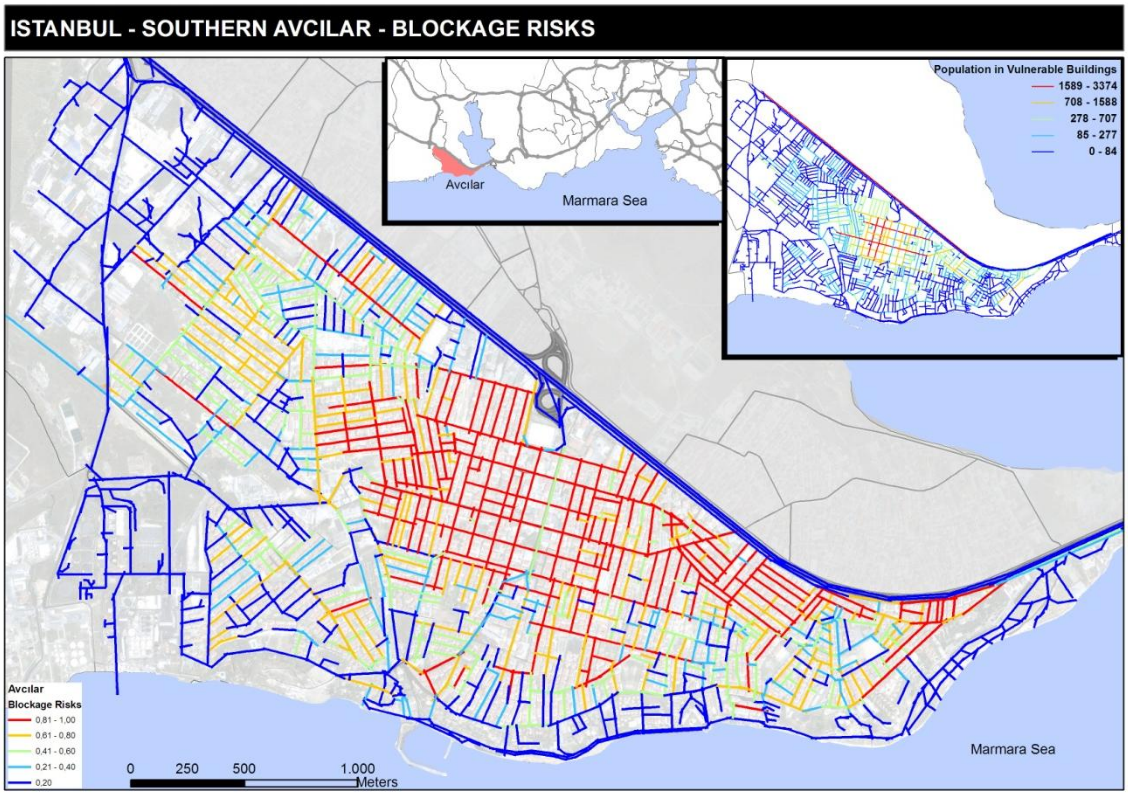


Figure 5.21: Avcılar - Road blockage risks.

There are 1,123 lines in this study. 145 of these are assumed having high potential to be blocked by a building collapse. Although it doesn't sound dramatic, spatial distribution of these front-runners to be blocked is alarming. Because, those are concentrated within 1 km radius where the entrance junction of the district centre is located.

5.2.2.13 Population under risk

There is a direct proportion between the building heights and the population even though there are additional non-residential functions in the core. So, if we draw the primary zones for vulnerable buildings, blockage risks and population under direct risk roughly, these patches are eventually overlapped within the centre of the district.

The point to be highlighted here should be the secondary risks that the rest of the population living outskirts of the centre in more secure buildings, since risk facts seem to not allow the access and egress to the district as a whole.

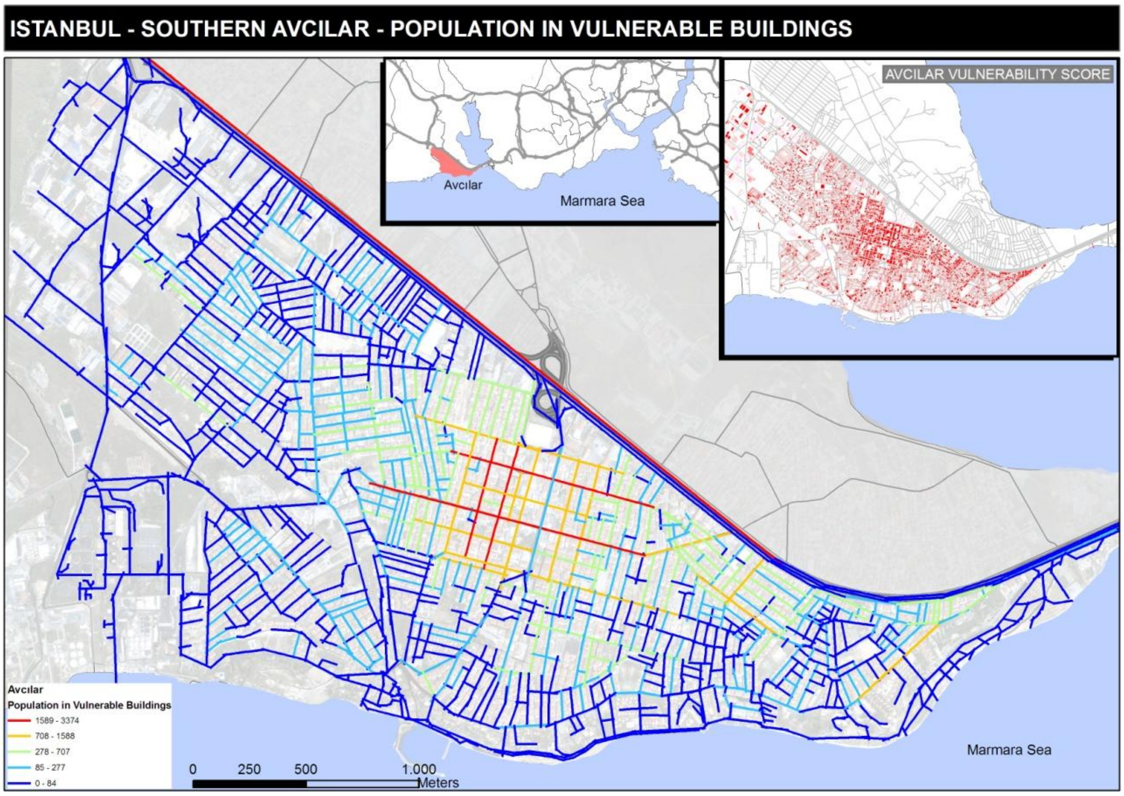


Figure 5.22: Avcılar - Population in vulnerable buildings.

5.2.2.14 Incline

There is a soft elevation grade from the north to south in Avcılar. Except the coastal band to the north, there is no major steepness which can manipulate the natural movement patterns or vehicular traffic.

Figure 5.23: Southern Avcılar - Concrete buildings having entrance from upper floors only.

In some parts of the southern edges, there are significant level differences between roads and the buildings due to the incline.

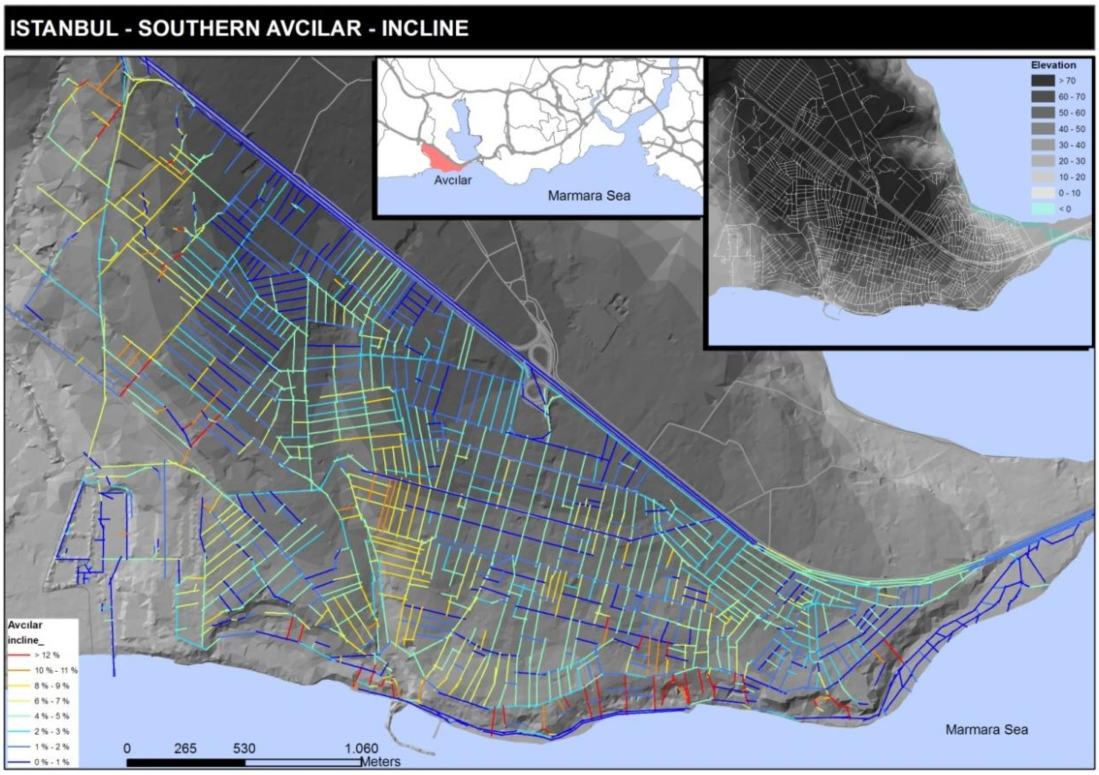


Figure 5.24: Avcılar - Incline percentage.

When a road is on the higher level than a building which has an opening to this road, the entrance of the building can be provided from 2nd, 3rd, or even from 4th floors as in figure 5.23. As the small bridge like connections to the buildings are weak, these connections also wouldn't help to evacuate people from these buildings.

5.2.2.15 Integration and land use

Theoretically, the integration measure shows the cognitive complexity of reaching a street, and is often argued to 'predict' the pedestrian use of a street. It is argued that the easier it is to reach a street, the more popularly it should be used.

Space Syntax global integration value indicates the centrality of the grid iron pattern for this settlement.

Commerce in minor roads is only directed at the internal inhabitants of the settlement, therefore has little economic relevance. Commerce in main axes in the centre, on the other hand, also attends the neighbouring area.

Therefore, if the settlement is well integrated in its local contextual area, it can become a powerful mechanism to bring in resources from outside the settlement (Greene, 2003).

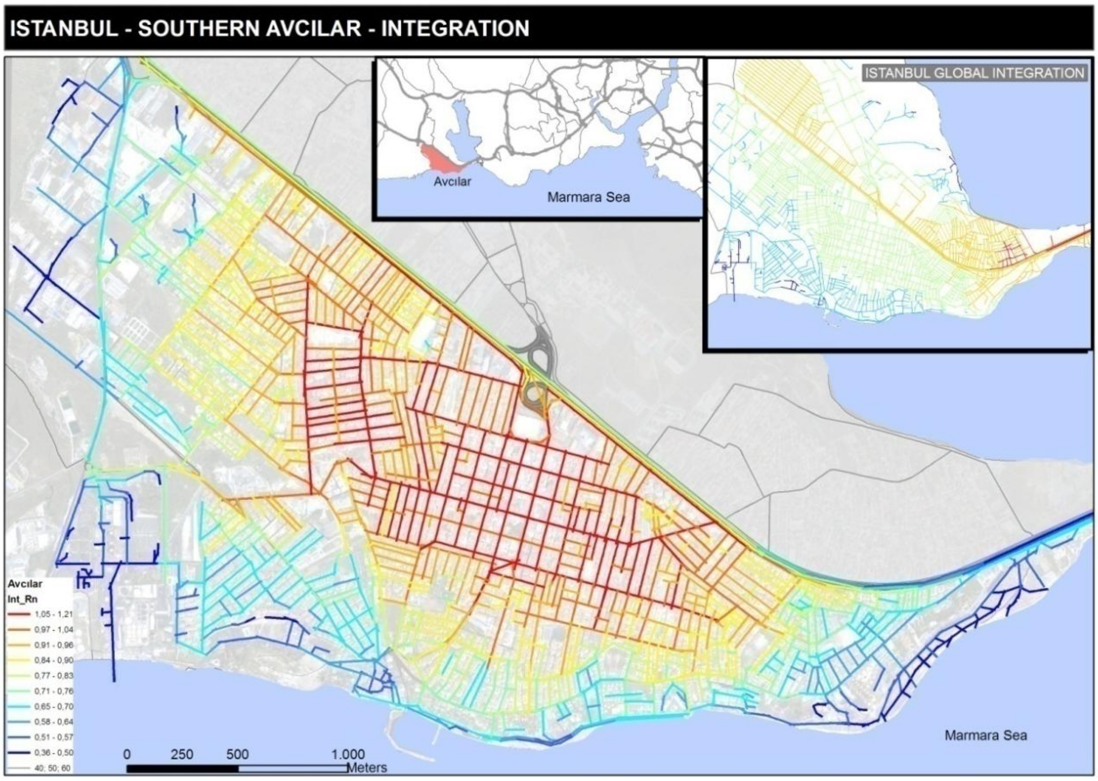


Figure 5.25: Avcılar – Integration.

Avcılar centre is densely used by pedestrians and vehicles since the area is the major destination with its functions. The western part is mainly industrial and the southern parts of Avcılar consists of low dense residential. Both regions are segregated with their functions and syntactic properties.

Major destinations are Marmara Caddesi (Very crowded pedestrian retail boulevard) in the heart of the district), Namık Kemal Caddesi, Kirazlı Caddesi and Reşit Paşa Caddesi, all boulevards with mainly commercial and public accounts.

5.2.2.16 Choice

Choice is a measure that demonstrates the existence of alternative routes from one space to another or the degree of choice that each space represents for its immediate neighbours as a space to move to. Choice may also be a better predictor of movement for inhabitants with better knowledge of the layout than strangers who rely on reading the layout in order to move.

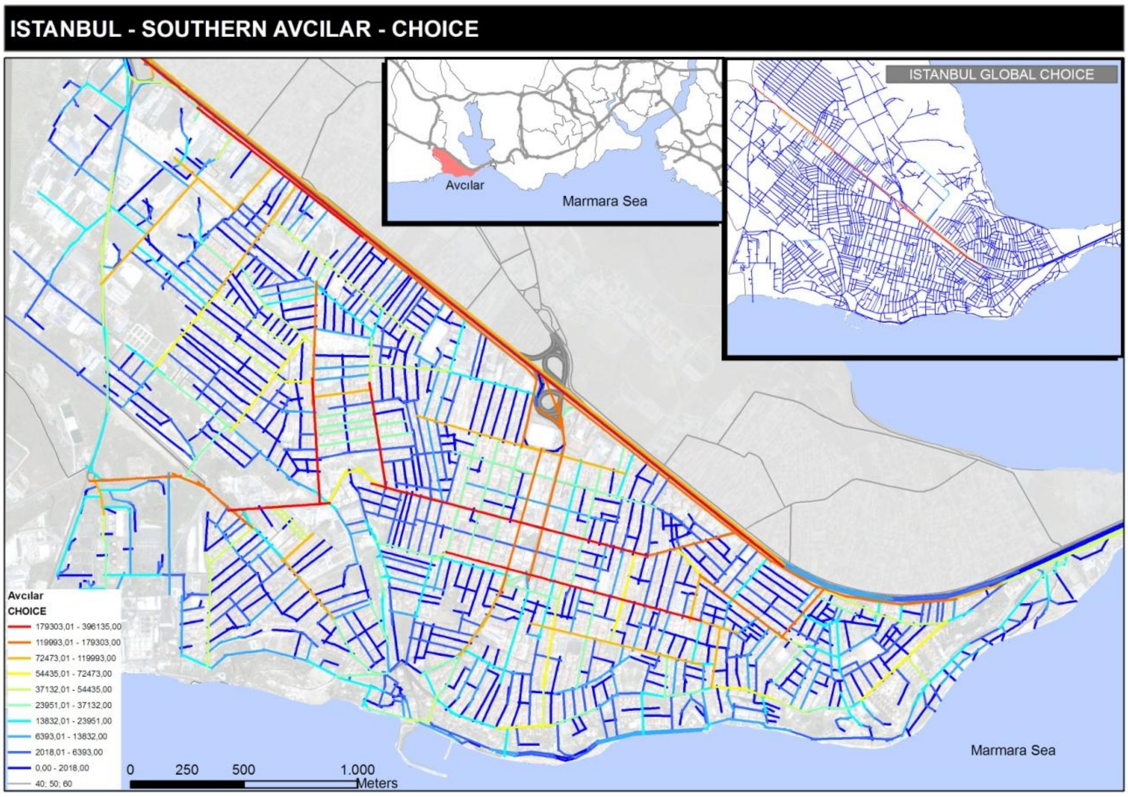


Figure 5.26: Avcılar – Choice.

Choice value in Avcılar expresses some ring connections to the highway.

But the design of the road directions doesn't actually indicate that the highest choice values completely overlap with the main drivers of the current through movement pattern. This might be a consequence of design decisions for the traffic circulation inside the area. Nevertheless, the outputs may help to evaluate the current spatial configuration of the roads and take an active role in any design process.

5.2.2.17 Connectivity

Connectivity sometimes means high choice level in some examples. In formal grids, we may also predict that the longest straight streets have the highest connectivity level.

For the topmost cluster, there is a significant correlation between connectivity and choice values in Avcılar example (figure 5.27), indicating that particular fragments of the grid are benefiting from being in the centre and also more accessible from the city main road network. This reveal as an opportunity to define the axes for initial intervention with the additional risk assessment works.

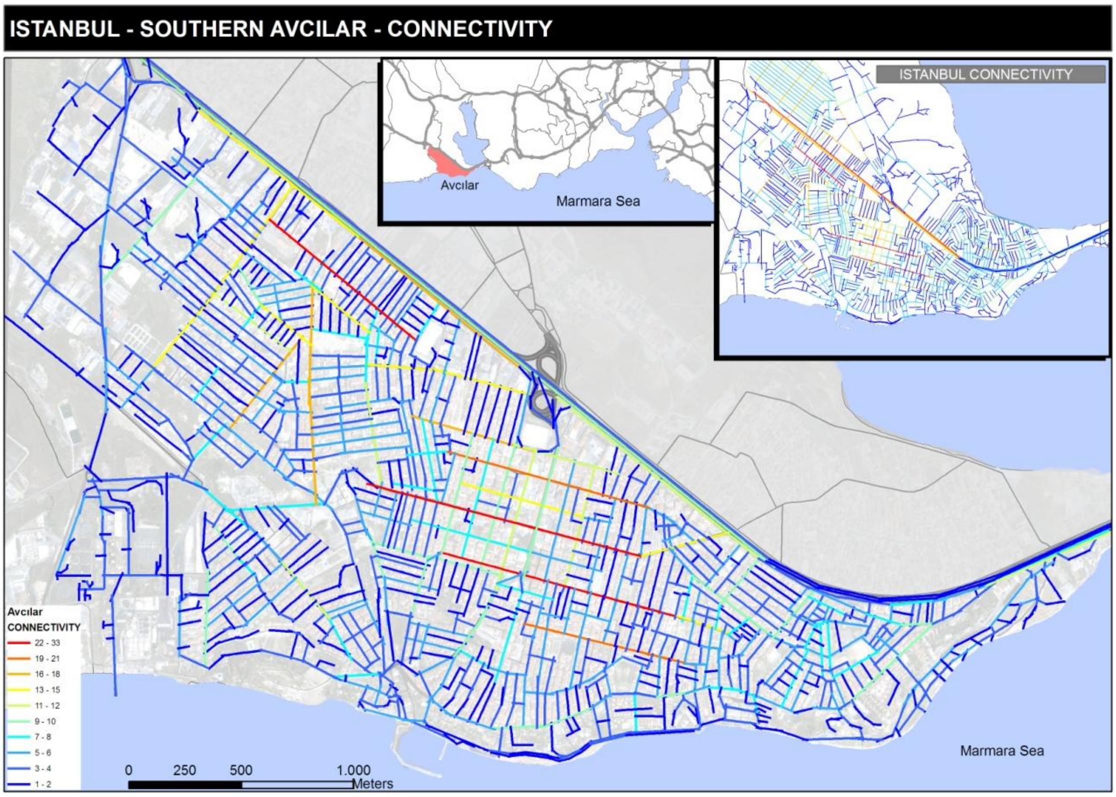


Figure 5.27: Avcılar – Connectivity.

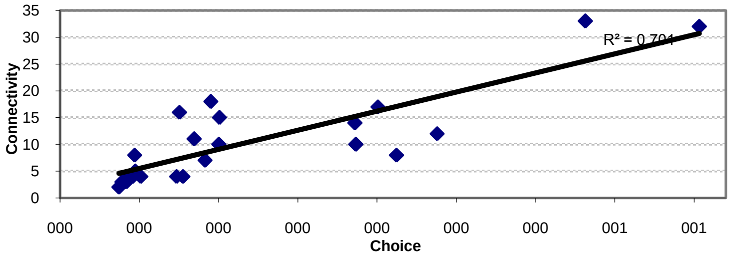


Figure 5.28: Avcılar - Relativity of Choice and Connectivity values.

5.2.2.18 Risk Value

As in Çırpıcı outputs, the risk assessment outputs in Avcılar give no spatially consistent outputs but scattered clusters throughout the settlement.

Although the seismically vulnerable buildings are mainly located in the central parts, additional population under risk due to the building collapses seem to located to the outskirts. This means risk in here will affect enormous proportion of the residents after the initial impact. So, although the population under primary and secondary risks should be the main concern here, the through movement potentials should also be added to the equation in order to define the order of intervention.

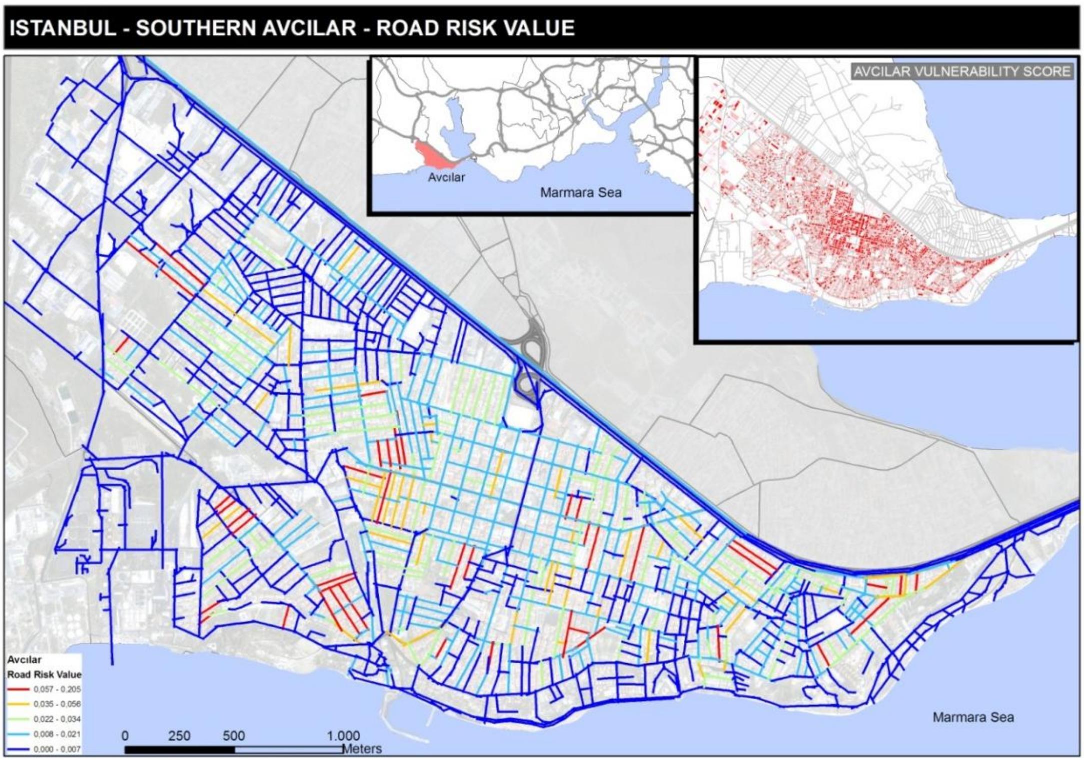


Figure 5.29: Avcılar - Road risk values.

5.2.2.19 Index of intervention

Central fragments of Avcılar districts in red colours in figure 5.29 basically indicate the initial intervention areas with;

- Density of pedestrian interactions (with most “shallow” syntactic properties)
- Retail facilities attracting these interactions,
- Population under risk inside the seismically vulnerable buildings
- Routes for securing the additional population living on outskirts under indirect risk during the disaster period (eventually use these roads to evacuate).
- Through movement potentials with assistance to evacuation.

These basic findings are discussed in the next chapter in comparison with Çırpıcı area in Zeytinburnu district. Evaluation of the intervention index maps and depicted outcomes are supposed to help the emergency planning process.

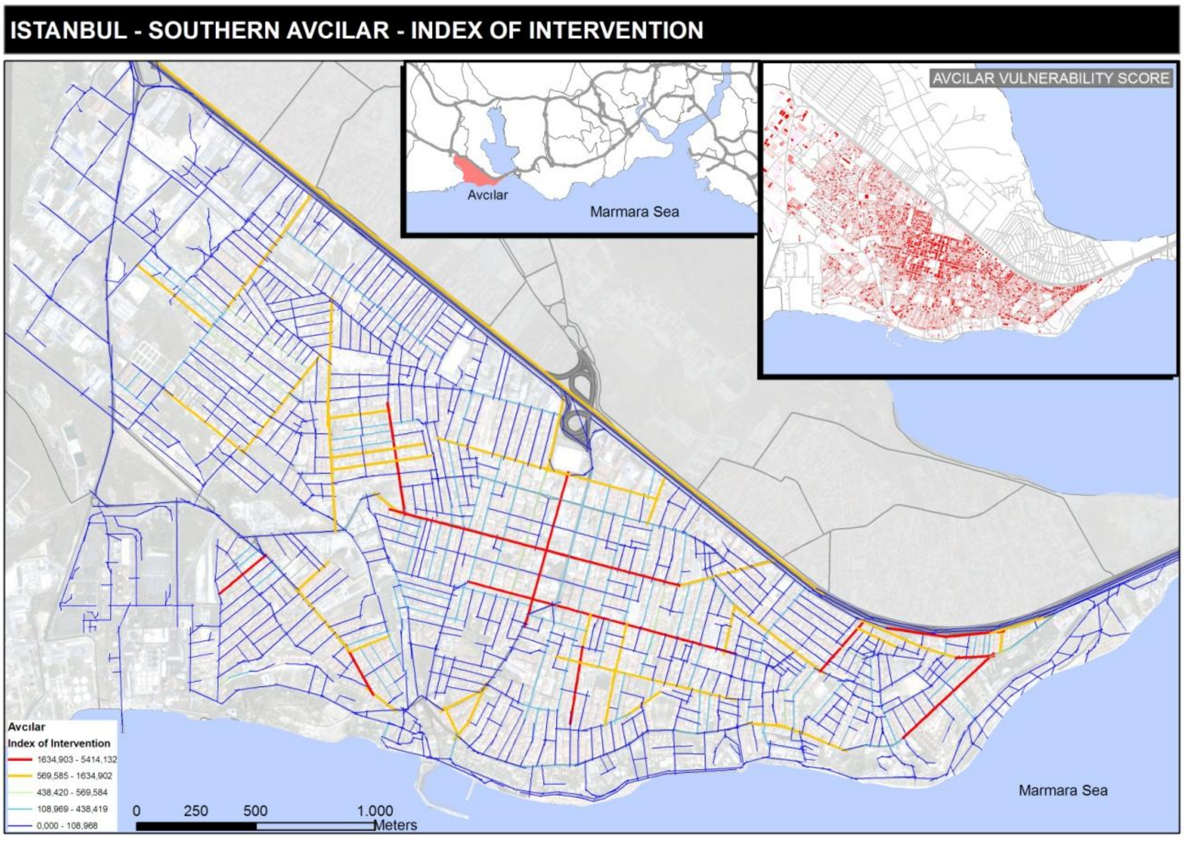


Figure 5.30: Avcılar - Index of intervention.

5.3 Review on the Case Sstudies and Key Findings

Although Zeytinburnu and Avcılar areas have distinctive physical and social configurations, they have high population density and vulnerable urban spaces as most important similarities. Therefore, these two settlements have been taken as case areas for this research.

Table 5.1: Çırpıcı / Zeytinburnu and Avcılar areas in numbers.

	Çırpıcı	Avcılar
Population	55.356	161.144
Area (sqm)	846.000	7.906.000
Density (Area per person)	15	49
Average No Of Floors	4	4
Buildings	3.177	6.977
Vulnerable Buildings	497	2.681
Population in vulnerable buildings	12.208 (22%)	82.479 (51%)

As seen in table 5.1, Avcılar and Çırpıcı settlements have different sizes in means of area and population. This is intentionally covered in this study in order to grab the outputs for different scaled settlements.

5.3.1 Vulnerability

Although Çırpıcı area has the higher population density, vulnerability seems to be more crucial in Avcılar. 51% of the population in Avcılar are living in buildings considered as vulnerable to earthquakes.

In fact, these numbers reveal one of the major demands for this study. Although Çırpıcı has relatively lower earthquake risk, it is still holding the casualty possibilities due to secondary effects of the earthquakes. With the help of the blockage risks and evacuation difficulties due to the usages inside the settlement, the expected casualties may be as high as in Avcılar area. On the other hand, Avcılar has different issues of vulnerability against the primary and the secondary impacts of the earthquakes too.

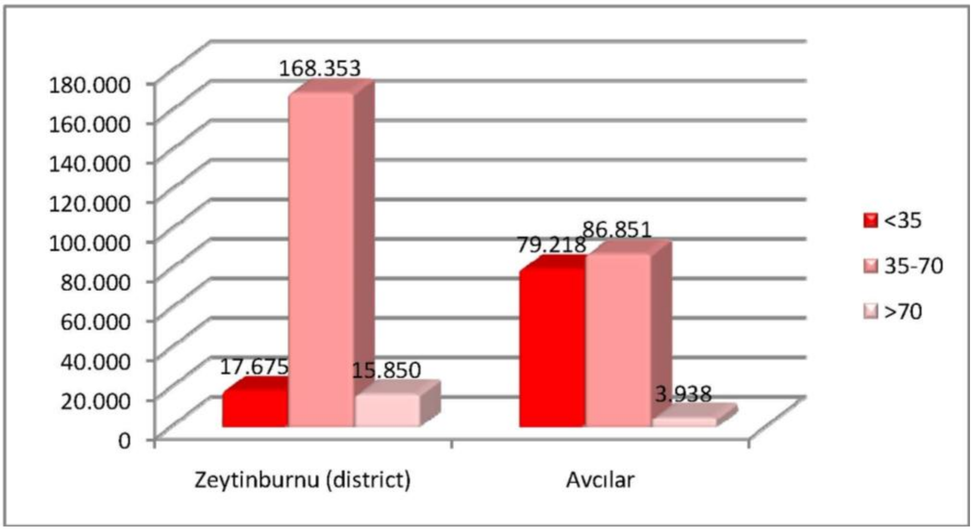


Figure 5.31: Number of people living in buildings, clustered with the seismically vulnerability scores in Avcılar and Zeytinburnu (IMM, 2005).

5.3.2 Accessibility: Connections with city main road networks:

Çırpıcı, as a whole neighbourhood, has convenient evacuation alternatives since the western boundary of it mainly consists of open spaces. Also, this settlement is very close to the city main road network (500 mt. to the D100 Highway) allowing the access to the area more comfortable.

Avcılar, on the other hand, has a face to the same highway but this is from a side road connects it from few points. Major access and egress from/to the area is provided by central junction. This is a very busy junction in terms of day time traffic. Choice, Integration and Index of intervention values showed that this junction and surrounding road network have a significant importance on security of people in the district.

Southern boundary of the settlement is coastal area which will allow emergency actors to reach the area from the sea. Despite the index of intervention doesn't show any major retrofitting in here, provision of the durability of the port in the case of emergency is crucial.

Figure 5.32 shows that intervention values in Zeytinburnu/Çırpıcı area reveal especially on the surrounding edges of the settlement. Besides, Avcılar has centrality issue that indicate significant number of people can be secured with the enhancing physical quality in the district centre first.

Index of intervention value for Çırpıcı and Avcılar should be considered as starting point rather than another layer for disaster mitigation planning process. Although these outputs can be scattered around the examples and there would be no consistency with the actual or proposed network, these lines should also be considered one by one as they have distinct risk factors and intervention possibilities.

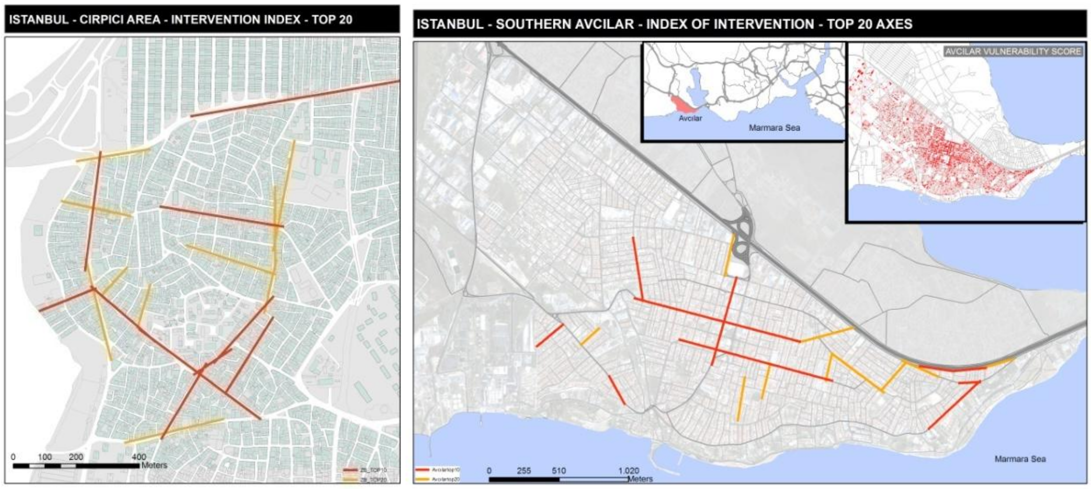


Figure 5.32: Index of intervention values (Highest 20) for Çırpıcı and Avcılar.

5.3.3 Overlaps with the proposed road frameworks:

Securing an area from a disaster requires articulated and detailed base data and constant management of the planning process. In the stage of defining risk and indexing the actions accordingly to these risks, the outputs of this study become important.

Zeytinburnu Pilot Project, which has a very detailed and sophisticated planning background and modern approaches to disaster mitigation, defines the evacuation routes for Çırpıcı area as seen in figure 5.33. Although index of intervention value outputs and these proposed evacuation axes don’t overlap. While the Index of Intervention offers the streets marked with A and B, the project offers C in project map.

The main reasons for this inconsistency may be;

-The scale differences between the plan and the proposed study,

-Property availability in C zone (Not considered in the proposed model)

-Lack of information on population density and blockage assessments in the planning process

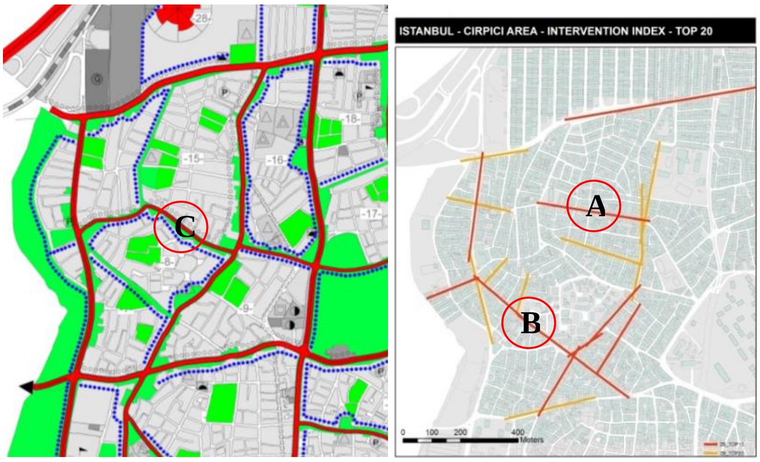


Figure 5.33: Proposed road hierarchy (Left - IMM, 2005) and Index of intervention values (Highest 20) of Çırpıcı Area, Zeytinburnu.

In Avcılar case, the proposed road network and anticipated evacuation corridors almost compasses on the lines in the index of intervention map successfully.

At this point, the important issue understands that the proposed network map is the future state of Avcılar. This means there will be a retrofitting process in order to secure these lines and build the proposed roads. This process needs time and money while the earthquake risk constantly remains the same. At this point, Index of intervention value gives a chance to define priorities among these roads to be secured. The highest value means highest number of people to be secured.

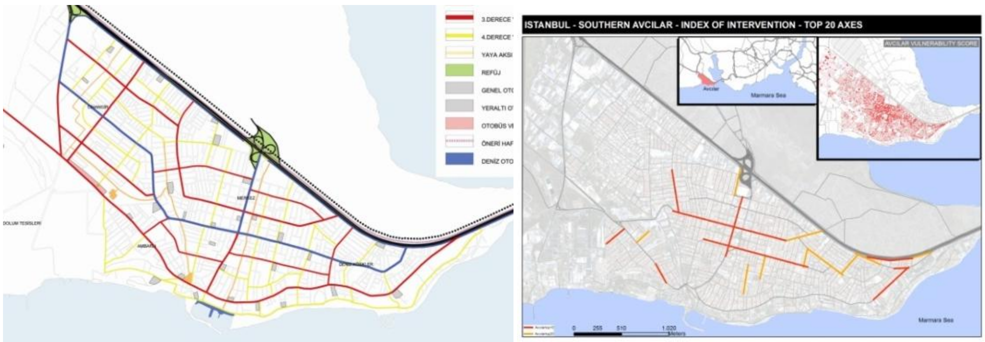


Figure 5.34: Proposed road hierarchy (Left - IMM, 2004) and Index of intervention values (Highest 20) of Çırpıcı Area, Zeytinburnu.

As seen in both examples, Index of Intervention gives solid outputs, consistent with the current and proposed road scheme, and giving priority of the earthquake risk.

6. CONCLUSIONS

In the response phase of any disaster, especially for the vulnerable settlements, evacuation and access facilities become dependent to physical durability of the disaster core. This means, in addition to initial casualties, weaknesses of buildings and infrastructure may dramatically increase these figures.

Main issue that has been taken into consideration in this study is the secondary casualties in the disasters core after the earthquake. People, who survive from the incident, may get trapped in the disaster core because of fires, collapsed buildings, fallen bridges, broken lifelines etc.

It has been assumed that the mitigation of these secondary risks need to be managed well and any intervention measurement should be done in most sufficient way since the vulnerable settlements in poor communities need urgent retrofitting works with very limited economic resources.

The issue of amplification of casualties due to the vulnerability of physical structure has been successfully avoided in developed countries. Even in most devastating earthquake scenario in California, the minimum expected casualties don’t get higher than 200 people while this number is 73,000 in Istanbul according to JICA report – Earthquake Model A.

According to the casualties from the earthquakes, the higher numbers take place in developing or poor countries. For the poor communities having the disaster risk in urban areas, it doesn’t possible to secure the population from the disaster risk in short time.

Also, with this study, it has been interpreted that a sufficient risk assessment and natural movement studies can produce a guideline for disaster intervention process.

The challenging questions considered in this study are:

- Can the casualties due to the weaknesses of the urban structure be higher than the initial casualties of earthquake itself?

- Can rapid avoidance from the secondary effects of the earthquakes be achievable with poor qualities of the urban space and economic insufficiencies?
- Is there any possible way to organize or sort the actions should be taken regarding the people under risk?

6.1 Achievements of the study aims

As the study focuses on the road blockages on the densely formed crowded settlements in the time of an earthquake, it is intended that in retrofitting process, giving the priority to the buildings seismically vulnerable and with high probability of blocking roads after collapsing, will eventually allow the post earthquake services to be provided more easily.

In other words, highly populated fragments with vulnerable buildings will suffer with road blockages due to building collapses. These road blockages may change the orientation of people and act as obstacles for the emergency tools such as ambulance and fire brigade.

In the light of the research questions, aim for the study is proposed as creating a model that provides an index of intervention to;

Save maximum life,

Within shortest term,

With limited economic resources in the case of an earthquake.

The model proposal evaluated two highly vulnerable settlements in Istanbul in order to investigate that whether this assumption can be achieved and successful intervention guidance can be provided to local authorities. Model, is aimed to be act as a layer and depiction tool for total risk assessment and process planning. While the earthquake reality makes the communities prepare disaster management programs and plans, helping professionals on this crucial issue is targeted in the first phase.

The study has two major and joint aspects; the risk assessment and the natural movement. These aspects shouldn’t be considered individually in such studies as the proper combination of these is supposed to give valuable output for disaster management planning process.

For example, risk assessment, including all physical analyses about the urban settlements, can be deficient on defining the social interactions taking place in these settlements.

For such reasons, seismic vulnerability studies, physical characteristics and social interactions are compiled in order to provide a successful output, consistent with the aim of the study.

For seismic vulnerability studies for buildings, the technique used in EMPI is adopted in the intermediate level. Originally it includes three stages, each requiring more detailed works after the previous stage. The first stage inspection/evaluation works are also referred as "street survey" and correspond to preliminary assessment. In this study, the seismic vulnerability evaluation is be used in this level.

Also, population, as the main driver is added to the model framework to achieve better understanding the proportion of the actual risk as it is directly related with the casualties.

For orientation of people and natural movement patterns, the theory of Space Syntax is used. This is a theory and a method for the description of built space, is created by Prof. Bill Hillier in "The Unit for Architectural Studies, University College London", has been used to treat spatial configuration as a variable in a variety of studies of the social functions, cultural significance and behavioural implications of layouts.

The basic findings of the model proposal outputs are briefed in chapter 4. Although the findings are necessary for the process, it is obvious that the disaster management plans require much more variables both local – global.

Avcılar and Zeytinburnu settlements are already in the agenda of Turkish government with supporting plans and action studies since these settlements hold significant proportion people under risk. These plans propose evacuation methodologies, orientation routes and capacity building programmes for securing a successful response period.

Also, these mitigation plans are applied on districts. However, the district boundaries are ineffective in some cases as these are not defined accordingly with the danger zones, topography, geographic conditions and barriers. The case areas are extended to have more proper boundaries in order to recommend efficient outputs to the process.

Summary of the local and overall findings in the light of these case studies as follows.

6.2 Observations

After the study evaluation in the case areas, the observed basic factors of secondary casualties in the case of earthquakes are as follows:

6.2.1 Configurational factors:

Urban pattern & Building density: The geometry of an urban pattern directly effects orientation and the distribution of functions in the urban fabric. In terms of disaster evacuation, grid shape patterns give more convenient alternatives than the organic or deformed geometries. Buildings are the volumes forming these urban spaces. Given the open spaces are the key factor for the security, density of these volumes are generally related with this issue.

Accessibility & Traffic Orientation & Nodes: Accessibility is a vital issue for any function in the urban space for surviving. In this case, being accessible means being reachable in an urgent situation.

The orientation of the traffic, road qualities, density of the nodes and junctions practically has an important role in disaster evacuation and rescue operations.

Seismic vulnerability & Road blockages: Although this issue is mainly related with density and accessibility, minimized seismic vulnerability in a settlement increase durability of physical structure and provide maintenance of the post earthquake operations.

Topography & Visibility & Orientation: The permeability of an urban space is related with these characteristics accordingly.

6.2.2 Social – economic factors

Population & Land Use: Population of a settlement and the distribution of functions in it are useful inputs of the risk assessment. In this study Avcılar is revealed as a highly populated district centre, holding much more people during the daytime, leading the higher earthquake risk.

Affluence: Income levels can be related with the quality of an urban space. However, in vulnerable settlements very close to the city centres, where the property values are high, people prefer to keep living in this vulnerable settlement to remain the economic value of the property. Also, car ownership is another indicator of affluence. In high dense settlements like Avcılar and Zeytinburnu, car parking is one of the major problems against the maintenance of evacuation corridors.

Awareness: Especially for the response phase of disasters, awareness helps reduction of the risks. This includes physical interventions like good signage, orienting stripes, information boards etc. Also training of the residents on disaster evacuation issue is useful action in terms of capacity building and nurturing the awareness.

6.3 Summary of the Research Outcomes

The rapid rehabilitation of urban areas need articulated organization and funding. Provision of cost-lowering process and efficient intervention should be the key issues for this type enhancement for cities.

The figure 6.1 shows the simple outputs from the proposed intervention model in this study. This shows a starting point for securing the roads for allowing post earthquake elements work properly. Each line has an intervention degree, related with risk assessment and natural movement. Securing one the red lines in here doesn't mean only securing people living in that street, also creating an evacuation preference for other residents through the settlement.

Index of intervention values in Zeytinburnu/Çırpıcı area reveal especially on the surrounding edges of the settlement. Besides, Avcılar has centrality issue that indicate significant number of people can be secured with the enhancing physical quality in the district centre first.

Index of intervention value for Çırpıcı and Avcılar should be considered as starting point rather than another layer for disaster mitigation planning process.

Although these outputs may indicate an irregular pattern and there would be a little consistency with the actual or proposed network, these lines should also be considered one by one as they have distinct risk factors and intervention possibilities.

Figure 6.1: Model Outputs for Avcılar (left) and Çırpıcı / Zeytinburnu (right).

These study outcomes are:

Contribution to planning process as a layer: The outputs mainly provide information for securing the durability of physical structure. These can be regarded as one of the layers used for superposing the facts about the settlement in the analysis phase. Planners and professionals on this process can use these to better depict the earthquake reality.

Focuses on streets as a joint media for physical and social evaluation: Model takes streets and alleys to combine the data and illustrate the risk assessment workings. This also allows the natural movement patterns to be evaluated with the same base with risk assessments, especially for the definition of evacuation corridors. With this approach, every street has its own population, building count, functional usage and blockage risk. Thus, outputs are articulated and solid as they consider both types of variables.

Fulfils the time & economy dilemma: It simply spots the most important segments in terms of earthquake security. The street which has the highest degree of index of intervention value is;

- One of the most common routes through that settlement,

- It holds the highest population under risk and

- Highest population to be secured from captivities due to the road blockages.

So, this indexation will allow taking the steps one by one which will save as much people as possible with the limited time and money.

Progressive: The study proposes an approach for disaster management process to be better executed. However, the variables used in this methodology are progressive. For example, model includes the seismic vulnerability scores of buildings calculated after the street surveys. Further evaluation of seismic safety will eventually be fruitful as those would be more precise. Also, model only includes concrete buildings as 98% of the building in case areas are concrete. The other building materials and seismic evaluation for that types of buildings needs to be added to model in order to use this on different samples.

Also, the streets can be divided into segments on each break. This will allow more information and detail about the local orientation patterns. Saving people with more “local” evacuation strategies might be possible with this approach.

Applicable: The application of this study requires minimized sources. Most of the works and calculations that produce the necessary data for the evaluation can be practically created on any GIS tools.

However, seismic evaluation workings need to be done by the professionals and buildings must be surveyed one by one.

Recurrent: After the retrofitting progress starts, the calculation should be done recurrently. Index intervention values and maps should be created again. Because, the system would become a different cluster. For example, after securing the most important axis, second one would loose importance against other streets or alleys. For this reason, this evaluation is proposed as a recurring activity. The success of the outputs lays on the representation of actual conditions through the model.

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APPENDICES

APPENDIX A: Zeytinburnu and Avcılar Land Use and Transportation maps (IMM, 2005)

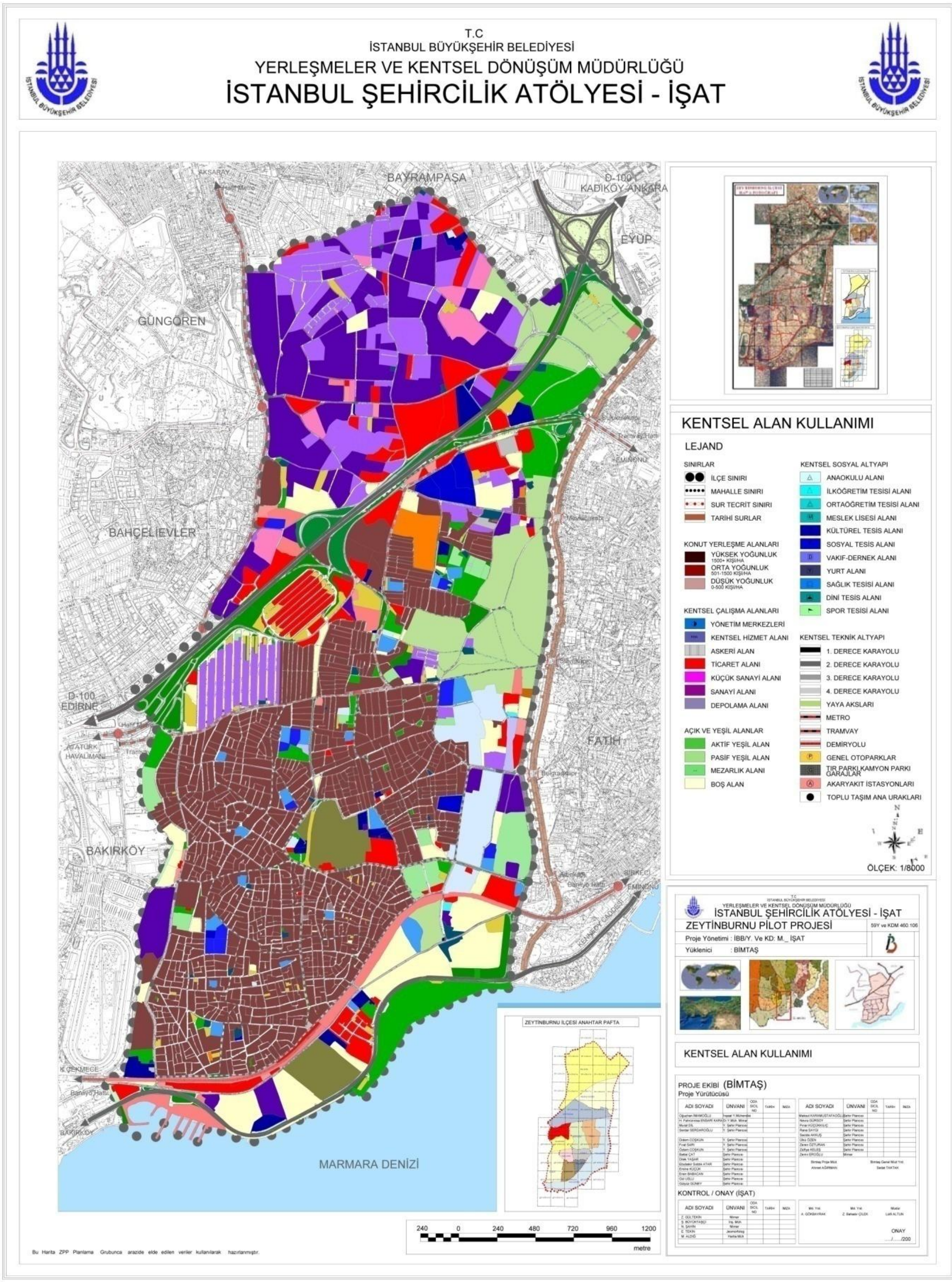

Figure A.1 Zeytinburnu Land Use Map (IMM, 2005)

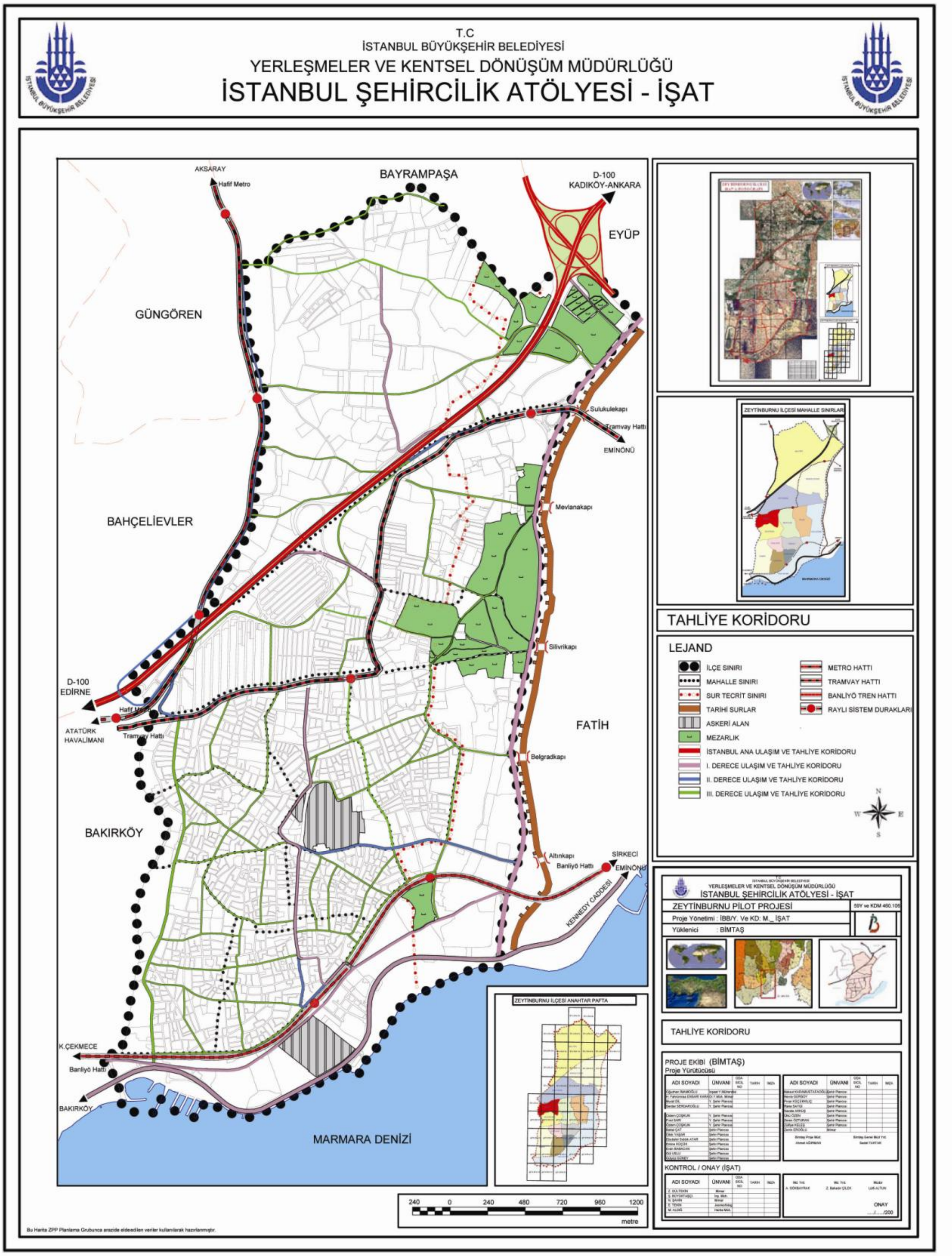

Figure A.2: Zeytinburnu proposed evacuation corridors (IMM, 2005).

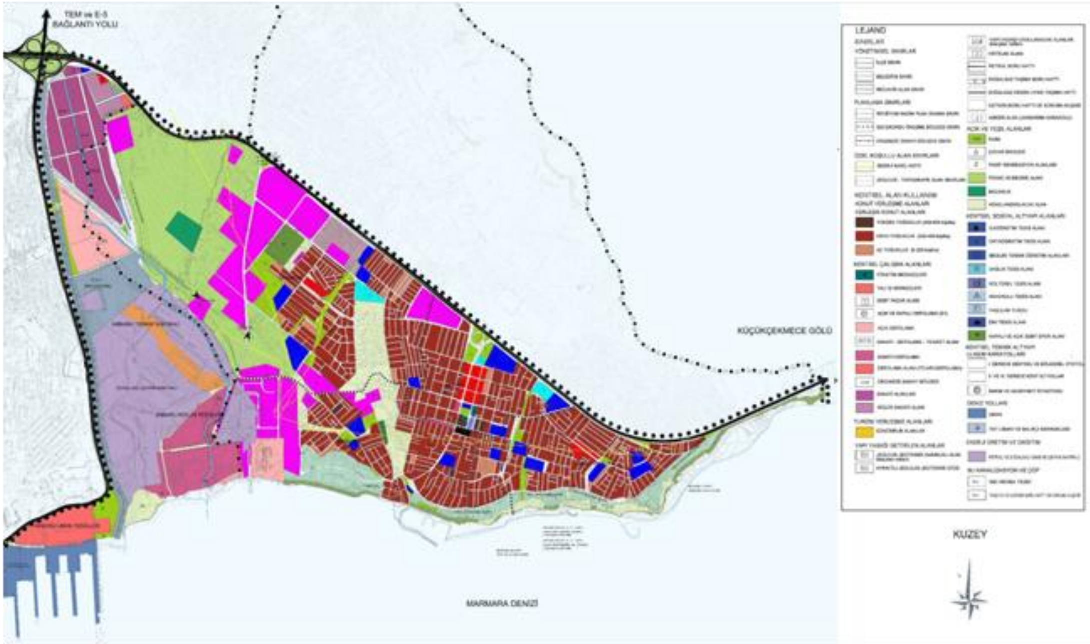

Figure A.3: Avcılar Proposed Land Use (IMM, 2006).

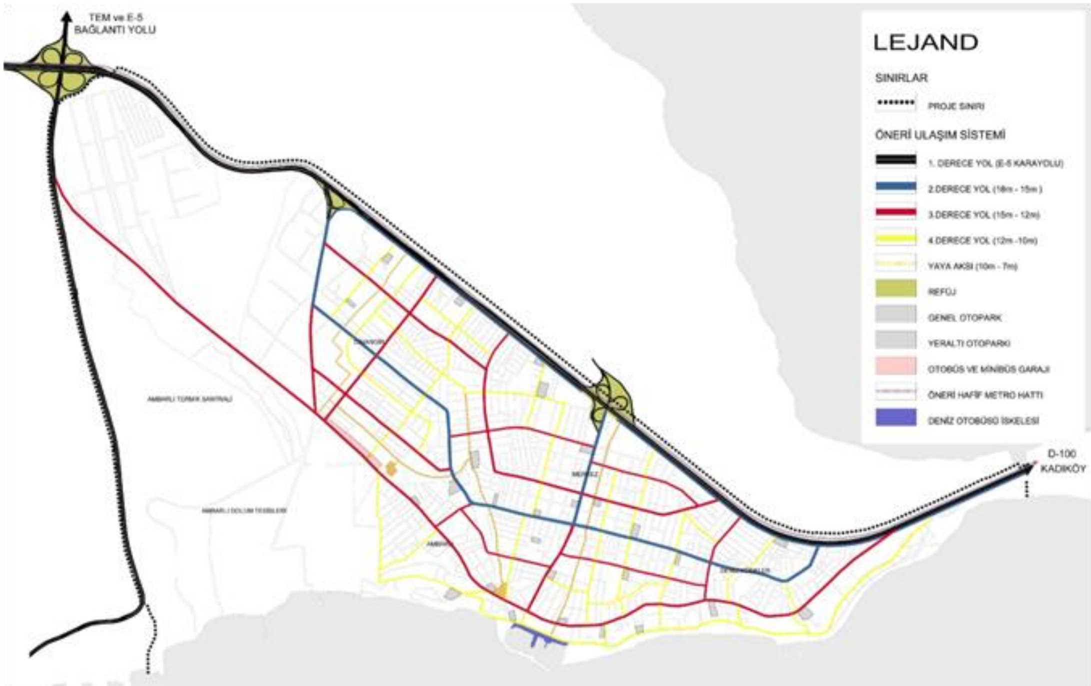

Figure A.4: Avcılar Proposed Evacuation Corridors Map (IMM, 2006).

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