CONNECTING URBAN PLANNING, MANAGEMENT AND OPEN SPACE IN SEISMIC ZONE

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Abstract

Tehran, the capital of Iran, is located in an area of high seismic risk and seismologists believe that a strong earthquake will affect Tehran in the near future. With a population of nearly eight and a half million, it is estimated that probably a large number of people would lose their lives.

Given this unfortunate possibility, and that the majority of buildings are built directly next to one another, any lateral force on one building could have a destructive impact on the others, on the network of connections and on the neighbourhood as a whole. A lack of open spaces in many residential and commercial areas will make immediate post-event organised responses, coordination, decision-making and resourcing difficult and challenging. These spaces may be considered for allocation of tasks such as providing emergency shelter, water and medical supplies, public health and sanitation, and housing replacement. Therefore, the question is whether Tehran is ready for the challenges, disaster mitigation and preparedness, response and recovery.

This research is focused on the interaction between physical systems and social systems to lessen societal exposure to the risks of earthquakes.

In doing so, first the approaches to integrated disaster and urban planning from other contexts were studied. After the selection of an assessment tool, the spatial, physical and social vulnerability of Tehran and the case study area were studied followed by the analysis of their risks and capacity. A detailed field study within the Khazaneh neighbourhood included estimating earthquake damage and casualties based on probable damage ratio and population distribution, and studying and developing criteria for identification and location of safety evacuation routes, shelter and other emergency utilities (hospitals, fire stations, etc.) in urban areas.

It was concluded that earthquake protection systems are now a critical issue for the enhancement of seismic reliability of this urban region. Preparing disaster reduction strategies in Tehran require comprehensive disaster measures to be implemented in urban development plans, open space designs, urban management and the building industry to enhance disaster prevention capabilities and to minimise and control disasters throughout the Greater Tehran Area.

Acknowledgements

This is a great opportunity for me to thank those who supported and inspired me during my doctoral study.

I especially want to thank my supervisors Mr Tim Townshend and Dr Sean Wilkinson for their guidance and assistance. Their perpetual energy and enthusiasm in research motivated me in a composed and rewarding environment.

My deepest gratitude goes to my family for their unflagging love and support throughout my life; this thesis would have been simply impossible without them.

Last but not least, thanks be to God for my life through all tests in the past years. You have made my life more bountiful. May your name be exalted, honoured, and glorified.

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Abbreviations

ADPC	Asian Disaster Preparedness Centre
ALNAP	Active Learning Network for Accountability and Performance in Humanitarian Action
ALR	Active Living Research
AMC	Adaptive Modal Combination
ASCE	American Society of Civil Engineers
ATC	Applied Technology Council
BHRC	Building and Housing Research Centre
BRCRS	Bureau for Research and Coordination of safety and Reconstruction Affairs
BSH	Basic Structural Hazard
CDF	Central Damage Factor
CEMS	Centre for Emergency Management Secretariat
CEN	European Committee for Standardization
CEST	Centre for Earthquake and Environmental Studies of Tehran
CVA	Capacity and Vulnerability Analysis
D17	District 17
DBELA	Displacement-Based Earthquake Loss Assessment
DEMP	Disaster and Emergency Management Presidency
DG	Damage Grade
DMA	Disaster Mitigation Act
DPM	Damage Probability Matrices
DPRI	Disaster Prevention Research Institute
DRM	Disaster Risk Management
DTLR	Department of Transport, Local Government and Regions
ECLAC	Economic Commission for Latin America and the Caribbean of United Nations
EMI	Earthquake and Megacities Initiatives
EMS	European Microzoning Scale
FEMA	Federal Emergency Management Agency
GDDA	General Directorate of Disaster Affairs
GFDRR	Global Facility for Disaster Reduction and Recovery
GFS	Government Financial Static
GNDT	Gruppo Nazionale per la Difesa dai Terremoti
GSI	Geological Survey of Iran
HAZUS	Hazard United States
HUDO	Housing and Urban Development Organisation
IAEE	International Association for Earthquake Engineering
IDNDR	International Decade for Natural Disaster Reduction
IFRCRCS	International Federation of Red Cross and Red Crescent Societies
IIEES	The International Institute of Earthquake Engineering and Seismology
INDPM	Integrated National Disaster Management Plan
ISDR	International Strategy for Disaster Reduction
ISG	Iranian Studies Group
JICA	Japan International Corporation Agency
LAA	Law on Adjustment of Agriculture

LCA	Land Consolidation Act
LDP	Linear Dynamic Procedure
LHMPs	Local Hazard Mitigation Plans
LR	Land Readjustment
LSP	Linear Static Procedure
MDGs	Millennium Development Goals
MDF	Mean Damage Factor
MDoF	Multi-Degree-of-Freedom
MHUD	Ministry of Housing and Urban Development
MMI	Multilayer Metal-Insulator
MMPA	Modified Modal Pushover Analysis
MPO	Management and Planning Organisation
MMR	Moment Magnitude Ratio
MTFFSSO	Municipality of Tehran Fire Fighting and Safety Services Organisation
MRH	Ministry of Road and Housing
Mw	Moment Magnitude Scale
NCNDR	National Committee for the Mitigation of Natural Disaster Effects
NDTF	National Disaster Task Force
NEHRP	National Earthquake Hazard Reduction Programme
NE–SW	North-East–South-West
NGOs	Non-Governmental Organisations
NIBS	National Institute of Building Science
NICEE	National Information Centre of Earthquake Engineering
NSP	Nonlinear Static Procedure
NSTC	National Science and Technology Council
NTF	North Tehran Fault
NTH	Nonlinear Time-History
OS	Open Space
PAR	Pressure and Release Model
PEPPER	Pre-Earthquake Planning for Post-Earthquake Rebuilding
PMF	Performance Modification Factor
PSHA	Probabilistic Seismic Hazard Analysis
RADIUS	Risk Assessment Tools for Diagnosis of Urban Areas Against Seismic Disasters
RC	Reinforced Concrete
RMS	Risk Management Solutions
RVS	Rapid Visual Screening
SA	Safe Area
SCI	Statistical Centre of Iran
SDoF	Single-Degree-of-Freedom
SEMO	State Emergency Management Office
SHMP	Seismic Hazard Mapping Programme
TCC	Tehran City Council (Tehran Municipality)
TCEMP	Tehran Comprehensive Emergency Management Plan
TDMMC	Tehran Disaster Mitigation and Management Centre
TDRM	Total Disaster Risk Management
TGIC	Tehran Geographical Information Centre
TMCSC	Tehran Municipality Communication and Statistical Centre

TPA	Town Planning and Development Act
UFC	Unified Facilities Criteria
UNCED	United Nations Conference on Environment and Development
UNDA	United Nations Disaster Assessment
UNDMTP	United Nations Disaster Management Training Programme
UNDP	United Nations Development Programme
UNDRO	Office of United Nations Disaster Relief Coordinator
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNISDR	United Nations secretariat of the International Strategy for Disaster Reduction
UNOCHA	United Nations Office for Coordination of Humanitarian Affairs
USPCT	Urban Study and Planning Centre of Tehran
ULO	Urban Land Organisation
UBPA	Upper-Bound Pushover Analysis
URM	Unreinforced Masonry Structures
VCA	Vulnerability and Capacity Assessment Tool

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1.1 Introduction

The frequency of disasters (either natural or man-made) has raised alarms worldwide over the last few decades (see UN, 2008; UN, 2000; TearFund, 2005). Disruption, in the form of earthquakes, has resulted in escalating human and economic losses all over the world, but particularly in countries such as Iran which is located on some of the most active faults.[1] On May 12th 2008, China's earthquake, with a magnitude of 7.9, killed 69,000; worst hit was Sichuan province's Beichuan county, where a further 10,000 were feared injured and 80% of the buildings were flattened, including eight schools and hospitals (*Guardian*, 2008). This once again brought the issue of earthquakes to the attention of the international media. However, in the last half of the century in Iran alone, 11 earthquakes have killed about 100,000 people (Jones, 2004:1).

Although there has not been a major earthquake in Tehran, the capital of Iran, it is recognised as a major hazard for the city and could occur in the near future (JICA, 2000; Nateghi, 2001; IIEES, 2009). The city holds almost 1/6 of the country's population of 77 million (Index Mundi, 2011), and is therefore the heart of economic, administration, education, political and cultural activities. Any disruption to these processes and this strategic point will have huge adverse effects on the country and people's lives. There are arguments that "urbanisation affects disaster just as profoundly as disaster can affect urbanisation" (Pelling, 2003:7). This highlights the importance of the quality of the urban built environment in terms of safety, structure, quality, and accessibility. With growing urbanisation in Tehran and the possibility of the occurrence of large- and small-scale earthquakes in different parts of the country, public policies and disaster response measures are being tested for their capacity to cope with the management and recovery process (Mitchell, 1999). International, national and even local organisations in the field of disaster risk management (DRM) have paid most attention to this, within the context of emergency relief (DFID, 2004).

[1] The important known faults to consider for Tehran are (Berberian et al.,1983):
- Mosha Fault: a fundamental fault in central Alborz (lower impact on Tehran)
- North Tehran Fault: most important in the vicinity of the city – 35 km long
- South & North Ray Fault: most prominent in the southern part of the city

It has even encouraged the government to invest in the preparation of a disaster-related plan (*ibid*).

In order to mitigate any risk of damage to the city's built environment and consequently urban life, local authorities, with the help of international organisations, developed a study to formulate a master plan for urban seismic disaster prevention and management within Tehran (JICA, 2000). It includes microzoning, building code changes and land-use planning. But the problem remains over its practicality and the adjustments to the present master plan of the city that guides the city's development. The municipality, and regional and national organisations, struggle to effectively tackle disaster risk because of their lack of institutional capacity (relevant adequate knowledge), cooperation, working relations, and use of the existing and potential capacities raised by exchanging knowledge and constructive discourse (Woiwode, 2007). The responsibility of architects, planners and other urban development actors is traditionally to develop urban growth. But their contributions in creating a city secure against the risk of disaster, the reduction of vulnerability and the increase of earthquake-resistant capacity is limited. It is even less responsive when we look at Tehran's master plans (AAFF and Gruen, 1970; Boom Sazegan, 2002; 2006) and the pattern and reality of urban development of the city.

With the possibility of an earthquake turning into a major disaster, preparedness, prevention and mitigation are some of the complexities of the issue that should be considered in the city plan. Adopting a conventionally responsive design to locate high-density buildings, resistant infrastructure and safe open spaces is the problem which exists within the city's planning practice. Also, theoretically, planning authorities do not follow certain frameworks in the city's master plan and districts' comprehensive plans. In fact, the interlinkages between disaster reduction, disaster management, city planning, and urban design are the problem that this research is keen to resolve. This leads us to the next part: identifying the research question and purpose.

1.2 Research Purpose and Objectives

In this research, the challenge is to find a way of minimising the effects of earthquakes by providing a network of safe urban open spaces. This requires an in-depth understanding of seismic damage on the built environment, urban design parameters, and in providing a conceptual, strategic and practical approach to disaster[2] management. It will focus on post-disaster measures to be accepted and acted upon in the preparedness stage. This concept of designing open spaces for urban resilience is a way of adapting cities for the worst case scenario while still accommodating/ encouraging everyday use:

> *It proposes that the key to the successful integration of recovery planning and urban design lies in a shift of thinking that sees a city's open spaces as a second city: a network of open space designed not only to contribute significantly to the quality everyday urban life, but with the latent capacity to act as essential life support and an agent of recovery in the event of an earthquake.*
>
> (Allan and Bryant, 2010)

With this in mind, the overall research objective is to enhance and develop new knowledge and innovative ways in which urban open space can contribute more effectively to earthquake recovery. This requires a highly inter-sectoral and multi-disciplinary interface of urban planning, disaster studies, open space design and management and risk management. It will investigate their relations and working fields to create a safer area for urban communities.

1.3 Research Questions

Distilling the objectives of the research, therefore, the overarching research question is: "How can urban open spaces influence urban resilience (the capacity of a city to absorb and adapt to disturbance) by providing safety and serviceability in the place

[2] Disaster refers here to earthquake. From now on disaster and earthquake will be used as synonyms.

where recovery occurs?" The expected outcome of the answer to this question is to develop the knowledge and concept of locating safe urban open spaces within city neighbourhoods, to reduce the risk of disaster and act as a catalyst for an emergency enquiry.

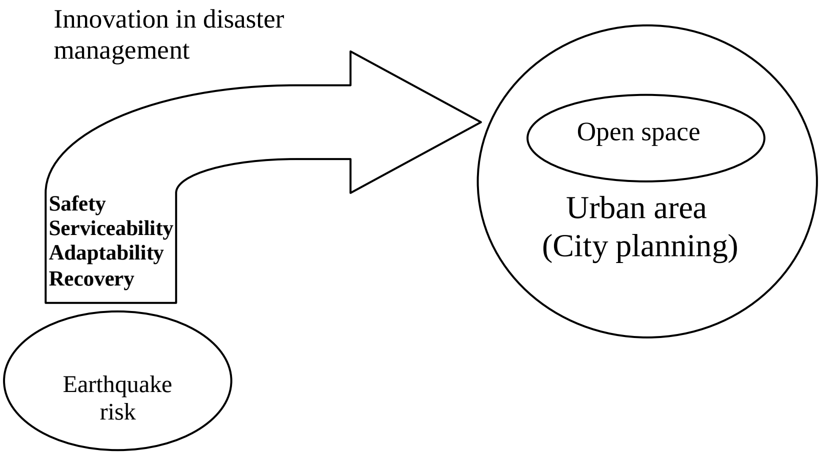

Figure 1.1: Illustration of the overall research question

Careful exploration of each part of the question is needed during the search for a better understanding of the various aspects of DRM and the recovery of an urban area (within the field of urban planning, which is keen to discover the nature of connections between building, planning practice, disaster and open space). The important part is to translate these relations into practical ideas to promote urban safety and recovery.

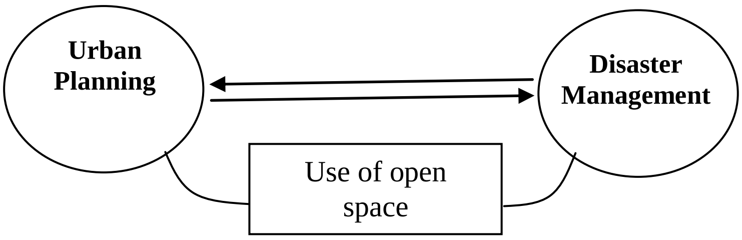

Figure 1.2: Areas of study

In order to answer to the main question, the research has to discuss and find answers to the intermediate but constructive questions regarding damage estimation of buildings, infrastructure and utility connections, urban development planning components including open space design and disaster risk and recovery management. Each element has connections with the design of a safe open space whether within the role of regulating its form, or its functionality.

Research main question: How can urban open spaces influence urban resilience (the capacity of a city to absorb and adapt to disturbance) by providing safety and serviceability in the place where recovery happens?

Series 1

The relationship between city planning and plans and disaster management

- What are the interlinkages between disaster risk management, urban planning and open space?
- What earthquake resilient characteristics for an urban area can promote the quality of urban design?

Series 2

The relationship between city planning, disaster management and open space

- What criteria should a development plan include to work with urban disaster prevention and management plan?
- Would the use of open space as a refuge and recovery place for post-disaster operations affect its use at city, area or neighbourhood level?

Series 3

The components of safe open space

- What capacity do our open spaces need to have to make them safe and serviceable places?
- What must planning authorities do in order to create integrated multi-purpose spaces and act collaboratively?

Figure 1.3: Overview of main research questions

The answers to these fundamental questions will shape the research discussion through different phases. They will build upon each other to create a respective context from reviewing the literature and investigations, and to reach a logical and practical outcome and concept.

Knowledge expansion and building the foundations: i.e. the connection between disaster and urban planning. Here the question is: “What are the interlinks between disaster risk management, urban planning and open space?” The first question’s aim is to identify how a disaster affects urban life and how this has influenced urban planning and development plans in many countries. More specifically, the question will discover the criteria of urban risk management in response to disaster hazards, planning-related issues of land-zoning, building damage and the role of open space in the present situation. It will argue that the multi-faceted relations between the above subjects are being missed in many planning systems and further, how exploiting literature, understanding the existing and possible network of connections may lead to an analytical framework and practical suggestion for the design of open spaces. The work of the UN on the International Strategy for Disaster Reduction (2010, 2009, 2008), World Bank (Dilley et al., 2005; Rajasree, 2006; World Bank, 2007), California Office of Emergency Services (Cal EMA, 2010a; 2010b), FEMA (1998, 2000) and many scholars such as Olshansky (2003) are examples of how the development of knowledge about the nature of disasters and risk management, developing and adapting design and construction standards for buildings and utility connections, as well as development plans' priorities, has improved this field of study. In this way, the existing and contemporary relations between city planning components and priorities; and disaster management and planning criteria, will be reviewed and examined within the literature and interviews.

The practicality of the plan: the second question points to the subsequent stage which explores using the knowledge obtained in the answer to the previous question, regarding the efforts that should be made in an urban development plan to produce a framework for an earthquake resilience and prevention plan. The relations between the two fields are analysed and then translated to a respective plan and design proposal for open space. The analysis covers subjects such as development plan criteria, the existing separation between city planning and disaster risk management theory and practice, and the way these may be successfully integrated and benefit from each other to create less vulnerable neighbourhoods. The analysis is based on the discourses of experts and practitioners, city and disaster planning practice priorities, working principles and tools. The outcome is a challenging subject for those planners to think about the potentials of open space in serving the local community for earthquake recovery purposes and creating a strong relationship between development plans. Thus, this guides the research to the next stage, which is a way forward of using these open spaces fully as safe places after a disaster without compromising their everyday function.

Futuristic Adaptive Response: "facing disaster in an urban area to characterise a resilient open space: what capacity do our open spaces need to have to make them safe and serviceable places?" This question's aim is to determine if the proposed ideas are practical and useful in terms of open space structure, function, distribution, proportion and design to improve risk reduction. Whilst conducting the field work, the question aims to measure the integration of the present and traditional functions of open space, with their proposed roles. The idea is to strengthen the link among key urban plans consisting of disaster plans and development plans. Firstly, it will look at the feasibility and accessibility of these spaces within land-zoning patterns, and how they can be safe places in the post-disaster period. Secondly, it will discuss the kind of services that the places could give to the city and its citizens after an earthquake. This will increase our knowledge and understanding, and guide us to an urban development plan which is adapted for disaster risk and is more proactive towards risk management.

1.4 Geographical Focus

Tehran is located in one of the most earthquake-prone areas (on the Ray Fault) (Mottaghi et al., 2010). Historically, it has suffered from at least one major earthquake which destroyed the city in 1830 (*ibid*). According to the 1996 population census, the total population of the 22 districts of Tehran proper is calculated at 8,332,276 (TMCSC, 2010). This is explained in detail in Chapter 6. The concentration of nearly 12 million people in Greater Tehran and surroundings makes it the most vulnerable urban area in the country (Boom Sazegan 2006). The trend of urban development and building activities, coupled with the high micro-economy relations of the construction industry, has changed the face of the city from predominantly four- or five-storey buildings to a plethora of high-rise buildings which can be vulnerable in any disaster, especially an earthquake; this is explained in detail in Chapter 7.

Its strategic location and functionality has attracted the attention of national and local planning organisations to prepare the city for large-scale disasters. In line with that, and particularly with the tremendous impact of damage in high-density areas of the city in mind, the research addresses the whole city in order to estimate possible disaster damage (Chapter 9), how the master plan guides urban activities and development to meet urban needs (Chapter 7), and other measures that direct general land-use planning. But for further conceptualisation of the use of urban open spaces, District 17 will be discussed in detail in Chapters 7 and 8. District 17, with a population of 287,369 (JICA, 2000), is an area with one of the highest densities, which accommodates people on low-to-middle incomes who do not necessarily live in earthquake- resistant buildings. The demographic situation has actually sabotaged open spaces and land for public or emergency services. This can be exemplified by the need for accommodating people in small dwellings; the price of land; and illegal subdivision of land which did not leave enough space for roads, parks and other public services. This makes this area an intensely important case study.

Another reason for choosing Tehran as a prime case for this research is (as mentioned before) the preparation of a disaster risk management plan (JICA, 2000) which has highlighted the potential risk of damage (physical, economic, utilities and infrastructure). This emphasises the necessity of considering such capacity for post-disaster events. From a planning perspective, the city’s development is derived from the past master plans that have considered general housing and urban development organisation guidelines which are/were about land-use planning, road enlargement and building density. Studying the possible integration between the two fields of planning in Tehran could result in a conceptual plan which might be expandable to other parts of the country.

In terms of local government power and influence, Tehran has a well-established municipality in each district which have control of major projects. They control the majority of urban activities by providing a comprehensive plan and by investing in leisure centres, roads, parks and similar infrastructure. They work closely with the disaster management organisation, which is officially part of the Ministry of the Interior subcommittees (represented by the provincial governor of Tehran). But the nature of their cooperation is not an authentic collaboration. Each tends to follow separate roles and do not share similar agendas.

Since the commencement of the study on Urban Seismic Disaster Prevention and Management for the Greater Tehran Area (2000), the idea that Tehran should be prepared for the worst was developed. Implementation of such a plan requires integration of effort, aims and approaches amongst the municipality, the stakeholders and the local communities across the different districts, due to their different building and population densities, main neighbourhoods, city or regional functions and available land and resources. There should be various plans to meet these unique specifications. District 17, based on its high degree of population concentration and of built-up areas, is the focus of the fieldwork of the research. It has a high vulnerability risk because of the high building density, which is mostly residential; the lack of available open space and parks, consisting of typical Tehran building types and structures; and the strategic location in the city for communication and networks. The fieldwork carried out in the area will form most parts of the case study discussion. Studying the pattern and functionality of present or proposed urban open space for the event of an earthquake in District 17 could provide planners with the conceptual idea of designing open space. It could be analysed and developed in order to serve the community after a disaster with initial emergency requirements.

1.5 Methodological Approach

The research has two main approaches in reaching the target of designing an urban open space that could help the community survive hours, even days, following an earthquake. From a timescale and functional aspect, the research focus will estimate the extent of damage on the buildings, utilities, infrastructure, and other significant interruptions to normal urban life.

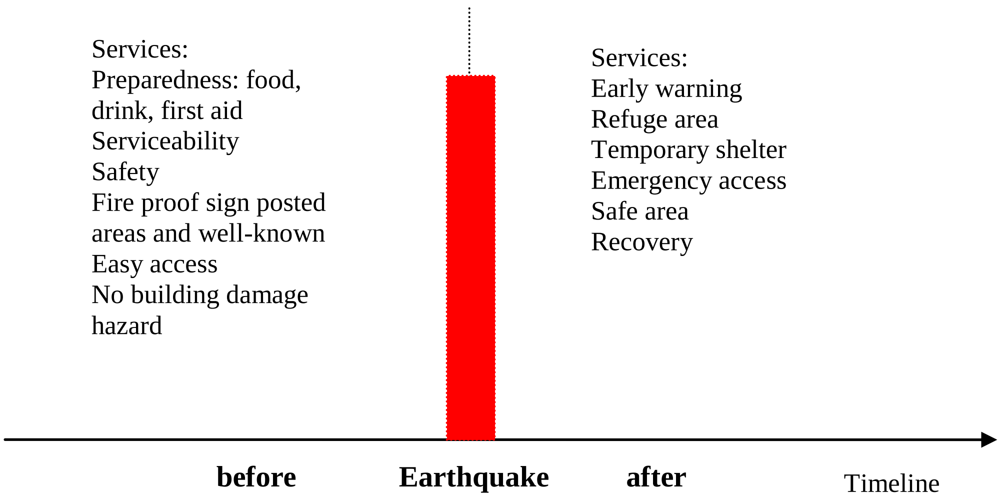

Figure 1.4: The focus of the research on “before earthquake” services

This gives the researcher an opportunity to illustrate the actual damage scenario and how a designated open space could minimise or mitigate these side effects and aid the recovery of the population and act as a link between urban planning and management. This is a cause and effect approach to earthquake damage in the hope of preventing it. In doing so, and in order to consider other aspects of urban development – the two fields of open space in urban planning (with special focus on the Tehran Master Plan (Boom Sazegan, 2006) and District 17 (Amco, 2011)) and disaster risk management (and the relevant plans, comprehensive disaster management plan (JICA, 2000) – seismic structure measures for the existing buildings) will be studied and analysed. This requires an in-depth study of documents, interviews with those who have a hand in this process – from council officials to the urban disaster management organisation – field trips and observation.

Each has an essential role in building up the theoretical and practical background discussion to lead the research to propose a conceptual framework for designing open spaces which would help the recovery from an earthquake. Based on the timescale of disaster planning (Figure 1.4) the research will be developed and designed in a circular way (Figure 1.5). It starts by building the foundation on the broader and more scientific/academic perspective on disaster (damage, planning management) and open spaces – which is in two sections; master plans and open spaces – at an international, national and local level, to gradually analyse the challenges and the gaps to which the research should selectively return. This is an appropriate research design for the multi-sectoral and interconnected research elements. It brings the voices of the lead actors and perspectives of theoretical context into a scene of discussion, and this will be supported by fieldwork.

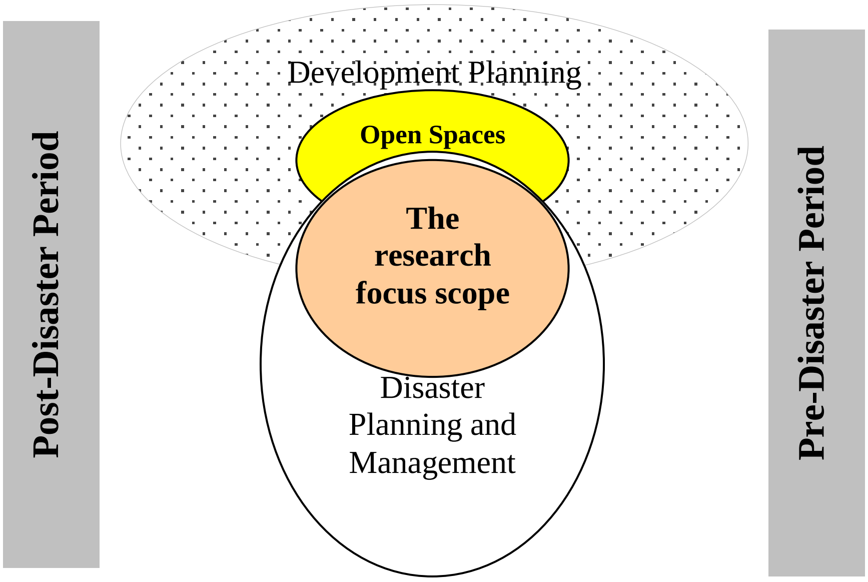

Figure 1.5: The circular process of the research

Based on the work on the particular area in the case study and its context, the research will develop a ground concept on the existing situation/system and how it can be improved. The detail of method will be discussed in the relevant chapter.

1.6 Target Group

The nature of the research has the potential to benefit different groups at different levels. It has an indirect effect on the lives of individuals, neighbourhoods, cities and countries. Its immediate beneficiaries are those people who live and work in the adjacent area. However, its primary focus is the urban disaster planning and management policies at a city and neighbourhood level; and those who make the policies, and design the plans, alongside those who are operational staff, are the prime target groups from whom the benefit of designing safe space to the locality would trickle down. The proposed concept might be applicable to other groups such as investors, settlement development planners or government organisations.

1.7 Limitation and Delimitation

Disaster risk management is not a new subject in the world of academics and experiments such as urban planning, but a theoretical and practical combination of these for “before”, “during” and “after” earthquake is the debate that is neglected in many aspects. Although there is extensive research and policy on building earthquake-resistant structures and how to react to an earthquake in a rescue mission after the initial disaster, there are limits on the knowledge and challenges needed to combine the above two fields into a routine urban planning practice. Therefore, the focus of this research will be on the study of the development of ideology for open space development for earthquake-prone zones within the ongoing process of disaster risk management; on the functionality, services, and location of general open spaces that have the potential to retain their traditional use, and which also can be used for post-disaster needs.

Compared to other extensive and valuable studies in the urban planning field, this specific aspect is quite a new idea, demanding an integrated approach to disaster risk management. The other main deficiency of existing research is the limited academic literature and practical knowledge concerning large-scale earthquakes in Iran generally and in Tehran specifically. This, coupled with a lack of classified documentary information about the background of planning theories and practice in Iran and Tehran, means it will be difficult to emphasise the role of urban management in the city’s disaster prevention and urban development. Lack of cooperation and interlinkages between different parties in these fields that act independently will complicate the practicality of the final idea. Therefore, this will be a completely new paradigm in an urban management context.

1.8 Content and Outline of the Thesis

The research aims to use a variety of relevant issues, open spaces, development plans, disaster mitigation management and planning in the light of building damage (Figure 1.6). It starts by conceptualising the thesis and methods. These are discussed and examined by others in other contexts in Chapter 2, and it becomes apparent that it is the best framework to guide the research through to the final stages. The literature review chapters each illustrate and discuss one aspect of the planning system for seismic management, each of which individually is important in their field. Damage estimation theories and method in the field of disaster mitigation discourses (Chapter

3), open space definition and functionality (Chapter 4) prepare the underpinning of this thesis for the next level. These chapters are not simply descriptive reviews of the literature, but constructive discussions for the selection of the best concept for the subject of this research. After the methodology chapter (Chapter 5), which outlines the fieldwork process, the analytical review of the case study data gathered by different tools (discussed in methodology section) commences.

It starts in Chapter 6 by identifying the spatial structure of Tehran and its main axes. This chapter also highlights the geographical situation of Tehran which exposes the city to earthquakes. In order to assess the vulnerability of the study area at city, district and neighbourhood level, Chapter 7 focuses on using risk assessment tools and their applicability to the city's social and spatial characteristics. This continues in more detail in Chapter 8, which evaluates building and infrastructure vulnerability assessments using primary and secondary sources. Chapter 9 is devoted to the assessment of capacity of sample open spaces existing within the pilot study area, which leads the thesis to the concluding chapter (Chapter 10). In this chapter there is a summary of the thesis context and recommendations for how disaster planning should become part of the urban development planning process.

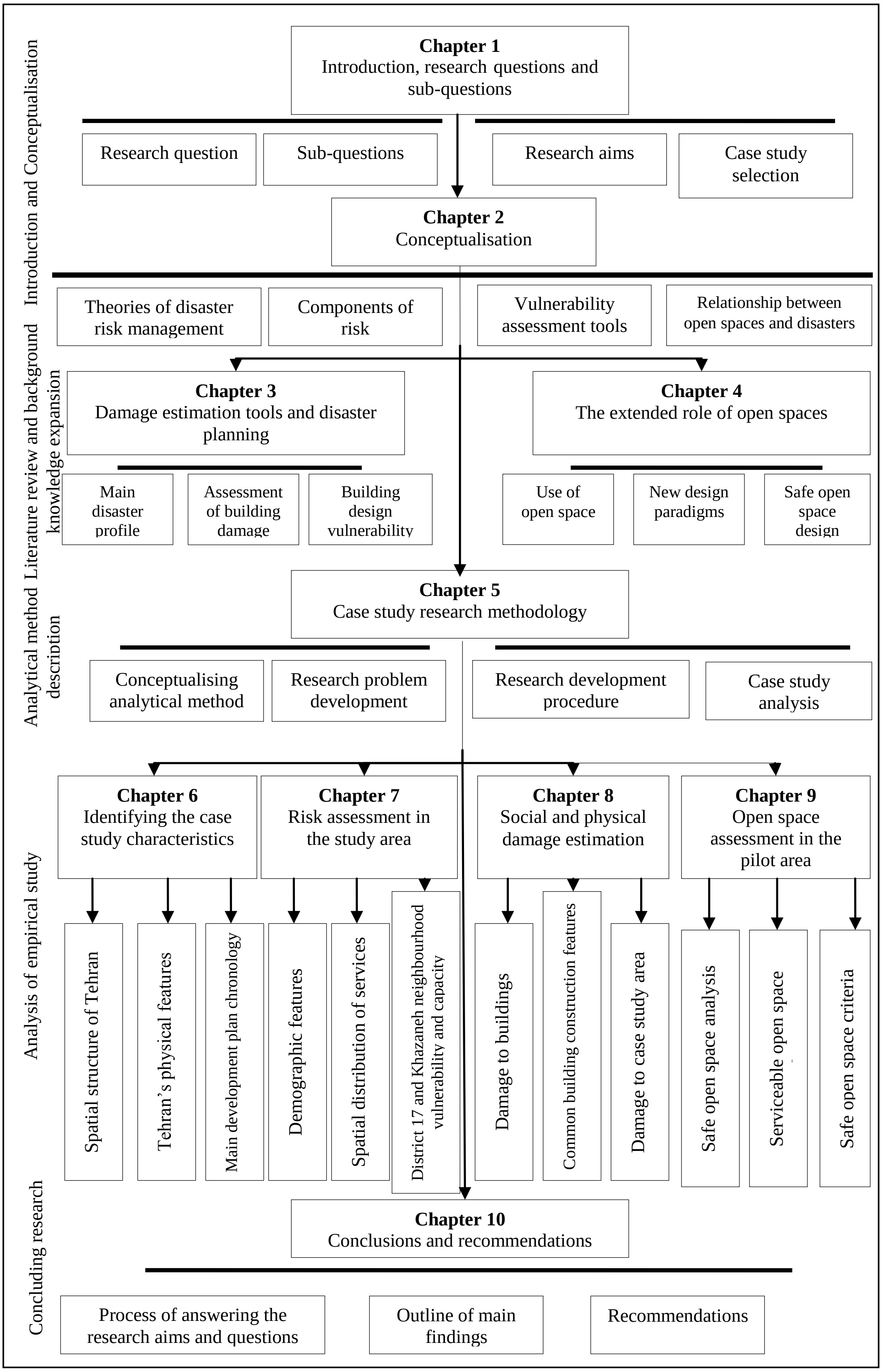

Figure 1.6: The research design

Chapter One................................ **Introduction**

Chapter Two......................... Conceptual Framework

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Chapter Ten..................... **Conclusions and Recommendations**

2.1 Introduction

The vulnerability of the urban environment against earthquake disaster has been the subject of many studies amongst academics and engineers (see Cutter, 1996; Kreimer and Munasinghe, 1992; Weichselgartner, 2001). Whilst "earthquakes continue to impose physical and human losses on the earthquake prone" (Motamed and Amini Hosseini, 2007:34) the gap between structural engineers and statistical methods to reduce building damage and urban planners to design a safer and accessible area during and after seismic strikes has not been bridged (see Godschalk, 2003; Ozerdem and Barakat, 2000). This may be due to:

- The nature and extent of possible damage to the city by earthquakes;
- The vulnerability of the buildings and urban infrastructure to earthquake tremors;
- Utilising a scientific approach in minimising building damage as a better option in combating earthquakes;
- Development of practical knowledge to manage the disaster as a separate issue from normal urban development processes;
- Ideally, achieving seismic-proof buildings with less physical and human damage.

Each of the above elements are interesting and valuable in their field; however, this research's focus is, briefly, the potential damage inflicted on the urban structure, including buildings, infrastructure and supply lines. It is also necessary to evaluate the existing urban open spaces, and the pattern of urban development; and to analyse the present urban disaster management policies (in Tehran in general and District 17 in particular). This will lead the research to a final stage, which is an exploration of a multi-functional and safe open space for the case study area using an integrated approach in urban disaster risk reduction. But first, in this chapter, the conceptual framework of the research will be developed. This is followed by two chapters looking at the literature concerning damage estimation on urban fabric including supply lines, infrastructure and buildings, and then planning for urban disaster risk management and the role of open spaces in this field.

This research is unusual in that it is interdisciplinary in nature, focusing on disaster (with particular focus on earthquakes), risk management and planning. The emphasis on these two fields and the nature of their influence on each other highlights the role of open spaces as a tool to fulfil everyday functions, whilst becoming a refuge and safe area in the event of an earthquake, possibly immediately after the disaster or in the following days. Due to lack of interdisciplinary work and theory connecting these fields, a short history of development of theory and practical aspects of the two areas are described. The analysis of the relationship between them and how they can lead planning authorities to develop design multi-functional open spaces in a given urban environment based on the conceptual framework is the outcome of this chapter's discussion.

2.2 Discourses in Disaster Risk Management

Risk (disaster) management is the direct proaction or reaction to risk (UNESCO, 2007). In general terms, disaster management is largely about reducing the possibility of an adverse effect on people's normal life (Slovic, 1999). For different communities and in different parts of the world, the definition and extent of risk is different, and so are the methods by which they control it or tend to manage it (see Cronin et al., 2004). Given the fact that post-disaster recovery processes can be classified in three linked stages: 1) immediate emergency response; 2) short-term rehabilitation and reconstruction; and 3) sustainable long-term recovery – the preparedness of the built environment before a disaster is an accepted mode in disaster management (Yodmani, 2000). Figure 2.1 shows how keeping this cycle connected using various professionals would have a direct impact on the art of disaster management (Tjiptoherijanto, 2008).

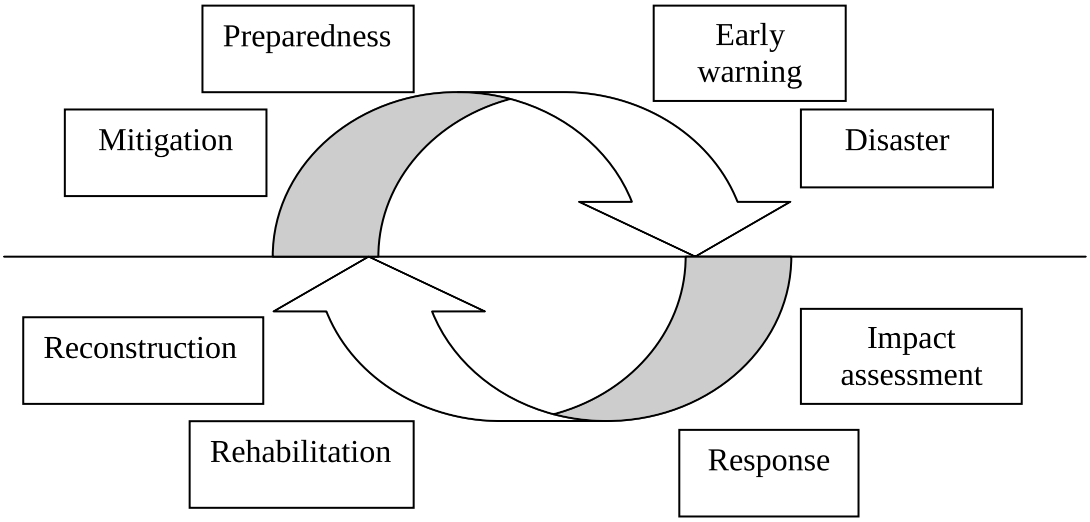


Figure 2.1: The cycle of disaster mitigation (Tjiptoherijanto, 2008:11)

In Slovic's (1999) opinion, it is not the definition that matters, but the risk management that characterises and prioritises the effects of the risk and perhaps incorporates political agenda. It has been the case in the majority of disaster management experiences that managers (at all levels, from international to local and municipal level) are more interested in relief and reconstruction than pre-disaster risk mitigation or preparedness (Wisner and Walker, 2006). Having to react to a disaster's effects requires a logical procedure which calls for fast and collective action of the government and various agencies, as they can see the problem and plan for its reduction (Kent, 1994). But planning for something that has not yet taken place and that requires extensive financial, research and cooperative efforts put many government authorities off planning and action (Tierney et al., 2001). It might not be applicable to the extensive academic and practical work of the engineers to attain to risk-proof (especially earthquake-resistant) building structures (*ibid*); however, this is not a developed discourse in urban planning field which observes and controls urban development activities (Wisner and Walker, 2006). Ignorance or disconnection of built environment professionals (in this research, these consist of architects, planners, engineers and surveyors) can exacerbate the delay in the recovery process of a post-disaster period. In other words, the most underdeveloped discourse is, in fact, the connection between engineers, planners and urban disaster management. This is the context of the following pages.

2.3 Risk Management: A Multi-Disciplinary Fact

There are various approaches used to describe risk and categorise it. Beck (1992:13), in a simple statement, categorises risk based on its origin as “manufactured risk” or “external risk”. All natural disasters, therefore, would be classified as unplanned and not produced by human forces. There are also other opinions that use a combined theory, placing the disaster in a socio-natural origin (Ferrero and Gargantini, 2006).

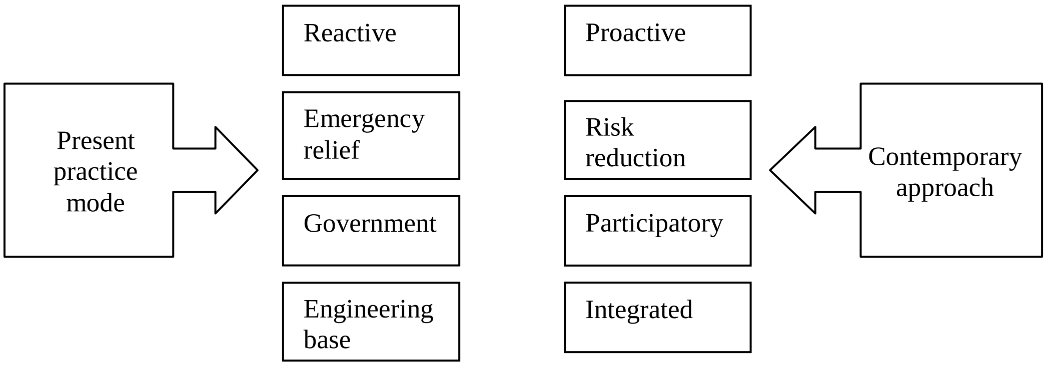


Figure 2.2: Reorientation in disaster management policy-practice (Tjiptoherijanto, 2008:9)

A disaster may be worsened by the extent of the capacity in the community and the built environment, as well as the government, to cope with it. There are other researchers who look at the risk differently, such as Douglas (1992), who believed in cultural enhancement, self-help and knowledge-based decisions, which can prepare the community for the disaster (anthropology/sociology approaches (cultural theory)); Sahlin and Persson (1994), who looked at the psychology of the risk by observing various outcomes of the risk in different societies (psychology approaches (heuristics and cognitive)); or Starr (1969), who found risk a variable mode in society, which, depending on people’s knowledge and background information, could be accepted or dealt with (interdisciplinary approaches (social amplification of risk framework)). But whatever the origin of the risk is and whoever voluntarily or unintentionally takes the risk, we should be able to manage it partly or fully (Persson, 2007). If it is not manageable, then it turns into a hazard. At this stage, then, the role of the researcher is to gain expertise in conducting disaster risk management theory and practice. Changes in the theoretical insight and practical approaches towards disaster management have been discussed by many scholars recently (Pearce, 2007; Knilnke and Renn, 2002;

Yodman, 2001). Figure 2.2 shows the highlights of today's main literature discussing disaster management issues.

Having government in addition to the management team has imposed certain modes of dealing with disaster including concentrating on post-disaster activities. Reports presented by the UN (2004) regarding government policy and action support this claim that the majority of national organisations have a tendency towards acting after disasters. There are differences with pre-disaster planning and management in terms of time, cooperation and financing the operation. Also, the undesirable impact of the physical built environment has superseded the power of structural and civil engineers in this field, which is appreciable (see, for example, FEMA303 (1997) (National Earthquake Hazard Reduction Programme (NEHRP)), but does not include all the potential knowledge that other parts of society can contribute to the urban disaster management process (Covington and Simpson, 2006). Being proactive towards urban disaster is not a new discourse. However, there are gaps between the theory and the practical experience of planning in a variety of related activities. Urban development plans are, for instance, still prepared independently from emergency plans. The concentration of government (central and local) on emergency relief is an inadequate but high-priority approach, which does not focus exclusively on risk reduction. Risk reduction is a process in which different parts of society should actively get involved in the long term, which is difficult to achieve in many aspects:

- Government's relief operation is relatively a straightforward operation (UN DMTP, 1993);
- After an emergency situation, governments have the attention and cooperation of many national and local organisations which is otherwise hard to achieve;
- There is usually financial help available nationally and internationally for an emergency operation that is not available in normal circumstances;
- Knowledge and expertise of countries for post-disaster operations is available for others to use whilst pre-disaster policies are context-based and specific to local circumstances;
- Reconstruction and rehabilitation is typically the physical redevelopment of an area by the government, but for disaster preparedness, the government has to

get involved in a wide variety of urban planning activities, from widening the roads to restricting public buildings and places, which is broader than a charrette single action of rehabilitation.

The past experiences of post-disaster relief have also proven that one-off responses from governments are inadequate (Pearce, 2007). This brings up the idea of a participatory approach, involving government institutions and all of society, including the local community, to enhance the capacity of the city after a disaster (Covington and Simpson, 2006). Involvement of various institutions which follow various different aspects of hazard risk mitigation makes achieving an integrated and comprehensive approach difficult. Also, local working experiences of carrying out risk management are exclusively based on practical use, traditional approach and local knowledge (Peters et al., 2009). In a fast-growing scientific and theoretical risk-management world, importation and exportation of knowledge and technology has made the role of local authorities and communities more difficult.

2.4 The Relationship between Components of Risk

Since the 1960s, when tackling natural disasters became an active and interesting discourse amongst academics and the humanitarian world, the definition of and insight into risk have evolved (Wassenhoves, 2006). Natural events became the cause of disasters and synonymous with their risk (*ibid*). Earthquakes, alongside other hazards such as flooding or drought, were seen as the real risk. A large percentage of the world's population during the last few decades have been affected by at least one of these natural disasters (UNDP, 2004a). There are discourses about the connectivity of natural disasters and human development. Some believe human development (especially of poor quality) is part of the risk (*ibid*). But there is a way through this, as development can save humans from the undesirable impact of natural hazards. Whatever the belief in the higher the magnitude of a disaster, the higher the extent of the hazard is.

Based on the above beliefs, the government and those who worked on this issue targeted construction resilience improvement using engineering approaches (Aysan and Davis, 1992) and reactions to the disaster during the reconstruction period (Davis, 1975). UNDP (1976) spent US$34 million on just under 250 disaster-related projects of various sizes during the 1970s and 80s, of which less than half addressed disaster prevention and preparedness (Siegel and Witham, 1991:297). As these decades passed, this process improved within the engineering context, whilst more severe disasters struck in urban areas and caused more physical and human losses. This became the cornerstone for further changes of approach in risk management (Pearce, 2007).

It was thought that building disaster resilience structures and infrastructure could bring total immunity into affected areas, but there are other elements that increase the vulnerability of people and their living environments (Wisner et al., 2004). However, it took years until these elements could push their way into disaster risk management literature. This can be seen in the UN guideline UNDRO (1976:14, 59) pointing to “physical planning”, “building measures” and “settlement management” as practical tools to recover after a disaster and to be prepared for the next one. Although the guide pinpointed very interesting solutions in this regard, the high level of cost, commitment and management demanded by the guide made it hard for many countries, especially the developing world (Wamsler, 2007), to implement its frameworks. Financial constraints and the management deficiency of many of these countries did not prevent the researchers and UNDP working on coordination and making the link between development planning and disaster management.

It was in the 1980s when the term “vulnerability” was first widely used for the areas affected by natural hazards among academics and researchers (Chambers, 1983). It was argued that the impact of a natural disaster is not only dependent on its severity of force, but also on the vulnerability of people and their living conditions (Maskrey, 1989). It was at that time that disaster risk management became a multi-faceted task, addressing both social and economic aspects (Wijkman and Timberlake, 1984). One of the most revolutionary approaches to disaster risk management was the relation between components of risk in a mathematical equation which shows the working pattern of each factor (Blaikie et al., 1994). In this equation, the risk of a disaster is caused by a hazard alongside the vulnerability of society, economy and the spatial built environment, whilst high capacity of each vulnerable element can reduce the risk.

Risk= Hazard*Vulnerability/Capacity

Figure 2.3: Risk equation (Blaikie et al., 1994:32)

Risk or probability of hazard occurrence, became the subject of three main debates which were not considered to be linked in the past (Kasperson et al., 2002): hazards, vulnerability and capacity:

- Hazards are the most common known disasters (natural or man-made) that occur in urban areas. They are known for their devastating impact on people's lives.
- Vulnerabilities are described by many (such as Birkmann, 2006) as the deficiencies in society – economically, physically, socially and environmentally – in facing hazards. Vulnerability factors escalate the damage to society if there is no improvement in its quality.
- However, capacity is an element of power and preparedness in the society which can reduce the impacts of disaster directly. There are various elements that build capacity, such as earthquake-resistant buildings, adequate safe areas in the neighbourhood or installation of flood-prevention infrastructure (Smit and Wandel, 2006).

With this new approach and fundamental reorientation towards risk management planning, the definition of each component broadened and brought the situation closer to the multi-disciplinary approach (Yohea and Tol, 2002). Whilst hazards were not only caused by natural disturbances, vulnerabilities were seen to exist within society, the economy, the political world and even the organisational bureaucracy (*ibid*).

Simultaneously, the ability to cope with the hazard by, for instance, an earthquake-resistant structure or an organised and prepared local government authority, falls into the third category, which is capacity. Simply, the better the capacity of the spatial, social, physical characteristics, etc., of a country, city or region, the less the adverse impact of the disaster (UNISDR, 2011). With this in mind, the impacts of natural disasters vary in different countries, areas and communities (Siegel and Witham, 1991). The joint venture of UNDP and UNDRO strongly recommended that disaster prevention should become part of government plans and funding programmes (*ibid*). This was not fully appreciated by any governments, and relief and rehabilitation remained their top priorities. People's vulnerability was added to the nature of hazards causing disruption within their daily lives. Research regarding disaster risk management was developed largely in the developing world where people are/were more affected by the risk of natural disaster (Yohea and Tol, 2002, UNISDR, 2011).

The 1990s were the decade of extensive concentration on disaster mitigation theories and practices, bringing sociologists, planners, economics and engineering together (Cutter, 2003). The emphasis on naturalness of disaster gradually became a debate of the past in which more and more attention was paid on the aspects of vulnerability (Wamsler, 2007). It became a belief that humans are not equally able to access the resources and opportunities and based to their income, social class, sex, age group, etc., they are exposed or vulnerable to particular types of hazard (Wisner et al., 2004, p.6). Another reorientation of the approach practised by the joint forces was to reduce the role of engineering and settlement development planning in disaster risk management agenda, due to the evolution of the approach in dealing with the causes as well as the symptoms (Wamsler, 2007). It is worth mentioning the international tendency towards thinking integrated and acting collaboratively, following the Agenda 21 (Earth Summit, 1991) framework. The supportive and prioritising ideas from international agencies, especially the UN, made 1990 to 1999 the International Decade for Natural Disaster Reduction (IDNDR) (UNDP, 2004a).

The Yokohama, Japan, agreement fulfilled the IDNDR purpose by highlighting two main approaches, studying and identifying the "cultural and organisational characteristics of each society" (Wisner et al., 2004:21) and the way they work to bring together the built environment, the participatory practice and involvement of local people and those who are not at the heart of administrative procedure. This, indeed, emphasised the role of social and economic indicators of disaster mitigation or vulnerability. It led to the introduction of the "Risk Assessment Tools for Diagnosis of

Urban Areas Against Seismic Disaster" programme (RADIUS) in the late 1990s (Ingleton, 1999). Based on this programme, the participant cities examined the participatory risk assessment and hazard mitigation techniques involving various sectors and communities, as well as government (*ibid*). But in practice, the international aid agencies still paid special attention to the emergency relief, reconstruction and development of long-term settlement (looking at the examples of work done in Turkey, El Salvador and India) (Aysan and Davis, 1992). The RADIUS (1999) work on disaster resistance plans, with particular focus on earthquakes, showed especially how single-approach, engineering-dominated work of hazard mitigation ignores the complexity of the issue and the links between hazard, vulnerability and socio-economic/spatial planning. This trend, continued through the 2000s, provided institutions, world agencies and researchers with more experience to evolve courses of action and understanding of risk management (Yodmani, 2001).

In recent UN publications (UNDP, 2004; 2005), and in some of the foremost countries in this field, such as the US or Japan, disaster risk management is known to be more complicated than the job of a single agency (Reid and Niekerk, 2008). The term "sustainability" became the framework for most spatial and environmental activities and expanded its vital and integrated meaning and framework to the planning and management debates (UNEP, 2009). The UN Environment Programme (UNEP, 2002) has an exclusive section on disaster-related issues and did try to pinpoint the extent of vulnerability in different countries (Wisner et al., 2004). The call for better land-use planning and relocation of the population in areas that are at risk was another important point discussed by many scholars in the later years (*ibid*). The role of urban development planning, which includes a wide range of issues from poverty and building regulations to networks of connection and infrastructure has been emphasised in increasing urban vulnerability and the consequences of disaster.[3] This insight demands an integrated and long-term commitment, even long before disaster may strike, to be reflected in planning policies and management. Two types of agenda were developed to make disaster risk management part of development planning, prospective disaster risk management (aiming to assimilate sustainable development

[3] See UNDP, 2004; UNISDR, 2000; World Bank Good Picture Notes, 2008; EMI Report on Earthquake and Mega-city Initiatives, 2007; ISDR, 2005; Lewis, 1999.

planning with disaster risk management) and compensatory disaster risk management (looking at the existing vulnerabilities and reducing them) (UNDP, 2004).

Creating the right combination of these fields requires development of step-by-step but interlinked planning. It is recommended by UNDP (2004) to start by incorporating adequate and relevant data in the fields of planning, vulnerability and disaster risk, building upon the most comprehensive theories and best practices (ISDR and UNEP, 2007) and finally turning them to policy frameworks and practical routines (ISDR, 2005). This consequently extends the role of international, national and local authorities from rescue and post-disaster agencies to policymaker and prepared organisation (*ibid*). This has brought both advantages and disadvantages to this field. From a positive point of view, the inclusion of various issues such as poverty, economy, urban development plans or even engineering gives everyone some kind of awareness and responsibility to be part of the risk mitigation process (Gopalakrishnan and Okada, 2007). However, in practice, bringing all these issues under one roof, influencing them and creating coordination amongst them is a challenge that cannot be accepted by the government of many countries, especially at local level.

One direct result of the above evolution is the change in the relationship between naturally occurring hazards and the vulnerability factors of those caused by human activity. Under the new approach, the distribution of urban life due to a hazard gets worse if that area's economy, environment or building vulnerability is of a high level (Blaikie et al., 1994) (Table 2.1). Opponents to economic globalisation believe one of the fastest-growing impacts of globalised economic policies may be the pressure of government expenditure cuts, which would put the health and life of the poor at greater risk (Friedman, 2000). The Pressure and Release Model (PAR) by Blaikie et al. (1994:22) focuses on three levels of vulnerability which are "global root causes, intermediate dynamic pressures and local unsafe conditions". Based on this model, disasters are the result of interactions between vulnerability and hazard effecting people or caused by them (Wisner et al, 2004). Figure 2.1 is the structure of vulnerability in the opinion of Blaikie et al. (1994) (explained by Davis et al., 2004:15). At the global level, factors such as the distribution of resources and power or macro-economy can dominate the extent of vulnerability (Davis et al., 2004). The second level is the intermediate level affected by the higher level and work at the urban scale. It is mainly related to the managerial aspect of disaster within the government capacity and practice (*ibid*). The very lowest level is the local economy, spatial structures, the physical condition of the living environment and unsafe living conditions of individuals that increase vulnerability.

Its focus on social and human related vulnerability makes the PAR model interesting and pioneering in opening new chapters in urban disaster planning, but hard to translate into policy and practical frameworks. There are arguments regarding the capacity of local people in reacting in time to reduce the impact of disaster immediately after the strike (UNESCO, 2007). Also, the separation of the natural hazard from the causes of vulnerability is another major criticism in this model. Although the hazard is not caused by local capacity, the role of capacity in responding to the disaster and the prevention of extreme vulnerability is inevitable. The next section is concerned with a more focused discussion of other models.

2.5 Vulnerability and Capacity Analysis: A Tool for Mainstreaming Disaster Risk Reduction

One of the tools for mainstreaming disaster risk reduction is the analysis of vulnerability and capacity (Natural Hazard Centre, 2007). This will help to:

- Measure the vulnerabilities of each urban element (social, physical, environmental and economic, institutional and political);
- Assess whether the capacity exists or can be developed under each element.

Based on the context of each country, city and region, the vulnerability criterion varies. However, for many developing countries, it is a combination of management, built environment and planning. Table 2.1 is a general hazard-related vulnerability classification and the capacity to mitigate its impact, prevent it or improve it. It is important to identify each vulnerability component via various tools, how it is vulnerable, what the effects of vulnerability are and whether all aspects are being considered (Davis et al., 2004). The more inclusive and detailed the identification process is, the better the needs and capacity to meet them are developed.

Looking at the table raises discussions regarding the possibility and extent of each vulnerability sub-category. Some of them, such as vulnerable occupants or unsafe infrastructure, might not exist in every disaster-prone area. Or under capacities, it might be difficult or impossible to apply them within certain social, political or economic conditions. But developing an appropriate tool to analyse them is an effective way – perhaps even an approach – and broadens the connection and possibility of networks of connection between relevant sciences, groups, institutions and plans. This also helps “the planners to understand problems”, “to prioritise actions” and to empower the “vulnerable communities” (Prevention Consortium Secretariat, 2007:13).

Table 2.1: Vulnerability and Capacity Criteria (Davis et al., 2004:17)

Sector	**Vulnerabilities**	**Capacities**
Social	· Occupation of unsafe areas · High-density occupation of site and buildings · Lack of mobility · Low perception of risk · Vulnerable occupants · Vulnerable groups and individuals · Corruption · Lack of education · Poverty · Lack of vulnerability and capacity analysis · Poor management and hardship · Lack of disaster planning and preparedness	· Social capital · Coping mechanisms · Adaptive strategies · Memory of past disasters · Good governance · Ethical standards · Local leadership · Local non-governmental organisations · Well-developed disaster plans and preparedness
Physical	· Buildings at risk · Unsafe infrastructure · Unsafe critical facilities · Rapid urbanisation	· Physical capital · Resilient buildings and infrastructure that can cope with and resist hazard forces
Economic	· Mono-crop agriculture · Non-diversified economy · Subsistence economies · Indebtedness · Relief/welfare dependency	· Economic capital · Secure livelihoods · Financial reserves · Diversified agriculture and economy
Environmental	· Deforestation · Pollution of ground, water and air · Destruction of natural storm barriers · Global climate change	· Natural environment capital · Creation of natural barriers to storm action · Natural environment recovery process · Biodiversity · Responsible natural resource management

There are other tools such as "Social Analysis" (Natural Hazard Centre, 2007), "Social Impact Assessment" (IFRCRCS, 2007a) or "Sustainable Livelihood Approaches" (Haidar, 2009) used by planners that can incorporate the above method in the use of plans. However, there are not many practical examples of using such tools in urban risk management plans, as many of them are used for assessing and estimating the damage done by disasters (*ibid*). This is due to a lack of understanding of disaster risk reduction and its incorporation into spatial plans. If there is consensus over the multi-faceted nature of disaster, then utilising this tool (VCA) would help to build up local government capacity whilst specific vulnerable groups or individuals within the context of economic, social or political sector would be prepared and be more able to participate (Davis et al., 2004).

In fact, the aim is to use "the concept of capacity in response to the negativity of the term vulnerability" (*ibid*, p.2). However, there are other views about the relationship between capacity and vulnerability, where they can be negative as well as positive towards each other (Cicone et al., 2003). But in this text, "capacity" means the potential and the factors that minimise the vulnerability of communities and their living environments to risk. Therefore, the basic steps in applying VCA in planning are described as follows:

Step 1: Selecting the right framework helps to establish a clear path to make strong and reliable links to the project components and is an appropriate tool to analyse the findings and get the best and most comprehensive outcome from it. It should be broad to include every relevant aspect whilst avoiding distractions and omissions (IFRCRCS, 2007b).

Step 2: Selecting the scope and level of analysis is an important factor in guiding the assessment to be focused and avoid mistakes.

Step 3: Identifying stakeholders who would involve the target groups or individuals, gathering data and analysing them to find the roots of vulnerability and the capacity of each involved party (IFRCRCS, 2007b). Having assessed the cause of decline or

increase in population status, for example, would not help disaster capacity analysis, whilst having the number, concentration pattern, or physical accessibility quality of elderly people in a region can help the possibility and timescale of an evacuation pattern and routes, which is part of the vulnerability and capacity assessment process.
Step 4: Selecting the appropriate approach for data collection and analysis. It is an important part of the process to gather enough information in a complex or unfamiliar situation when there is no willingness to cooperate or classified data is involved. It helps to follow a rational sequence in the methods used to collect data (*ibid*).

Step 5: Collecting data, using the initial data which has come from primary sources such as interview, and observation and secondary sources which fill the gap and could not be filled by participants' information (*ibid*). This can cover a wide range of issues from planning to management, experiences and opinions.

Step 6: Analysing the data; this stage is difficult as much data is descriptive rather than analytical. Giving weight to each aspect of the multi-faceted nature of vulnerability of an urban area may make the analysis complex. However, as the focus of this research has clearly indicated in the research question, this would be limited. And finally:

Step 7: Decision-making and recommendations; this step, which has been built upon the previous steps, plays a crucial role in recommending ideas and practical tools to fill the gap in a specific area (*ibid*).

The three main and most common frameworks are:

1) The "Capacity and Vulnerability Analysis" (CVA) model, a matrix developed in 1988 by Anderson and Woodrow to analyse the vulnerability and capacity of community under chosen categories of "physical/material", "social/ organisational" and "motivational/attitudinal" (Anderson and Woodrow, 1988:12). Table 2.2 is the summary of the framework.
2) The "Crunch" model – "Hazard*Vulnerability = Disaster or Risk of Disaster" – which is broadly a descriptive model, first introduced by Davis in 1978 and later defined by Blaikie in 1994 and Eritrea and India in 2004.

3) The "Vulnerability and Capacity Assessment Model" initiated by the International Federation of Red Cross and Red Crescent Societies in the 1990s mentioned earlier.

The CVA model, which was explained by Anderson and Woodrow (1988) and which is quite similar to VCA, has differences in approach and priorities of assessment within the context of capacity and vulnerability.

Table 2.2: The Capacity and Vulnerability Analysis Model (Anderson and Woodrow, 1988:12)

	Vulnerabilities	**Capacities**
Physical/Material: what productive resources, skills and hazards exist?	Extent of vulnerability, unsafe conditions, characteristics of vulnerability	Assist in reducing pressure
Social/Organisational: what are the relations and organisation among people?	Analyse present threats, social condition	Root causes
Motivational/Attitudinal: how does the community view its ability to create change?	How different people are	Establish the source, assets and entitlements

Figure 2.4 is the summary of the PAR model, which looks at the issue from the two interrelated angles of vulnerability and safety.

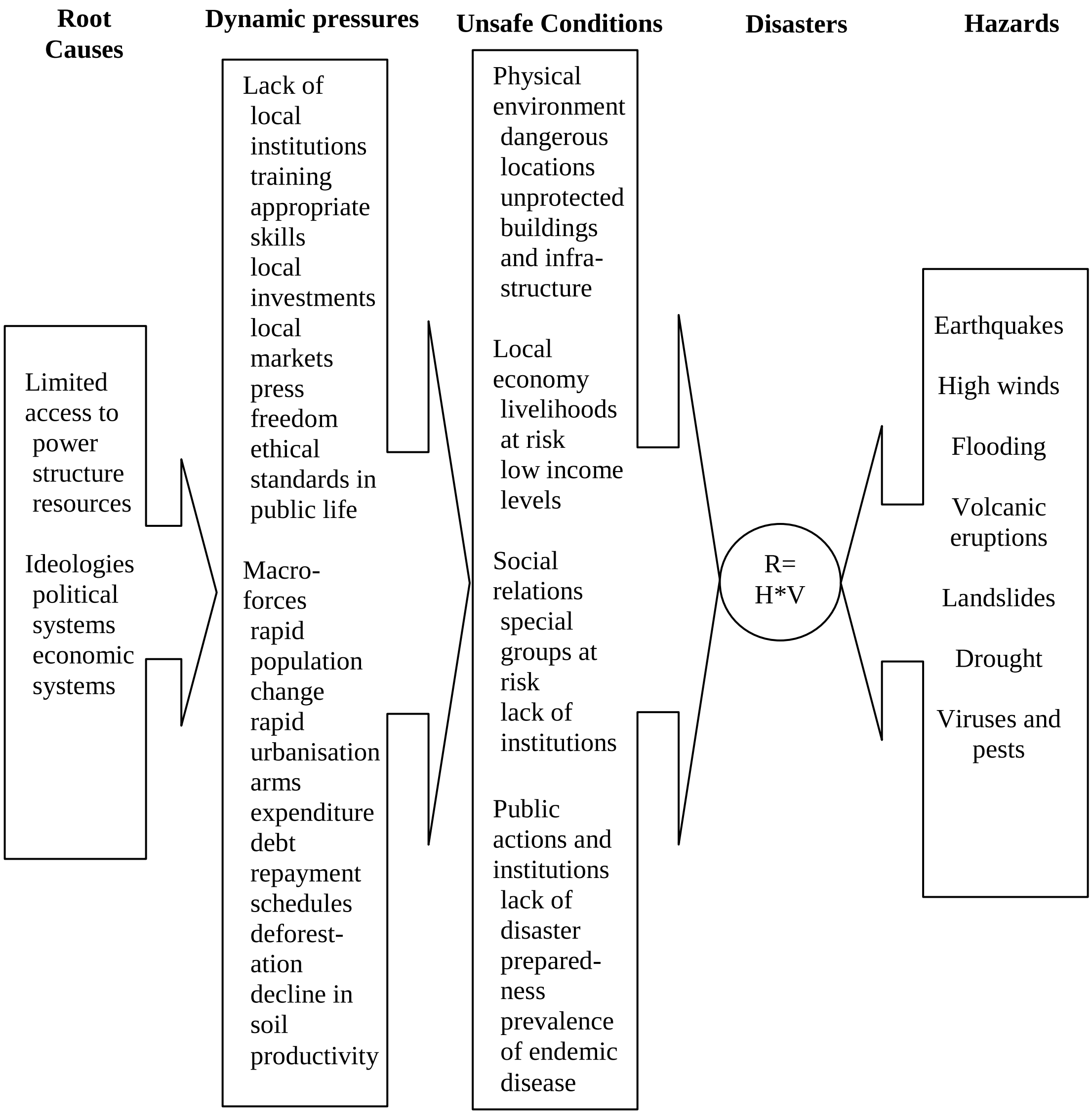


Figure 2.4: Pressure and Release (PAR) Model: the progression of vulnerability (Davis et al., 2004:15)

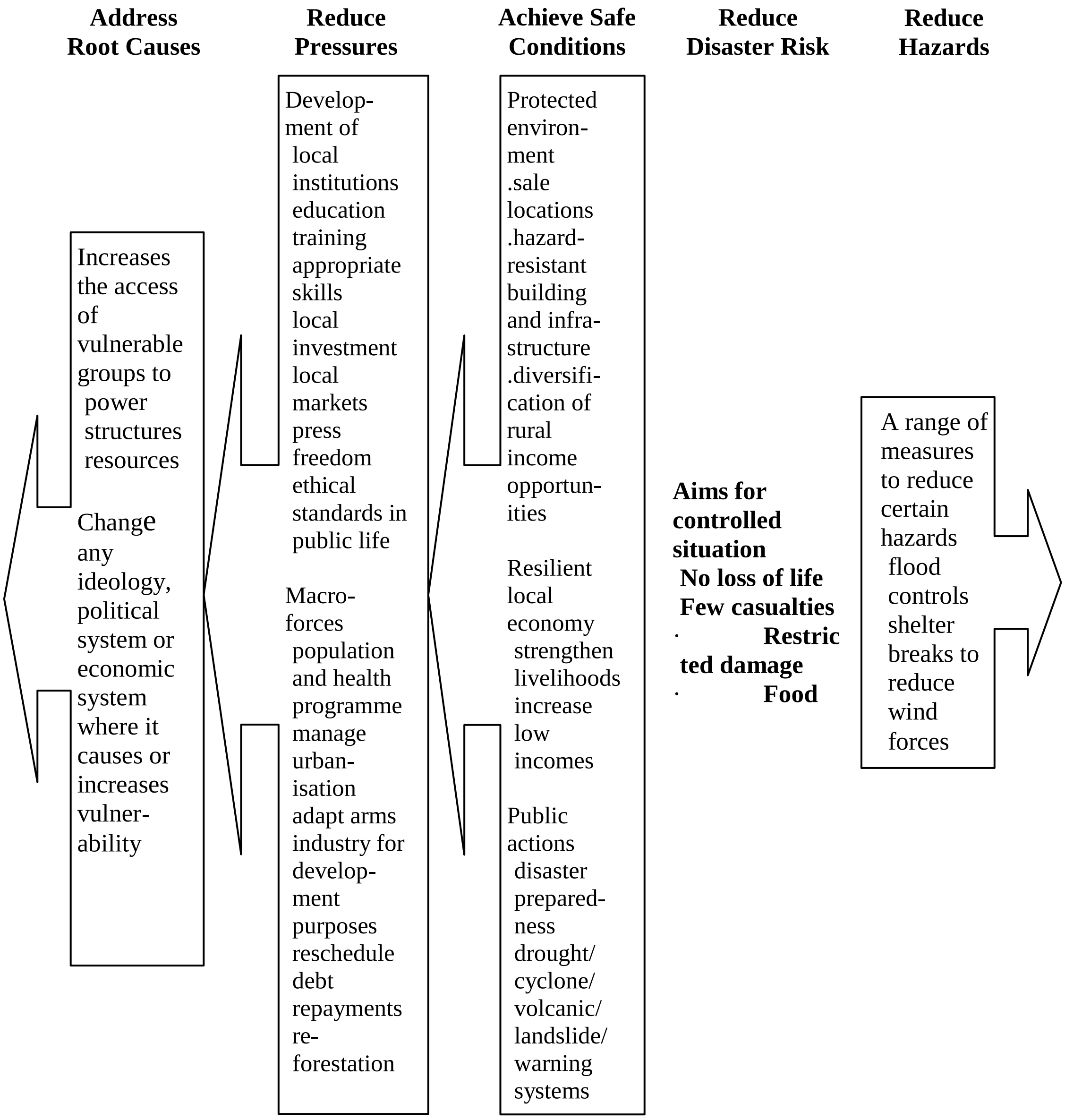


Figure 2.5: The release of pressures to reduce disasters: progression of safety (Davis et al., 2004:15)

The "Vulnerability and Capacity Assessment Model" is quite similar to the CVA matrix but is more specific. Table 2.3 is a summary of it. Some of the discussions are borrowed from CVA. As each framework indicates, vulnerability is not limited to building structure and should not be considered a post-disaster issue only. The CVA model is a simple but practical tool in expanding the extent of discourses and involved parties within the disaster management field (Enders, 2001). Interestingly, it goes beyond physical damage assessment and highlights the role of community and non-governmental organisations as well as the built environment in creating vulnerability, whilst they can also become elements of capacity and reduce the effect of disasters (*ibid*).

Table 2.3: VCA model (Davis et al., 2004:13)

Step 1: Identifying potential "threats" (based in nature, violence and deterioration)
Step 2: Identifying social vulnerabilities (proximity and exposure, poverty, exclusion and marginalisation)
Step 3: Assessing capacities and strengths (physical/material, social/organisational, skill/attitudes)

But it does not clearly provide the framework for identification of the cause of vulnerability, which leads us to the next framework, the "Crunch tool". The Crunch model is a very detailed but theoretical tool focusing on every detail of vulnerability, its causes and the recovery process. Increasing safety at every level of the city is one of the main goals of this approach (Heijmans and Victoria, 2001). However, it does not provide specific information about capacity assessment tools. Its dependency on the two steps of progression of vulnerability and progression of safety (Twigg, 2004) is a view that cannot be the best model for the nature and objectives of this research, as there is more a tendency towards the social aspects of vulnerability rather than urban planning measures. Vulnerability and Capacity Analysis has also been criticised for the gaps exists within the connectivity of technical, social, conceptual and development aspects which needs to be filled (Davis et al., 2004). But it has an enhanced assessment tool which contributes to a better understanding of building vulnerability as well as urban development planning. It also goes beyond the disaster risk context and provides the vital data on how cooperation amongst key organisations and the community can help urban design and resource allocation. Table 2.4 is a summary of advantages and disadvantages of the three main models discussed.

Table 2.4: Assessment approach of PAR, VCA and CVA

APPROACH MODEL	VULNERABILITY	CAPACITY	HAZARD
PAR	–Details of causes of vulnerability –Unsafe social, economic and physical conditions –Political and administrative causes	–Wide range of available assessment criteria	–Identification of hazards –Local causes
VCA	–Building quality and damage –Calculative and non-calculative assessment tools	–Social knowledge adoption ability –Physical resistance and infrastructural empowerment –Economic strength and recovery capacity	–Identifying the potential natural and man-made threats
CVA	–Governmental and non-governmental deficiencies –Physical and social vulnerability analysis	–Vulnerability-oriented assessment –Analysis of social capacity	–Different forms of hazards

2.6 The Relationship between Disaster Risk Management in Urban Planning and Open Space

The nature of urban contexts, in many researchers’ opinion, makes them more exposed to both man-made and natural hazards (Moser, 1996). Building structure and density or proximity to hazardous areas are some examples of this exposure. In small cities, urban growth, coupled with low capacity of technical experience, financial ability and planning, increases the risk of disaster; whilst although big cities are in a better situation, poor settlements in and around the cities cause a large number of people to be exposed to high risk (Palakudiyil and Todd, 2003). Therefore, for both small and big cities, urban development plans play a crucial role in increasing or reducing disaster risk. However, only recently has some research shown an interest in making a connection between disaster management planning and urban development plans

(Batuk et al., 2008). The present disconnection makes cities more vulnerable to various disasters, especially in high-density urban areas (Pelling, 2003). Within the context of urban planning, open spaces are/were designated as places of leisure, recreation and green space located at accessible distances for local people (Simela and Tembo, 2005).

Traditionally, urban development plans give direction to urban activities, building activities, infrastructure, roads and the locations of the main services such as hospitals, schools, parks or public buildings. These plans follow certain regulations derived from planning organisations that are not necessarily the same institutions that deal with urban disaster risk management. In many public buildings, it is required to consider an assembly point in the event of danger. But this is not particularly a part of regulating the use or location of open spaces in the wider context of neighbourhood, district or city. On the other hand, many countries have attempted to prepare disaster mitigation plans to guide regional and local government in creating a less vulnerable environment. This includes building resistant structures, creating an ideal refuge space for the post-disaster situation, and also some guidelines for working in collaboration during disaster management (*ibid*). These plans are prepared, proposed and controlled by various different organisations, instead of city councils, which are in charge of development plans.

In countries like Japan, due to the past chaotic experiences of fires and earthquakes, planning for disaster prevention became part of city land-use planning, which since 1923 has recommended separating high-density areas from other parts of the city by canals, or considering parks as post-disaster refuge areas (Ishikawa, 2002). The criteria, framework, approach and discourses that create the later plans vary in comparison with usual master or comprehensive plans.

Nevertheless, Broadbent (2nd ed., 2001) discusses that even within the field of disaster risk management, settlement development planning and housing provision are influenced by political decisions, which make control by planning authorities more difficult. The economic and political pressure on urban development plans for countries with a less flexible and integrated bureaucratic system makes the plans more vulnerable to disaster risks (*ibid*), as the regulations will not be put into practice fully, and illegal alterations to them reduce the possibility of full control by the government. Urban sprawl, the general feature of the developing world (Kotter, 2005), is characterised by extensive illegal settlements, the majority of which are occupied by urban poor and which do not normally fall into the category of disaster-resistant structures (Freire, 2006). This is due to many factors. Some of them are more important than others. The most important ones are (Simela and Tembo, 2005):

- Lack of government control on building structures;
- Lack of affordability by low-income inhabitants to hire engineers or use the best materials and follow building regulations;
- Development of areas outside the urban development plans, lacking in standard roads and service areas.

Disaster risk management has only found its place amongst government authorities within a limited number of countries, through the technical and financial support of UNDP (for instance, crisis prevention and recovery in Africa, Asia and South America). Its tools for estimation of damage caused by disaster to buildings, social life, the economy and the environment are a valuable method (ECLAC, 2003). But the organisations which are in charge, the approaches they use to create the plans and the contexts in which they put the plans into practice are not necessarily similar to those of the land-use plans. Also, the role and location of open spaces are not a significant part of disaster management plans. That is why there is not much literature which discusses this issue or has worked on it. In terms of urban governance having balanced development, discourses and distribution of responsibility, within the field of urban planning management and disaster risk management, there are shortcomings. The following section will develop a theoretical and practical discussion of the above subject to lead the research to the final conceptual framework which will form the literature review (Chapters 3–4) and case study chapters (Chapters 6–9).

2.7 Urban Planning Features

The concentration of population in urban areas exposes cities to various vulnerabilities such as famine, war and natural or man-made hazards (Godschalk, 2003). Ideas for reducing these dangers have evolved over the years by the development of planning theories and practice. It might not be possible or even necessary to go into the details of patterns of urban development in previous centuries, but a quick review of the shortcomings of development plans since the 1960s will help to identify some main points:

- Traditional development plans, even in their most recent format, do not focus on disaster prevention or preparedness (Martorell et al., 1996);
- The main feature of development plans are economic development, physical and spatial quality improvement, social and cultural value improvement (Kirkpatrick et al., 2001);
- The inclusiveness of planning procedures in terms of public participation is still not ideal (Enyedi, 2004);
- Institutional capacities are not fully developed and engaged with the development planning process, which undermines use of local knowledge, relationships between authorities and increases in the capacity of the governance system (UNDP, 2008);
- The design of open spaces is not an important part of the risk reduction approach even within disaster management planning (American Planning Association, 2006);
- The theoretical and practical interaction between disaster management and development planning has not been developed (UNDP, 2003).

The 1960s was the decade of large-scale physical intervention of government in many countries, pointing to the poor condition of some inner-city areas and the concentration of unhealthy living environments in the cities (Taylor, 1999). The most controversial but influential theory, “garden cities” (Howard, 1946), was a planning guide to help cities to improve the living built environment inherited from the Industrial Revolution. The trend was continued in the form of new towns all over the world, which were largely used to cope with the growing urban population (Hall, 2002). Government intervention was focused on housing production, job creation and recovery from the World Wars (*ibid*). Disaster-related planning was mainly about the improvement of building resistance in a purely physical context (Inglesby, 2011). Most of the literature and planning policies looked at the cities as a prime place of economic growth, without taking notice of the role of urbanisation in increasing the vulnerability of supply lines and triggering the extent of natural disasters (McGranahan et al., 2001). Even within the UN publications in this period, there is no specific discussion about social vulnerability, the role of planning or pre-disaster management (UNDRO, 1976); instead they focus on post-disaster reconstruction and rescue programmes. There was not a similar scenario in developing countries, as their governments were/are still not keen to become welfare states or take responsibility for providing all the major services (Quarantelli, 1998).

Governments' policy and management systems and financial constraints did/do not support an integrated disaster prevention mechanism and planning (*ibid*), leaving this to international and national relief and reconstruction agencies. The role of lead architect in charge of the design and planning team was the most distinctive characteristic of this period. It was more the practice in the developing world, as master plans were significantly influenced by western planning theories and were dominated by central government in a top-down direction (Jenkins et al., 2007). Therefore, land-use planning was (and in some developing countries still is) about giving initial educational, administrative, leisure, health or economic services to citizens (Kotter, 2005). It did not thus create any integration between disaster prevention planning, disaster management organisations and the community.

Whilst physical development planning was spreading across the planning system, some authors such as Newman (1972) started to question the concentration of economy, population and services in the cities and to discuss how these could make cities vulnerable to natural hazards, and man-made ones such as crime. Therefore, it was then (in the 1970s) that social and economic aspects were given special attention (Taylor, 1999). However, although bringing other aspects of the society into urban development plans was the beginning of integrated thinking and acting collaboratively, there was, firstly, still no place for disaster-related planning in this field, and secondly, the use of open spaces did not change at all.

The general disaster-related literature still focused on the nature of hazards, not vulnerability criteria (Aysan et al., 1995). The fast-growing informal settlements with poor physical and service conditions were pinpointed by international agencies (Jenkins et al., 2007) and regarded as locations vulnerable to disasters (Tobin, 1999). The World Bank "Sites and Services" programme (1993), alongside other schemes,[4] targeted these areas as prime locations for upgrading and improvement. Despite all the negativity about the relationship between disaster risk and urbanisation, there was a belief in improving this interlinkage by implementing risk reduction, prevention and preparedness measures into buildings, services and plans (Frumkin, 2002).

Considering social, economic, physical and spatial elements in development plans imposed considerable change to the aims and approaches in urban planning management from the physical and design-based approach, which had roots in instrumental rationality planning to structure planning (Jenkins et al., 2007). Based on this paradigm, the structure plan would consider major hazardous areas when it set out the infrastructure and strategic building locations (Wamsler, 2007). Having all these major progressive approaches in mind, the design of open spaces, however, did not face any change. Avoiding locating building construction in hazard-prone zones did not necessarily mean designing open spaces for disaster prevention (UNDP, 2004); it only reduced the risk of vulnerability. For many developing countries which basically import their planning knowledge, the above discussion was not fully developed or put into practice; this is discussed in Chapters 3 and 4.

Having in mind structure planning in action, internationally funded projects also tried to correct the master plans' failure to meet multi-dimensional urban issues (Wamsler, 2007). Specific budget was allocated by international organisations such as the World Bank and the UN to the governments of some countries to improve the quality of slum settlements, reducing the risk of flood or drought by subsidising infrastructure projects and also by investing in risk assessment and disaster management planning. Jenkins et

[4] See Hanza and Zetter (1998), Schumacher (1973), Moudon (1986).

al. (2007) mention community action planning, which aimed to improve slum sites, services and buildings and discuss why it could not meet its goals. The reasons were:

- They could not raise public awareness (Hamid and Goethert, 1997);
- The process of management was a top-down system (Jenkins et al., 2007);
- The role of local community or even local government was underdeveloped (Mitlin and Thompson, 1995);
- The benefits of recovery or investment did not "trickle down" (Stein and Vance, 2008).

Gradually, international agencies and national governments learned from previous experiences and developed a locally-oriented approach which engaged local communities, municipalities and other groups and agencies (Jenkins et al., 2007) in the mitigation of disaster risks, from which would evolve structural disaster-resistant improvements etc. (UNDP, 2004a). This brought some advantages to risk management planning. It broadened the extent of issues that should be considered in this field (Jenkins et al., 2007) whilst giving the researchers and planners the opportunity to bring various experts from different backgrounds to spend time on the studies related to disaster risk mitigation (Stoddard et al., 2004). However, in practice there are ambiguities about who the responsible bodies are and how collaboration actually works in the planning process, especially before a disaster. The role of open space in planning for disaster became more evident (American Planning Association, 2006). In other words, it became a generally agreed theme that the more vulnerability was reflected in planning, the more influence it could have on spatial plans (Simela and Tembo, 2005).

The private sector has gradually also become one of the most influential elements in shaping building development (Bryson and Roering, 1987), which is good, as it is more cautious about the structure of buildings. Many public buildings and shopping centres were invested in and built by the private sector with regular observation by building control officers. Therefore, the private sector can also force their way into the decision-making process (Healey, 1998) to secure long-term profitability and return on investments. Transforming or sharing part of government's responsibility for disaster risk reduction activities with the private sector, other organisations and the community (Østensvig, 2006) was a step forward in managing a multi-disciplinary issue collectively; but arguably, in the author's experience:

- It is not the case in many centralised systems of government;
- It can be easily overruled by internal and external forces;
- Participation takes place in practice, not decision-making;
- It does not make fundamental changes within the planning framework.

The shift of attention and responsibility from government to a so-called "enabling" agent (Sahu, 2008), however, brought a wide variety of national and local organisations into the urban planning scene and tried to limit government's involvement to providing legal, institutional and economic frameworks (Winser et al., 2004), but essentially increased the vulnerability of urban settlements, especially in poor areas, by reducing government observation and intervention in maintenance and structural adjustment practice (*ibid*).

Despite the changes which occurred in risk management systems, the position of government in prioritising the stage in which disaster planning and management should be dealt with did not change (Sahu, 2008). One of the disaster-related aspects that was developed during these decades was work on post-disaster rescue, rehabilitation and recovery (Sinha, 1999). The role of international agencies and aid organisations in delivering services through governmental and non-governmental agencies for emergency relief and reconstruction of affected areas was/is inevitable and has played a crucial role (TDRM, 2005). This has increased the dependency of national organisations on outside help, and could not create a permanent collaboration between disaster management teams in countries like Haiti or Iran (Raschky and Schwindt, 2009).

Technological progress in the building industry, disaster prediction techniques and other scientific activities have also focused mainly on post-disaster scenarios (GFDRR, 2006). Also, the extensive intervention and financial help of international agencies has weakened the exclusive and important role of national and local government to be prepared and make plans for hazardous situations (Raschky and Schwindt, 2009). Within the urban planning theories and practice context, despite understanding the nature of disasters, pre-disaster development plans did not become a matter of priority and it took the researchers and practitioners all this time to give urban risk reduction and management the same weight as the urban development plan. The disconnectivity of urban development plans and disaster risk reduction plans is apparent in most of the relevant literature (Tobin, 1999) and the plans of many cities, including Tehran. Extending relational resources and empowering local government has not automatically brought about common ground and an integrated approach within these two fields. The use and prime location of open spaces (as the focus of this research) in these contexts is not of the same purpose, which makes them irrelevant.

Dealing with different kinds of problems in the developing world (Hirt and Stanilov, 2008) coupled with the frequency of urban disaster disruption (Romero, 2008), dependency on foreign relief help and a lack of belief in investment before disaster strikes (Raschky and Schwindt, 2009) put the governments of these countries in a different position from more advanced countries. For fast-developing cities which require job creation and investment to meet the population's needs, urban ecology, congestion (UN-Habitat, 2008), earthquake-prone zones and landslips are not restricting factors. Open space design is regulated for use for a variety of purposes other than disaster risk reduction. In other words, planners aim to give direction and manage urban development (Freire, 2006) rather than prevent or be ready for future disasters. Local authorities are/were not capable or interested in devoting their capacity to risk reduction management before disasters occur (Malalgoda et al., 2010). Therefore, improving building resistance became the only feature of disaster management (Smith, 2005).

Following the adoption of Agenda 21, targeting human settlement and adequate shelter for all people at Rio de Janeiro in 1992 (UNCED, 1992), the 1996 Habitat Agenda in Istanbul (UNESCAP, 1996) emphasised sustainable human settlement development to reduce urban poverty, prevent disaster and enhance community participation. This became the framework for the 2000s and the new millennium, opening a new chapter in disaster risk management systems. Conceptualising the idea of integrating urban planning with disaster-related planning became an effective and accountable tool in the hands of some governments to promote the theoretical and practical base of disaster risk management (ISDR, 2010). Combating urban poverty found priority according to a set of agendas (Millennium Development Goals) (MDGs) (UN-Habitat, 2007) and underwrote disaster risk management planning as well. The focus is on improving the living environment of slum areas which are at higher disaster risk (ISDR, 2010). One of the most foremost publications discussed the issues related to the natural disasters was the Global Report on Human Settlements (2007) (UN-Habitat, 2007) emphasising the post-disaster recovery and reconstruction as well as pre-disaster development. Having all the above conceptual background in mind, the next part will identify the shortcomings of disaster risk reduction planning, which are more related to this research.

2.8 Connecting Disaster Planning, Urban Development Plan and Open Space via VCA

The complexity of urbanisation, which makes vulnerability and planning for preventing or reducing the risk of disaster intricate, requires a tool to be able to cover all aspects, whilst also being able to translate them for planning purposes. Another element that the assessment tool should be capable of is to integrate pre-disaster preparation with post-disaster damage and needs. VCA is an assessment tool which analyses the vulnerability and capacity of a given context to hazards (natural or man-made) to be used for the planning and implementation process. There are shortcomings about this tool (Davis et al., 2004) which will briefly be discussed later, but it is a socially-oriented tool which has elements of management and planning, and can provide the research, especially the empirical part, with an assessment and analytical tool. From an open space design and functionality criteria under the disaster management perspective, VCA provides the necessary data that a planner needs to create a safe open space for the event of a disaster strike. The initial stages which contribute to make the link between the development plan and disaster damage has been described below (Figure 2.6).

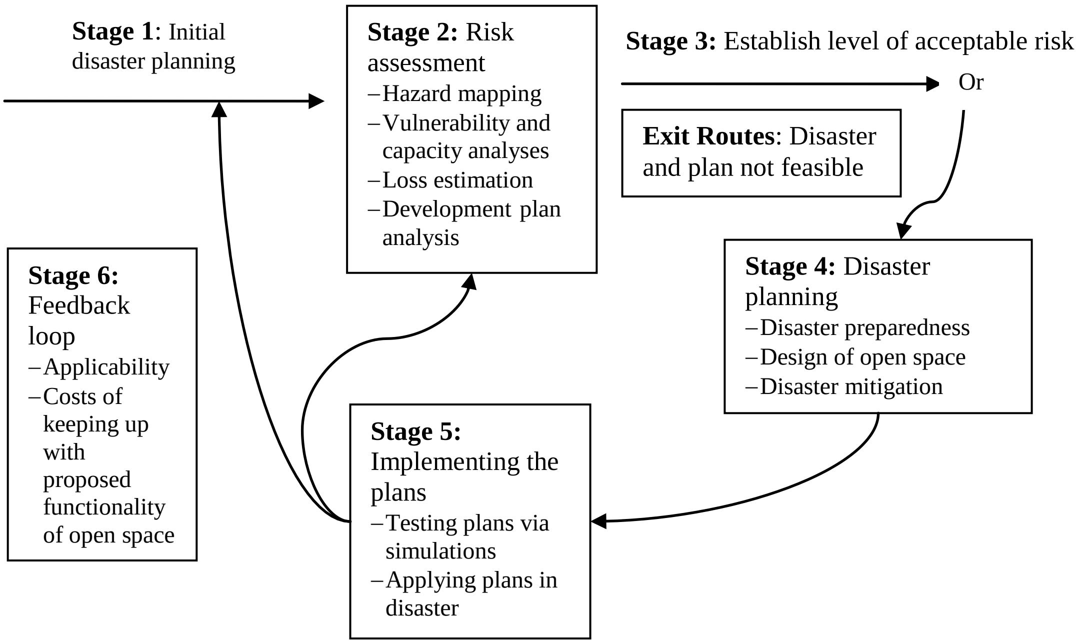


Figure 2.6: VCA initial stages for assessing and analysing disasters (Davis et al., 2004:8)

Stage 1: Initiation of disaster planning: this has been identified amongst academics, government and aid agencies. But it is at a stage of being appointed as a new and separated planning practice, which should be undertaken by a group not necessarily similar to the urban development planning authorities. This initiation, according to the VCA framework, requires a committee consisting of local and national government, the community, NGOs and the private sector, who would deal with traditional development plans and disaster management (IFRCRCS, 2006).

Stage 2: Risk assessment: this gives the planners essential data and realistic measures to use in creating plans. Identifying the main hazards and mapping the area of their effect would highlight the safe and unsafe areas (*ibid*). Estimating the loss in population and in the physical, economic, spatial and environmental fields would illustrate the most vulnerable aspects and their severity, as well as the capacity of each area (*ibid*). In terms of the present development plan, it would also provide the analytical framework to assess urban features, the use of land and current open spaces.

Stage 3: Establishment of acceptable risk: this is a matter of cost, enforcement tools, management and power (*ibid*). Although decision-making power is not dominant in VCA, it provides the political and planning authorities with the facts. As the figure shows, highly vulnerable areas or those expensive to restore can be dismissed from the cycle (*ibid*).

Stage 4: Planning risk reduction measures and disaster plans: this is a multi-disciplinary plan involving horizontal and vertical connections, which have been missing in planning tradition. Open spaces (in this research) are one of the answers to disaster risk preparedness.

Stage 5: Implementing the plans: this can occur via testing processes or during an actual disaster event.

Stage 6: Feedback: the plan for open space serviceability can be tested or critically analysed during each stage and/or after use.

> [The] effective VCA will contribute to a greater understanding of the nature and level of risks that vulnerable people face, where these risks come from, who will be the worst affected, what means are available at all levels to reduce the risks and what initiatives can be undertaken to reduce the vulnerability and strengthen the capacities of people at risk.
>
> (Davis et al., 2004:3).

There are also critical points raised by many critics for this tool (Vatsa, 2004):

- VCAs are localised and context-related and cannot be used widely;
- VCA works better in small-scale localised areas; for larger areas the context should be divided;
- The professional-dominated nature of VCA makes it difficult to implement for those governments who do not have the qualified assessors;
- Measures for social vulnerability can change over time, which is a critical point to be considered;
- This tool can undermine already vulnerable conditions, which needs to be carefully avoided.

Having all these in mind, VCA is a suitable assessment and analytical tool for this research by providing a framework to assess building, infrastructure, supply line and planning vulnerability and proposing a design principle for urban open space to offer service to people in the event of disaster.

2.9 Conceptual Positioning

Based on the above discussions and the research question three main deficiencies within the context of urban disaster planning are:

- There is a lack of referral literature to provide guidance for the development and practice of sustainable urban disaster risk reduction management (Bendimerad, 2003).
- Disaster risk management is not equivalent to disaster risk reduction (ISDR, 2002).
- Integrated disaster risk management is not a well-developed practice (Bendimerad, 2000).

The review of some of the international disaster-related literature revealed reactions to losses after each disaster. In future, academics and governments need to concentrate on building structure resistant improvement, but not on how the general risk management should operate. Each aspect of urban planning plays a crucial part in the reduction of urban risk and vulnerability against disasters. “Sustainability” here means a balanced and inclusive theory or guideline. But there is no theory or practical framework to explain how risk management, rather than prevention, can be sustainable in terms of costs, design and planning. This research uses urban open spaces as a means of facilitating a sustainable and practical refuge space which has been prepared pre-disaster to operate post-disaster.

The review of literature addressing the impact of disaster on the cities is well-developed by utilising a scientific approach in this field, but the outcome concentrates on risk reduction rather than management. This forms the second conceptual framework of this research: to learn from earthquake damage to building, infrastructure and urban services, proposing the application of safe urban open spaces within the master plan. In order for these spaces to offer adequate service, the third conceptual aspect of the research, which is integrated disaster risk management, that should work before, during and after a disaster (earthquake), will be developed within the literature review and guide the discussion of the case study. Municipalities have been empowered over the past few years to be the main development plan service providers and controllers of urban settlements. However, this does not lead to an integration of this power with the disaster management authorities, especially before a disaster. The notion of integration, synonymous to collaboration amongst members in the management field, is not well-developed.

For this research, such a challenge is not limitless, but within a specific context and for a particular natural disaster. Most of the available literature only paraphrases and develops a strategy for disaster risk management purposes. But it does not indicate or explain how this integration can take place in practice, what aspects should be improved or what elements should be avoided, or, indeed, how open spaces can actually function as a means of disaster refuge alongside the provision of their usual services to the city. The most important conceptual framework of all which this research will implement is that in normal circumstances, open space design is a set of regulatory comments which are not open to disaster mitigation, multi-functional disciplines in hazardous situations or urban services. The research will carefully widen the narrow professional areas of disaster risk management, and form an advanced idea of integrating the above three aspects in a proactive context.

PROGRESSION OF VULNERABILITY								
ROOT CAUSES	⇒	*DYNAMIC PRESSURES*	⇒	**UNSAFE CONDITIONS**	⇒	***DISASTERS***	⇐	**HAZARDS**
Limited access to		**Lack of**		**Fragile physical environment**				**Earthquake**
• Resources		• Institutions		• Dangerous locations		**RISK**		
• Structures		• Training		• Unprotected structures				**Wind storm**
• Power		• Skills				=		
		• Investment		**Fragile local economy**				**Flooding**
Ideologies		• Markets		• Livelihoods at risk		**HAZARD**		
• Political systems		• Press freedom		• Low income				**Volcano**
• Economic systems		• Civil society				+		
				Vulnerable society				**Landslide**
		Macro-forces		• Groups at risk		**VULNERABILITY**		**Drought**
		• Population growth		• Little capacity to cope				
		• Urbanisation						**Viruses and pests**
		• Arms expenditure		**Public actions**				
		• Debt repayments		• Lack of preparedness				**Heatwave**
		• Deforestation		• Endemic disease				
		• Soil degradation						

Figure 2.7: Progression of vulnerability (Blaikie et al., 1994)

Chapter One……………………………… **Introduction**

Chapter Two…………………………… **Conceptual Framework**

Chapter Three…….. **Evaluation of Damage and Risk due to Earthquakes**

Chapter Four………………… **Open Space and Diversity of Services**

Chapter Five…………………………… **Research Methodology**

Chapter Six…. **Identifying the Spatial and Geographical Structure of Tehran**

Chapter Seven. **Use of Urban Risk Assessment Tool for Main Planning Resources**

Chapter Eight.. **Evaluation of Risk in the Study Area**

Chapter Nine.. **Open Space Design Criteria for Refuge Areas**

Chapter Ten…………………… **Conclusions and Recommendations**

3.1 Introduction

The progress of technology and science during the last few decades has not stopped nations of the world suffering from disasters. The cost of recovery and loss from disaster has become a challenging issue for many governments and organisations (Lyons et al., 2010). It has been understood that fast response and recovery, alongside enhancing disaster resilience culture, are some of the combined approaches that should characterise disaster management and policies (Brewster 2005; Basher, 2006). In doing so the challenges are:

- Providing the community with relevant information about the nature of hazards;
- Enhancing government's and people's knowledge about the process, progress and causes of hazards;
- Producing policies, techniques, and integrated collaborative management systems and planning for hazard mitigation theory and practice;
- Identifying vulnerability in society – socially, physically, environmentally, politically and managerially;
- Spreading the culture of disaster resilience within government and amongst the community;
- Enhancing the ideology of sustainability by promoting integration, collaboration and authenticity amongst the community, government (national and local) and international agencies (NSTC, 2005).

Addressing the issue of disaster, this chapter and the next aim to identify the main impacts of disasters on city life, looking at the earthquake impetus on the urban environment, infrastructure and damage estimation, which would be the basis of the preparedness plan, in the form of open space, later on in this research.

3.2 Reviewing Main Disaster Profile

Based on the geographical location and other factors such as global warming, growing population and urbanisation, disasters have unforeseen consequences on people's lives. The existence of the culture of "wait and see" (EMI, 2007:3) has escalated the impact of natural hazards. The natural unprecedented activity is "caused by geological, biologic, seismic and hydrologic symptoms" which undermine the usual way of life (ADPC, 2000:2). Epidemics, plant disease, volcanic eruptions or typhoons are also among natural disasters (*ibid*). However, Table 3.1 briefly mentions the most frequent causes of natural hazards and possible damage.

Table 3.1: Example of hazards, their cause and possible damages (Inter-American Development Bank, 1999; Price et al., 2007; Arya et al., 2001)

Hazard	Cause	Vulnerability	Damage
Earthquake	Underground movement, soil liquefaction, surface fault rupture, ground motion amplification, induced landslides	Infrastructure, buildings, people, economy	**Structural, buildings, supply lines**
Drought	Dry weather, lack of underground water resources	Growing population, agriculture, economy, urbanisation	**Natural environment and trees, corpses, soil, animals**
Flood	Constant heavy rain, over-full rivers, thunderstorms	Urban river bank areas, population, water and land, buildings	**Structural, infrastructure, disease**
Tsunami	Underwater earthquake, underwater landslide, high wave	Infrastructure, buildings, people	**Urban environment, coasts, buildings, supply lines**

As the table indicates, the expansion of knowledge in terms of identifying the causes of disaster has gradually helped researchers and aid organisations develop their understanding of the aspects of vulnerability, and continue to conduct hazard and vulnerability assessments (Arya et al., 2001). In a simple but worrying statement by TearFund (2005), by 2025, nearly half of the populations of developing countries would be affected by disaster (p.4). In many instances, especially in developed countries, "well-prepared community" invested in by the government and the community prevention plan had "minor loss of life", showing the result of advance knowledge and planning ahead (*ibid*, p.5). The loss of only three people's lives on the east coast of America in September 2003 when Hurricane Isabel hit (*ibid*, p.5) is the staggering result of hazard assessment. In fact, our understanding of disaster has become inclusively magnified from physical and infrastructural evaluation to the critical examination of social, environmental and economic effects (Flax et al., 2002).

Rapid disaster loss estimation involves the preparation of a pre-disaster local and regional map, a disaster intensity map and a physical damage and loss map (Erdik et al., 2010:1). The work of the US National Disaster Council (1999) to estimate the damage to the coastal area of Florida in 1994, and Zhifeng et al. (2010) on the Fuhe flood damage loss estimation, are examples of physical damage and loss maps in comparison with pre-disaster conditions. These maps help to estimate the damage and analyse the most vulnerable elements of city life. These maps can aid the immediate and directed search for resource operations and emergency response (Zhifeng et al., 2010). Although the damage caused by each disaster is different, technological advances have permitted national and international organisations to analyse the distribution and extent of damage, estimate the number of casualties, and plan for immediate rescue action (*ibid*). The capacity of government, in using this advanced technology, management and communication style, can affect the area's resilience (Pelling, 2003). The more in-depth and accurate this understanding and estimation is, the more effective the post-disaster practice is. Considering a disaster map, which executes damage estimation pattern, can partially help regulate the urban activities and reduce the risk of destruction (ADPC, 2000); it could be one of the activities which uses post-disaster experiences for pre-disaster preparedness. The next part will exclusively develop discussion regarding the damage estimation due to earthquakes which will a) aid in understanding of the vulnerability level of urban areas, and b) help to develop the plan to be prepared for disaster.

3.3 Seismic Risk Terminology

Like other hazards, people, urban and rural buildings and infrastructure, supply lines, and the economy, are all exposed to earthquakes. There is a direct relationship between the level (severity) of a hazard and its frequency, and the probability of risk which can occur in a vulnerable context which is specifically exposed to a hazard (Koch and Arlia, 2008). The extent of the exposure depends on each vulnerable object, which is not necessarily similar in each context (Pelling, 2003). The quality of the same material, for instance concrete, is not even similar due to the process and quality of preparation. The exposure of buildings to the risk of earthquakes is “expressed by functions or matrices which can be obtained either by statistical studies of damaged buildings in earthquake-struck areas or by simulations using numerical or analytical models of buildings” (Lang, 2002:2). An earthquake is hazardous by causing the ground to shake which is sometimes due to the rupture of a fault (Graf, 2006). The risk is the relationship between the vulnerability of the physical, social, economic and environmental context, their extents of damageability, and the scope of frequency of the hazard which increases the exposure of urban life (Figure 3.1) (*ibid*). In other words, the seismic risk is “the probability that social or economic consequences of earthquakes will equal or exceed specified values at a site, at several sites, or in an area, during a specified exposure time. Risk statements are thus given in quantitative terms” (Dowrick, 2003:1).

Table 3.2: Seismic risk standards (Graf, 2006:17)

Damage Relationships	ATC 13 ATC 13-1 NIBS-HAZUS
Seismic Risk Terminology	ASTME 2026-99
Rapid Visual Screening	FEMA 154
Vulnerability of Buildings	ASCE 31-03 (FEMA 310)
Vulnerability of Contents	FEMA 74
Rehabilitation of Buildings	FEMA 356

The higher the magnitude of the earthquake, the longer its return time and the more damage it causes (Wetzel, 2005).

Ground Motion: The main cause of earthquake damage is the ground motion which is measured by peak ground acceleration (PGA), and which is given as a percentage of the acceleration of *g* (Koch and Arlia, 2008). The level of ground motion is dependent on the distance of its epicentre from the specific site and the magnitude of the earthquake (Wetzel, 2005).

Ground Motion Amplification: Factors such as local geology, soil and their arrangement can intensify the ground motion, known as ground motion amplification (Koch and Arlia, 2008). It can cause damage even if the epicentre is located far from the built environment.

Liquefaction: If the base of the ground is made of soft sand and soil, the ground motion can be liquefied which results in failure of foundations (*ibid*).

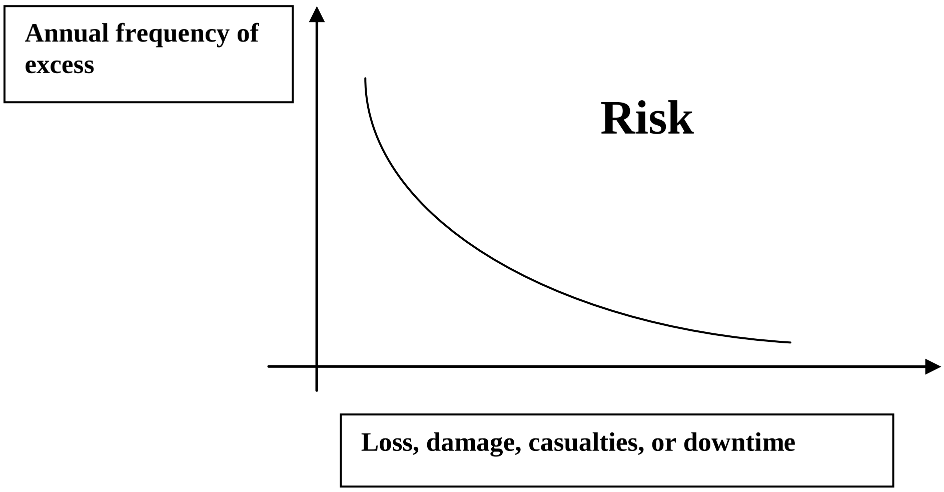


Figure 3.1: The relationship between damage and earthquakes (Graf, 2006:2)

This is the general picture in many areas which are close to rivers or the sea.

Earthquake Induced Landslides: If the area includes steep slopes, earthquakes can cause severe damage, which is the case in many cases of seismic shake (Rodríguez et al., 1999).

"Quantitative and rational management of earthquake risks" are considered at three stages; before, during and after the strike (Bayraktarli et al., 2004). The most popular risk assessment standards are summarised in Table 3.2. The following table defines the general magnitude of an earthquake and the possible damage to the physical built environment (*ibid*). Although material, the ground bedrock quality and the quality of construction play a crucial role in affecting the severity of damage, the probabilistic seismic hazard analysis (PSHA) is the base for the predictions in the table.

Table 3.3: Earthquake intensity classification and damage (SEMO, 2008:4)

Magnitude and Intensity Comparison	
Richter Magnitude Scale	Typical Maximum Modified Mercalli Intensity
1.0 to 3.0	I
3.0 to 3.9	II to III
4.0 to 4.9	IV to V
5.0 to 5.9	VI to VII
6.0 to 6.9	VII to IX
7.0 and higher	VIII or higher
Defined Modified Mercalli Intensity Scale Rating	
I	Not felt except by a very few under especially favourable conditions
II	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many do not recognise it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Felt indoors by many, outdoors by a few during the day. At night, some awakened. Dishes, windows, doors disrupted. Walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone. Many awakened. Some dishes, windows broken. Usable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved, a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction. Slight to moderate in well-built ordinary structures. Some chimneys broken.
VIII	Damage slight in specially designed structures. Considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walkways. Heavy furniture overturned.
IX	Damage considerable in specially designed structures. Well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed. Most masonry and frame structures destroyed with foundations. Rails bent.
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown into air.

3.4 Methods for Assessment of Building Damage

In a rapidly progressive world of scientific earthquake loss estimation technique, pointing to a fully effective method is not easy. Experiences gained from a large number of earthquakes and the performance of the buildings during them, which consequently affect people’s economic, social and environmental life, can simply be classified into different methods based on targeting a large number of buildings or a detailed analysis of individual ones. “Typical (categorisation methods, statistical method) inspection and rating methods (indirect expert judgement) and mechanical methods (analytical)" are the main categories identified by Bedford and Gelder (2003:672). Table 3.4 summarises some general building vulnerability assessment methods which can be used for either individual or groups of buildings. Also, in a simple but inclusive figure (Figure 3.2), the classic methods for risk assessment are shown, which indicates the complexity and sensitivity of choosing a method that most suits the case study area.

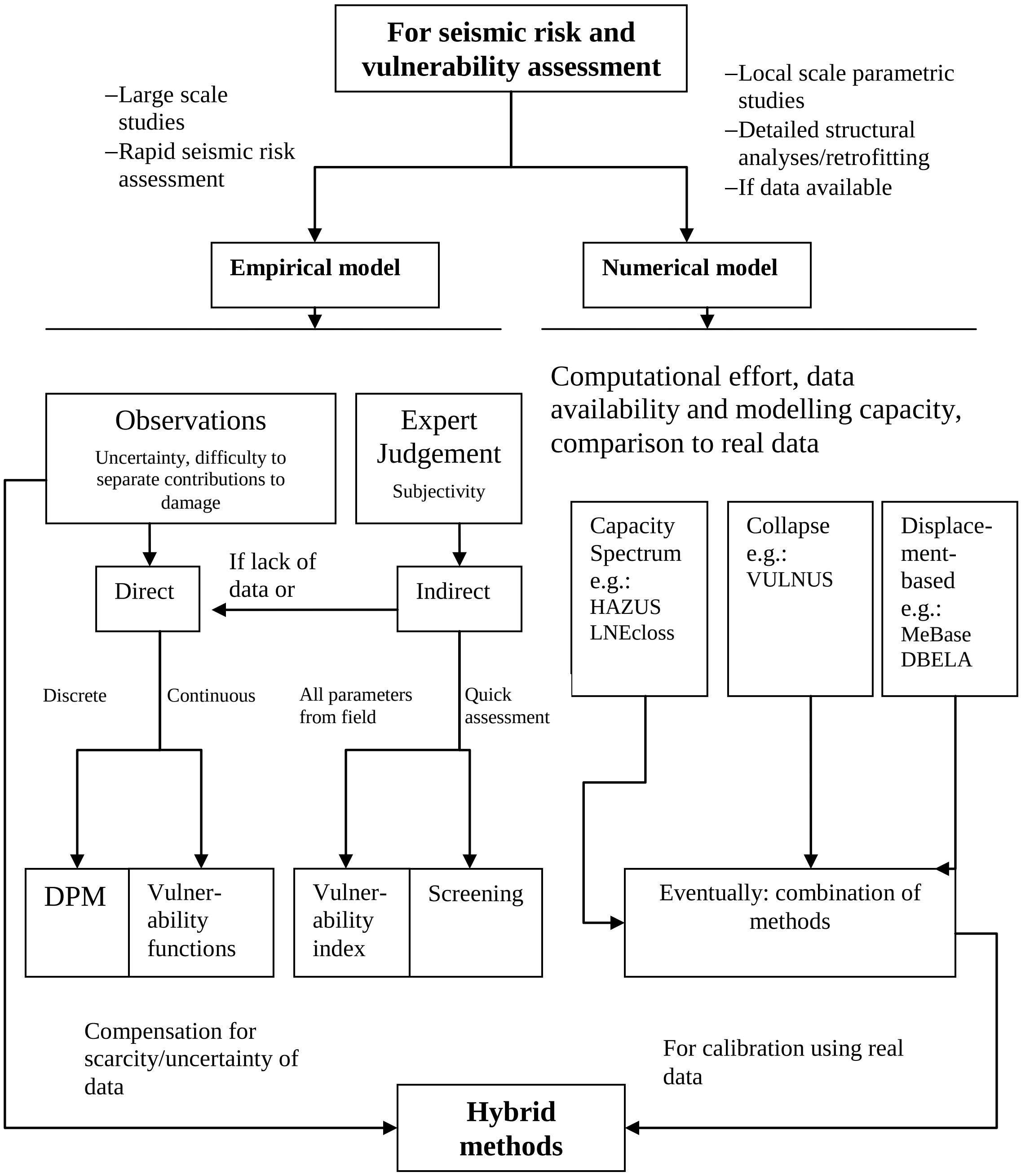


Figure 3.2: Schematic representation of the classical models for seismic vulnerability and risk assessment (Foerster et al., 2009:20)

Programmes such as GIS are tools for the development of vulnerability maps, by using other associated programmes such as HAZUS (1999), RADIUS (1999) or Risk-UE (2004) (Langomarsino et al., 2005:2). Regardless of major international programmes, planners have to use one of the main methods to analyse the vulnerability of the existing buildings. In typological methods, buildings are put into different categories "by their materials, structural characteristics and constructive techniques" (Bedford and Gelder, 2003:672). Using this categorisation, in order to calculate their vulnerability against earthquake severity, each group uses a curve or a damage probability matrix (*ibid*). In inspection methods, each structure's ability to restrain the earthquake is measured from a vulnerability index (*ibid*). Implementing mechanical methods requires experimental validating for each structure, using programmes such as HAZUS (1999) which are not available in many countries (*ibid*).

Table 3.4: The building seismic vulnerability assessment tool (Penna, 2010; Karbassi and Nollet, 2007; Palacios, 2004)

	Typical	**Inspection and rating**	**Mechanical methods**		
Method	Observations of Actual Damage Vulnerability	Engineering Analysis	Simple Analytical Model	Score Assignment	**Detailed Analytical Procedure**
Application	Group of buildings	Group/indi-vidual	Group/indi-vidual buildings	Individual buildings	**Individual buildings**
Expenditure	**Assessment of damaged buildings, non-complicated structures/ material**	**Codifying and classification of buildings, professionals knowledge and opinions, spectral displacement acceleration**	**Limited input, fast, structural damage, displacement assessment of existing buildings, macroseismic scale**	**Structural deficiency, existing building plans and elevation, performance modification factors**	**Potential hazardous buildings, linear procedure, nonlinear procedure**

3.4.1 Observed Vulnerability

This method is mainly based upon past earthquake damage, especially that involving non-engineered structures (Lang, 2002) which statistically use DPM (Damage Probability Matrices) (Table 3.5) (Withman et al., 1974), or vulnerability or fragility curves (Rossetto and Elnashai, 2003). Within this method, Table 3.5 was used to generate a DPM that classified each affected building, as shown:

Table 3.5: Damage Probability Matrices (Whitman et al., 1974)

Damage State	Structural Damage	Non-structural Damage	Damage ratio (%)	**Intensity of earthquake**							
				V	VI	VII	VIII	IX	X	XI	XII
0	None	None	0-0.05	Few							
1	None	Minor	0.05-0.3		Few						
2	None	Localised	0.3-1.25		Many	Few					
3	Not noticeable	Widespread	1.25-3.5			Many	Few				
4	Minor	Substantial	3.5-4.5				Many	Few			
5	Substantial	Extensive	7.5-20					Many	Few		
6	Major	Nearly total	20-65						Many	Few	Few
7	Building condemned	Collapse	100							Many	Many
8	**Collapse**	**Collapse**	**100**								Most

Use of this table gives the analysts a comparable damage estimation technique, which has been modified to a scale of 0 to 8 to make the damage ratio more accurate and easy to follow (Lang, 2002). Porro and Schraft (1989) have summarised the extent of the damage in affected buildings of the Germany (September 1978) and Chile (March 1985) earthquakes. In this investigation, the relationship between "type of construction, the mean damage ratio of the affected buildings and the earthquake intensity" helped to estimate the total amount of loss within the current building density (Porro and Schraft, 1989:180). As this method assesses the damage after the earthquake in many countries that are not in seismic-prone zones, it is not an applicable or reliable method (Rossetto and Elnashai, 2003). Other disadvantages of this model are the collection of a large amount of quantitative data in a specific field which is only extendable to a similar building quality and density region; and also, in this method, any modifications made to the structure of the building cannot be detected and counted (Lang, 2002).

3.4.2 Inspection and Rating

In a revolutionary attempt to systematically "codify the seismic vulnerability of the buildings", in 1985 the Applied Technology Council (ATC) utilised a wide consultation initiative by asking the opinion of engineers and expert builders regarding the damage estimation of 36 classes of building in a given earthquake condition (ATC, 1985; Shuhaibar, 1999). These buildings are divided into four main damage categories of slight, moderate, extensive and complete structural damage (ATC, 1985); this does not include non-structural damage (*ibid*). In terms of seismic design level, again four classifications – high-code, moderate-code, low-code and pre-code – are used to place the buildings (*ibid*). After considering all the parameters such as building type and design level, structural damage is estimated. Also, the building capacity, drift ratios and the spectral displacements of the building structure are calculated (*ibid*).

Expert opinions are one of the bases for accumulating the fragility curves which define the relation between intensity of ground motion and the probability of reaching or exceeding the appointed response level (Elnashai and Jeong, 2009:335). Therefore, out of four existing fragility curves – empirical, judgement, analytical and hybrid – the judgement-based fragility assessment uses expert opinion alongside ATC-13 (ATC 1985) and HAZUS (NIBS, 1995), to rapidly assess the probabilistic damage to the structures (*ibid*). HAZUS is, for instance, a risk assessment programme which was first developed by experts to calculate the spectra displacement and acceleration in 1997 in a project funded by FEMA (Kircher et al., 1997). Having used a regional code for seismic vulnerability, Fah et al. (2001) have used the Macroseismic Intensities Scale to illustrate a Basel earthquake scenario, by implementing European Microzoning Scale (EMS) parameters. In this study, the mean damage factor (MDF_I) for a certain intensity was considered to have a direct relation with the Central Damage Factor (CDF) and Damage Grade (DGi):

$$\mathbf{MDF_I = \sum p<DGi|I>. — t\%.}$$

Figure 3.3: Mean Damage Factor (Bernardini, 1999)

In this model, although using personal knowledge and the experience of experts may cultivate the outcome and accuracy of the result, it suffers from some major deficiencies in terms of its applicability to other areas – the actual damage to the building in the event of an earthquake strike – and also adds new data to the existing pool of damage estimation criteria (King et al., 1997).

3.4.3 Simple Analytical Model

In the field of building seismology, it is important to be able to analyse a large number of buildings in a rather short period of time (Comité euro-international du beton, 1994). The emergence of analytical/mechanical methods which developed spectral ordinates and developed more detailed and transparent assessment of building stock and hazard helped to overcome the disadvantage of empirical methods (Calvi et al., 2006:84). Due to limitations in input data, this model is rather easy to use. Also, in order to use the advantages of observed damage data that utilises vulnerability curves and DPMs (*ibid*), some changes have been made in this method, summarised in Figure 3.4.

“The approach is based on the identification of potential collapse mechanisms yielding the equivalent shear capacity, expressed as the critical acceleration using only geometry and boundary condition data based on individual estimation of the necessary” (D’Ayala et al., 1997:783). The basis of this model study is the plan and elevations of the building under two collapse mechanisms of in-plane and out-of-plane (*ibid*). In this study different mechanisms within the in-plane and out-plane are summarised in Figure 3.4 and Table 3.6. Each of these can cause critical damage to the buildings, especially those built from non-reinforced and masonry materials, with unpleasant consequences.

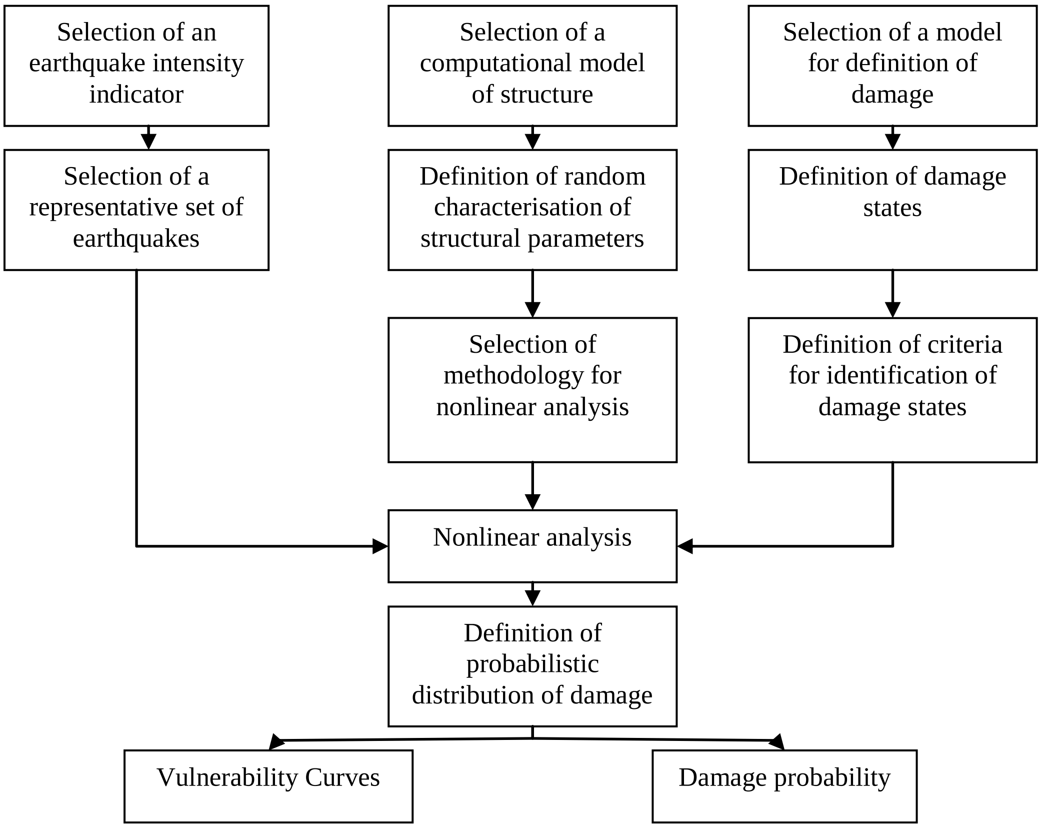
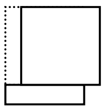
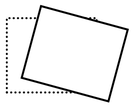
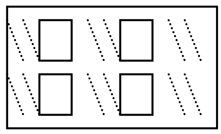
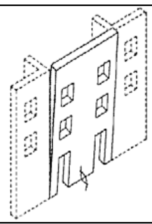
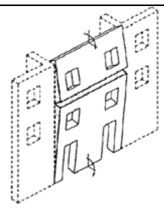
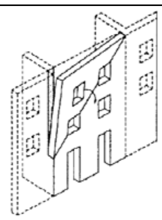
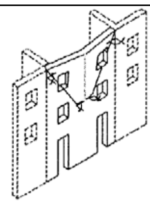


Figure 3.4: The basic components of vulnerability curves and damage probability matrices (Calvi et al., 2006:84)

According to Calvi et al. (2006), one of the fundamental disadvantages of this model is that the analytical vulnerability curves are produced through an extensive computer-intensive process and cannot be adapted for other contexts with similar construction characteristics. However, it has aided in deriving the empirical DPMs from observational damage data, leading to another group of analytical methods called hybrid methods (*ibid*:86). Calvi (1999) also used the very simple model to assess the vulnerability of buildings in Catania, Italy. The factors for assessment of the displacement capacity of the building come from four limit states: LS1, when there is no damage; LS2, when there is minor structural damage; LS3, when there is significant, extensive structural damage with moderate non-structural damage; LS4, when the building collapses (Faccioli et al., 1999:332). Within their calculation and assessment process, a few factors were used, including the period of construction, number of stories, and construction material and frame (Faccioli et al., 2004). This model is not as accurate as other models, which use more data and are based on rather statistical meanings (*ibid*). However, in given conditions with limited data, it can be a good solution to assess a large number of buildings (Calvi et al., 2006).

Table 3.6: In-plane and out-of-plane failure mechanism (Lang, 2002:10, Calvi et al., 2006:88)

IP1: Sliding joints	**IP2:** Global overturning	**IP3:** Crushing of compressed edge of piers
		

OP1: Free-standing wall plane	**OP2:** With ties to transverse walls	**OP3:** Connected to transverse walls	**OP4:** With ring beam
			

3.4.4 Score Assignment

This model is good as an initial step to improve the seismic strength of vulnerable and more specifically hazardous buildings (Fardi, 2009). In order to identify those buildings, both expert opinions and structural characteristics of the building are used (e.g. ATC21 1988, FEMA154) (Lagomarsino et al., 2006). When there is insufficient observed data, due to technical, capability and knowledge deficiencies, predicting the seismic vulnerability of buildings is a method developed by many scholars to score potential structural deficiencies under different structural classes (Fardi, 2009). In this method, “the expected performance of building classes based on calculations and design specifications” will be evaluated (Karbassi and Nollet, 2008:2). This is a popular method in Japan to assess the seismic performance of reinforced concrete buildings with less than six storeys (Calvi et al., 2006).

Using the score assignment method to evaluate a group of buildings, or a single building, is beneficial for public safety and to identify those that require improvements; and also, any structural damage of the building can be seen as life-safety hazards, which can be studied from past earthquake damage (*ibid*). The process starts with rapid visual screening (RVS), which was first initiated in 1988 (see FEMA 154 and FEMA 155). Also, the ATC (1987) and FEMA (1992) are two other major documents in developing evaluatory tools. In fact, this method's aim is to identify potential hazardous buildings without going into detail in a given area (Agrawal and Chourasia, 2007). In doing so there is a:

- *Screening phase*: this is about the identification of buildings with vulnerable deficiency. Therefore, the initial building's load-resisting system according to the construction material will be studied;
- *Evaluation phase*: provides a checklist for the evaluation of appointed buildings using certain criteria, which means doing the initial score assignment under certain seismic hazards that can cause possible major structural damage;
- *Detailed evaluation phase*: utilises a displacement-based tool instead of a force-based assessment tool, which was widely used before, which would result in modifying certain factors of defects monitored by observers (Karbassi and Nollet, 2008; NEHRP, 1997).

Under 15 main categories of building structure, the vulnerable areas of the structure are identified (Bachmann, 2003). The extent of data needed for the FEMA178 and FEMA310 is vast enough to make this assessment tool an individual building evaluation tool but is hard to be used in a group evaluation scenario (Steimen, 2004). That is why the use of FEMA155 and FEMA178 can still be suitable for a rapid screening process: an average of 15 m per building without requiring extensive details (FEMA155, 1988; FEMA178, 1992). In this method each building would be examined and scored structurally within a range of 0 to 6; a low S score means that the building is vulnerable to earthquake forces, and a high S score means the opposite (Agrawal and Chourasia, 2007) . Figure 3.5 is the expression for structural score:

S (Structural score) = BSH (Basic Structural Hazard) + PMFs (Performance Modification Factors)

Figure 3.5: Structural score (Agrawal and Chourasia, 2007:187)

Table 3.7: Performance Modification Factors (Agrawal and Chourasia, 2007:188)

Modifiers	**Description**	**Modification Factor**
High-Rise	Up to 2 storeys	0
	Between 3 and 7 storeys	-0.2
	More than 7 storeys	-0.5
Quality of construction	High	0
	Medium	-0.25
	Low	-0.50
Vertical irregularity	Steps in elevation, inclined walls, discontinuities in load path, building on hills	-0.50
	Without vertical irregularity	0
Soft storey	Open on all sides of the buildings, tall ground floor, buildings on stilts	-0.50
	Without soft storey	0
Plan irregularity	“L”, “U”, “E”, “T”, or other irregular building shape	-0.50
	Without plan irregularity	0
Pounding	Floor levels of adjacent buildings not aligned and less than 100 mm of separation per storey	-0.50
	Without pounding	0
Cladding	Many large heavy stone or concrete panels, glass panels and masonry veneer do not qualify	-0.50
	Without vertical irregularity	0
Soil condition	Buildings builton rocks (SR)	0
	Buildings built on uncohesive soil (SC)	-0.30
	Buildings built on black cotton soil (BC)	-0.60
Ground condition and slope ambience	Buildings on flat/plain land domain	0
	Buildings on hill slope/tank bunds/reservoir rims with slope>10° – gentle	-0.10
	-do- moderate	-0.20
	-do- steep	-0.30

Using the BSH scoring system, each typical building structure is assigned for its resistance in a major seismic load (Steimen, 2004). ATC-21-1988 and ATC-21-1-1988 consist of BSH for various building types in California, which since has been modified for other countries (*ibid*). The better the seismic performance of the building, the higher the value. Table 3.7 summarises the modifying score factors when subtracted from BSH. As the table indicates, there are a number of factors, such as quality of construction, plan irregularities, pounding, soft storey or soil/ground condition, which can affect PMFs (Agrawal and Chourasia, 2007). A number of these performance modification factors are applicable for individual buildings (*ibid*). However, extending the scoring system after years of surveying the past earthquake damages has resulted in the production of such a table below.

The basic structural hazard is calculated by the following formula:

$$\boldsymbol{BSH=-log[p(D\geq 0.6|ag)].}$$

Figure 3.6: Structural hazard calculation (Lang, 2002)

In this formula, *D* is the probability of damage, and *ag* is affected peak acceleration which is applicable to the average building in each group (Lang, 2002). The rapid screening procedure was, for instance, used in Catania, Italy, in terms of intensity, by using the original building plans and elevations, and also some structural modifications (Steimen, 2004). This initially evaluates basic structural hazards, utilising the Eurocode 8 and GNDT methods (Benedetti et al., 1988; FEMA154, 1988; CEN, 1998). Based on visual observation and identification of deficiency, a vulnerability index was prepared from those elements. In this project an extensive number of buildings were approached by considering parameters such as building type, age and structure (Benedetti et al., 1988). It became one of the largest vulnerability assessment and damage estimation projects in Italy, by utilising the relationship between damage, vulnerability index and seismic input, as well as past earthquake damage (*ibid*).

The Vulnerability Index Method is a common tool, which has been used in Italy for the past few years, for collecting a vast amount of survey data for the damaged buildings (Calvi et al. 2006). The advantages of score assignment are:

- the ability to assess a large number of buildings in a short period of time, using a combination of observation and expert opinion;
- the ability to re-evaluate any upgrading of existing or old buildings (Karbassi and Nollet, 2008; Lang, 2002; Agrawal and Chourasia, 2007).

3.4.5 Detailed Analysis

In this method, very detailed information is needed, hence it should not be used for large earthquake projects (Lang and Bachmann, 2004). The four main categories of this model are (*ibid*):

1) Linear Static Procedure;
2) Linear Dynamic Procedure;
3) Nonlinear Static Procedure;
4) Nonlinear Dynamic Procedure.

All of these methods could lead to a further possible evaluation method, after the screening of potential hazardous buildings (*ibid*); it acts as an assessment tool which can widely be used in design process (Marchand, 2009).

1) In a linear static procedure (LSP), the single-degree-of-freedom (SDoF) system is the main building model used when "the building is modelled with linearly-elastic stiffness and equivalent viscous damping that approximate values expected for loading to near the yield point" (UFC, 2005:44; FEMA273, 1992). The lateral force is intended to produce a similar stress to the strains and stress of an earthquake on buildings (UFC, 2009). If there are no structural irregularities, defined as follows, then the LSP is usable (*ibid*). The linear model is subject to lateral loading for buildings without irregularity, both as defined in ASCE 41 (Roeder et al., 2001). A structure is considered irregular if any one of the following exists: "out-of-plane discontinuities, in-plane discontinuities, weak stories irregularities, torsional strength irregularities" (Williams, 2009:6):

> 1. Significant discontinuities exist in the gravity load carrying and lateral force-resisting systems of a building, including out-of-plane offsets of primary vertical elements, roof "belt-girders", and transfer girders (i.e., non-stacking primary columns or load-bearing elements). Stepped back stories are not considered an irregularity.
> 2. At any exterior column, except at the corners, at each story in a framed structure, the ratios of bay stiffness and/or strength from one side of the column to the other are less than 50%. Three examples are: a) the lengths of adjacent bays vary significantly, b) the beams

on either side of the column vary significantly in depth and/or strength, and c) connection strength and/or stiffness vary significantly on either side of the column (e.g., for a steel-frame building, a shear tab connection on one side of a column and a fully rigid connection on the other side shall be considered irregular).

3. For all external load-bearing walls, except at the corners, and for each story in a load-bearing wall structure, the ratios of wall stiffness and/or strength from one side of an intersecting wall to the other are less than 50%.

4. The vertical lateral-load-resisting elements are not parallel to the major orthogonal axes of the lateral force-resisting system, such as the case of skewed or curved moment frames and load-bearing walls.

(UCF, 2009:45).

The lateral force is distributed over the height of the building and the corresponding internal forces and displacement are determined using linear static analysis (Williams, 2009). In order to reach a more accurate result, the LSP considers a stronger lateral force which is greater than the capacity of the building structure (*ibid*). This model is mainly used for regular building designs. As the LSP is elastic, the equivalent element forces are considered in excess of the optimal actual earthquake forces that can be experienced in nonlinear behaviour (Ayala and Charleson, 2002). For calculation purposes, the considered load is distributed vertically (in accordance to seismic weight) and the height of each storey and building period is considered (Williams, 2009).

2) However, the linear dynamic procedure is a model with the multi-degree-of-freedom (MDoF) system, with a linear elastic stiffness matrix and an equivalent viscous damping matrix (Mansur et al., 2000). In this model the seismic input is based on two models; spectral analysis or time-history analysis (*ibid*). The former "assumes that the dynamic response of the building can be found by considering the independent response of each natural mode of vibration using linear elastic response spectra" whilst the latter "involves a time-step-by-time-step evaluation of building response, using recorded or synthetic earthquake records as base motion input" (Lang, 2002:15). The elastic spectral analysis model is categorised under probabilistic response spectra whilst encapsulated by the capacity/demand ratio formulation (Jernigan and Hwang,

2002, Nielson, 2003). In this model, the produced base shear is generally smaller in the LDP than the LSP, as Figure 3.8 indicates (Williams, 2009:9).

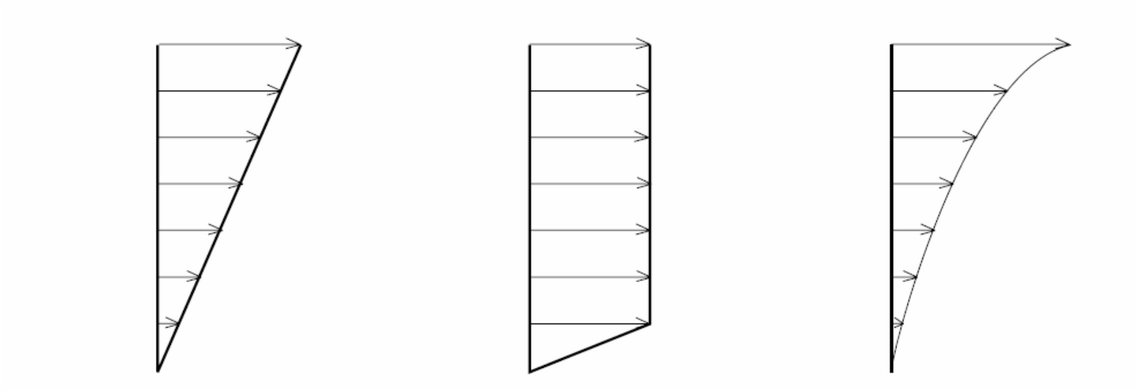


Figure 3.7: Sample Inertia Force Distributions (FEMA 274, 1997 in Williams, 2009:9)

The advantage of this model, against linear static procedure, is its applicability to be used for irregular buildings (Nielson, 2003). However, again, in this model the base shear is greater than the capacity of the building structure and is modelled with linearly-elastic stiffness (*ibid*). However it is still not a responsive model for nonlinear behaviour (Williams, 2009).

3) Using a third model, the Nonlinear Static Procedure (NSP), the nonlinear force deformation of individual elements of the building (inelastic material) can be measured (Kalkan and Kunnath, 2007). For estimating the seismic damage, the NSP can be used "directly from a site-specific hazard spectrum; nonlinear time-history (NTH) analyses require an ensemble of ground motions and an associated probabilistic assessment to account for aleatoric variability in earthquake recordings (*ibid*:305). These forces include a "pushover curve", "displacements, "mode of vibration" and "building collapse" (Lang, 2002:16). This model directly incorporates the nonlinear response of members in the structure. Generally speaking, in this model the "nonlinear load-deformation characteristics of individual components of a building is loaded with monotonically increasing lateral loads representing inertia forces in an earthquake until a target displacement is exceeded" (Williams, 2009:9). Using simplified NSP has been widely recommended in ATC-40 and FEMA 356, which is based on monotonically increasing predefined load patterns until some certain displacement is achieved (Kalkan and Kunnath, 2007). Kalkan and Kunnath (2007) have classified NSP into three major sets according to the type of lateral-load pattern applied to the structural

model during the analysis: "invariant single vectors (FEMA 356), invariant multi-model vectors (MMPA and UBPA) and adaptive load vector (AMC)" (p.306). The model creates the opportunity for nonlinear material response due to a seismic force to be calculated, but still it cannot be used for irregular buildings (*ibid*).

4) Therefore, it has been met by the nonlinear dynamic procedure, which incorporates the inelastic material response, but using the time-history analysis input model (Wong, 2009). The model requires several time-history inputs to be able to give an accurate detail of the building structure displacement profile, the propagation of the cracks, distribution of vertical and shear stress, the shape of the hysteretic curves etc. (Lang, 2002). It is quite similar to the NSP, with some differences to the loading and computational model (Wong, 2009). Each individual ground motion is used in computer modelling (Lee, 2008). This model is the most comprehensive and accurate, but with complex earthquake analytical procedure which helps the design engineers (*ibid*). However, it is hard to obtain the earthquake ground motion time-history as it is uncertain and difficult to predict (Wong, 2009). On the other hand, it is valuable for the prediction of individual buildings' seismological behaviour (*ibid*).

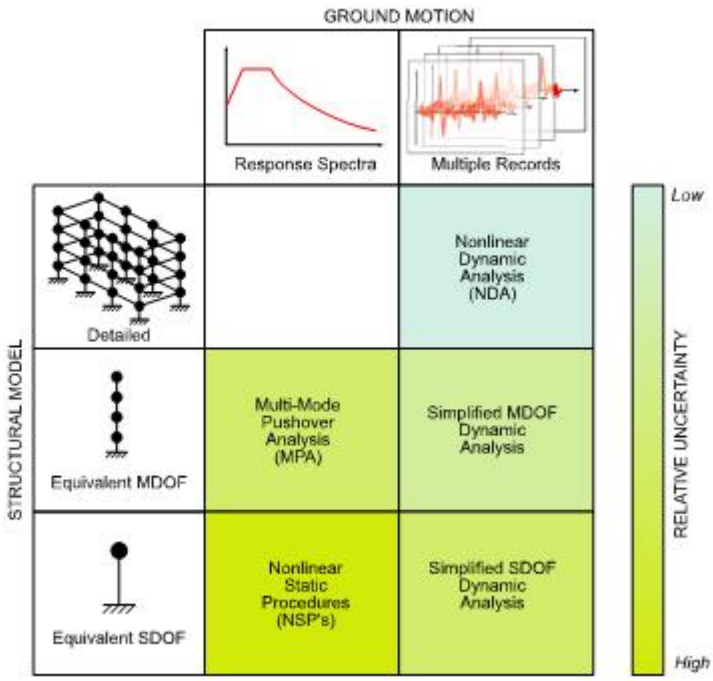


Figure 3.8: Matrix of possible inelastic seismic analysis procedures for various structural models and ground motion characterisations along with trends of uncertainty in the result (FEMA 440, 2005:2–9 in Wong, 2009)

3.5 The Method to Estimate the Damage in the Case Study Area

In order to determine the damage estimation of existing buildings in Tehran, the capital of Iran, an evaluation method was developed, which was inspired by the most appropriate method within the context of Tehran and its available data. This section is dedicated to the principles of evaluation, in a general way, and is valid for masonry, reinforced concrete and steel frame. Following this, in Chapter 7, the buildings in District 17 of Tehran will be assessed in terms of their seismic vulnerability and possible damage to their structure. As discussed so far, each method has some advantages and disadvantages in their applicability, evaluation method and accuracy. The global loss estimation method based on observation and expert opinion has been widely used (Lang, 2002) and is a popular tool for countries with frequent earthquake damage, giving the researchers a significant number of opportunities for statistical evaluation (Jaiswal et al., 2011). However, due to a lack of organised studies about earthquake causes and damage in Iran in general, and in Tehran in particular, this method loses its validity for this specific case. The linear analysis procedure is rather time-consuming for the empirical work, as District 17 is one of the city's densest areas.

The simplicity of the building plans and elevations of the selected case study area buildings, alongside a complexity of nonlinear static and dynamic analytical models (Lang, 2002), simply makes the damage estimation study, or detailed analysis procedure, of no value. Score assignment is also a time-consuming method for a large number of buildings, and there is a need for past earthquake experience. For the possible earthquake scenario project for the city of Tehran, it was therefore decided to use the simple analytical model, which may be applicable for a large number of buildings, requires limited input, but considers the structural material as well as the geo-seismology of the study area. All of this implies that the simple analytical model is the main assessment tool in this research to estimate the possible earthquake damage.

3.6 Building Design, Vulnerability Evaluation and Function

The aim of any new designated building (which is part of the wider safety margin) is to be resistant to earthquake forces (IAEE, 2004). The designated structure of the building should meet the requirements by utilising specific materials in specific elements of the building. During the design process, it is commonly accepted to consider a slightly higher resistance material and seismic model (*ibid*), firstly, to resist the worst case scenario, and, secondly, to leave some space for structure construction material that is not ideal or usually utilised. The extent of possible damage to the building, and a prediction of the components of the building which are most vulnerable (Porter and Kiremidjian, 2001), is a way to determine the best material to use and the best model to utilise in order to build an earthquake-resistant building. Figure 3.8 shows how the prediction of damage can help lead to a better design.

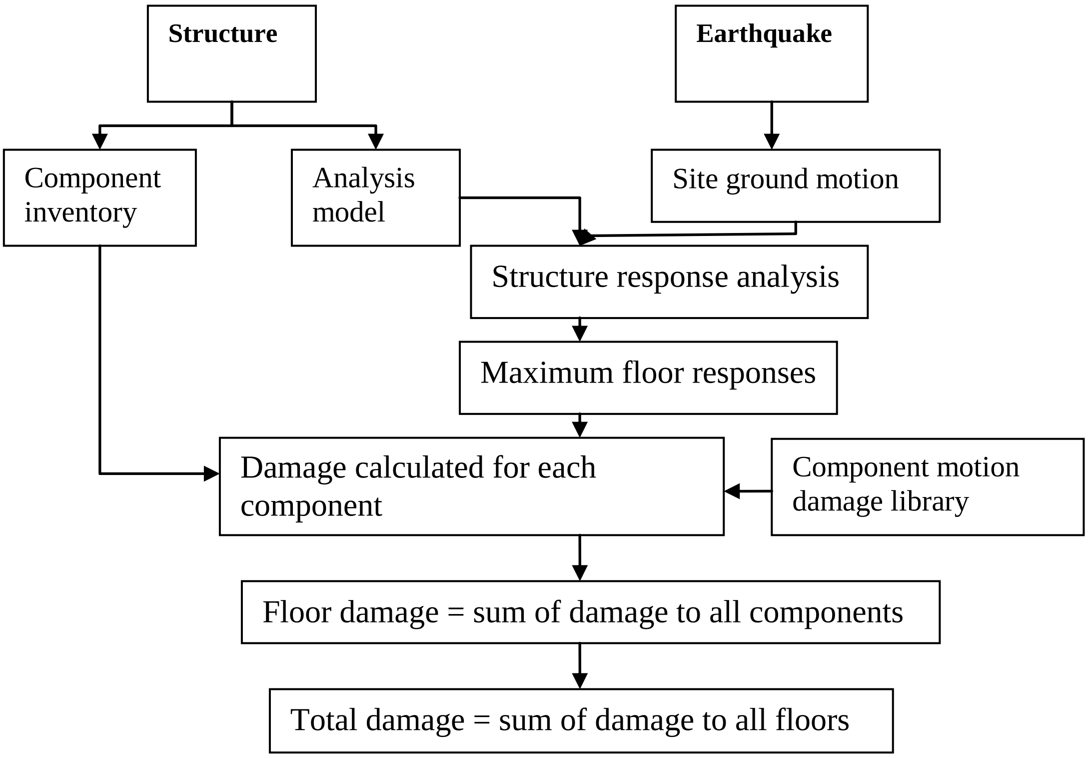


Figure 3.9: Component-based damage prediction (Porter and Kiremidjian, 2001:11)

As discussed above, “the evaluation of the expected performance of building classes based on calculations and design specifications, analytical models can be applied to define the capacity curves which provide a representation of both the displacement and the force capacity of different building classes in terms of roof drift and base shear” (Karbassi and Nollet, 2008:1). The choices of the strength reduction factors and the design forces “are influenced by economic optimization” (Lang, 2002). However, it is acceptable for the building design to achieve the ultimate capacity of about 0.01% (Paulay and Priestly, 1992). How the building will react to a given seismic force is a matter of design for higher risk damage: so-called working stress design (Ambrose and Vergun, 1987).

This will be analysed within various structural elements, material and dead load. However, it is still difficult and expensive to design a residential building for the worst case scenario, for instance (IAEE, 2004). On the other hand, ignorance of material safety factors would create a false calculation base for the structural model (*ibid*). There are assumptions that following the building code is not always the best idea (Bruneau, 1994), especially for masonry buildings. However in a country like Iran, the frequency of earthquakes, the extent of damage, and the construction method and material require a conservative building code to minimise the undesirable effects of earthquakes (Manafpour, 2004). It largely derives from past earthquake damage. Also, it highlights the role of evaluating existing buildings to estimate damage and make radical and clear strategic plans to reduce the risk of damage (*ibid*). As the figure below indicates, ideally the building capacity should meet the seismic demand (motion) to avoid building collapse or major damage.

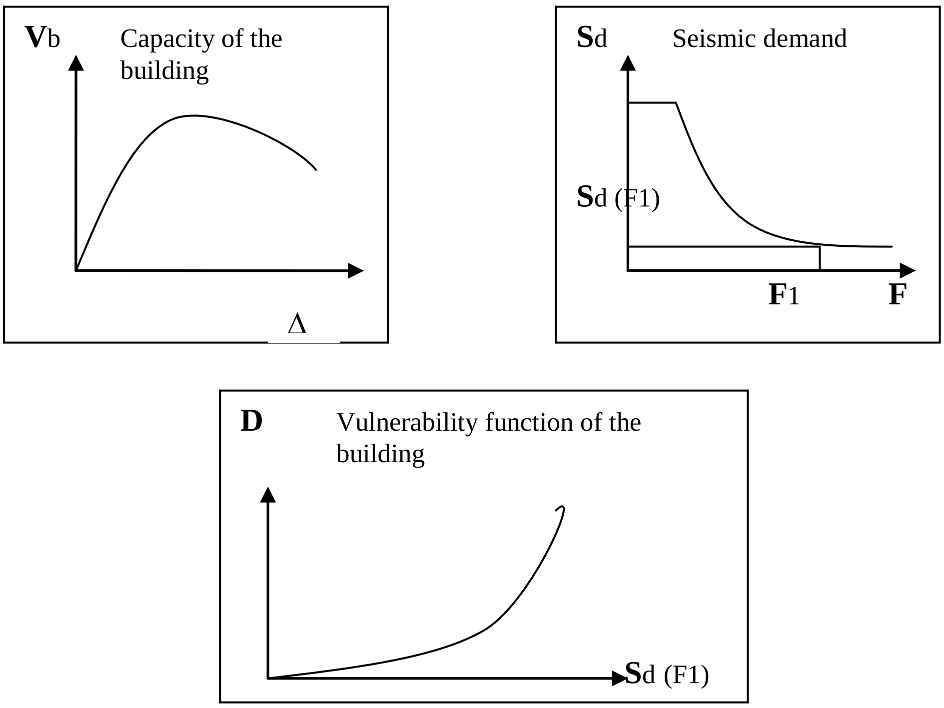


Figure 3.10: Principle of a vulnerability function (Lang, 2002:19)

Vb is the capacity of a peak response of the building to resist seismic action, which is defined as the capacity curve as the base capacity shear (Polese et al., 2008). In order to estimate the damage to the existing building (*D*), the main calculation tool is the highest constraint of the structure to the earthquake ground motion, which measures the horizontal displacement of the building at the top (Δ or pushover curve) (Mondet and Bumann, 2007). To meet the seismic demand, the capacity of any structural building or structural element (wall etc.), is measured by spectral acceleration *Sa*, spectra displacement *Sd* and the peak ground acceleration *Ag* (Polese et al., 2008). They all consider the information related to ground motion, the duration of the earthquake, the direction of ground movement, and its frequency (Karbassi and Nollet, 2008). The established capacity curves, via the utilisation of analytical models of typical buildings based on their structure, can vary when combined with the seismic demands in order to produce the vulnerability curves (*ibid*:2). It has been understood that the ground movement model is discredited in terms of real ground movement (*ibid*). However, in practice, and for designing seismic resistance buildings, based on historical data on earthquake motion, two main orthogonal directions are considered as the biggest amplitudes of ground movement, which is different from damage estimation which considers median spectral analysis (Wen et al., 2004). Amongst the above-mentioned two directions, and after consideration of their mean, two vulnerability forces, the one which causes the worst damage will become the principle for further calculation. In reality, the two major directions of vulnerability may impact differently; however, the accuracy of the result, and building a structure to be able to resist the earthquake scenario, are the most important elements.

3.7 Disaster Prevention Plans

With the growing chance of disaster occurrence and the disconnection between disaster prevention plans and the resistance of individual buildings, scholars such as Wamsler (2004) claim that "the trend is for risk to become urban" (p.11). Whether it is urbanisation that affects the extent of disaster risk, or disaster that causes disruption in the process of urban development and activities, recognition of the fact that urban planning can be a powerful tool in the mitigation of risk is a profoundly new debate in academic, management and planning policy and processes.

Many countries that face regular disasters in different forms have tried to prepare and produce plans for recovery after the disaster strike, and to be ready before it **(**Lyall, 1993**)**. As mentioned in Chapter 2, a large number of plans mainly focus on post-disaster emergency services, the recovery and rebuilding process, managing the devastating impact of disaster and bringing urban activities back to normal in a short period of time (*ibid*). It is an accepted fact that adherence to planning standards and building codes can reduce the undesirable consequences of disaster; however, they are usually "unevenly applied because of one or a combination of factors, namely:" (Zapata-Marti, 2005: 32):

- Proposed building standards used by many countries [developing countries such as Iran] do not have statutory effect because they have not been passed into law;
- A high percentage of buildings are constructed without planning approval;
- In some countries government buildings are not regulated by law for compliance with building standards and codes;
- A high percentage of residential and government buildings are not insured and therefore … standards applied by insurance companies as the basis for giving rebates on building insurance premiums do not apply.

(*ibid*)

The process of mitigation plan preparation consists of (Anne Arnudel County, 2004):

- Identifying hazards;
- Performing a risk analysis;
- Identifying vulnerability in the region;
- Involving the region's agencies;
- Drafting feasible mitigation strategy aiming to reduce or eliminate the risk to the residents;
- Actively involving emergency services and local authorities.

Some countries like the US (FEMA reports and publications), Japan (DPRI publications) and even Turkey (GDDA publications) have taken effective steps in proposing disaster prevention plans which provide a set of regulations for the building industry (for example, FEMA 382 – California), appoint some safe places for giving shelter to victims of disaster (for example, DEMP's 2006 report – Turkey), and discourage high-density buildings in hazardous zones (Al-Ansari and Senouci, 2011). The tools and policies vary in every country and region based upon the nature of the possible disaster (*ibid*), the extent of the plan, its importance, accountability and even the team responsible for its preparation. The plan's context is based around some key discussions.

Identification of the nature and causes of the disaster is essential, whether it is an earthquake caused by fault lines beneath a populated urban area, a volcano with active ash and gas, or even a flood-prone zone next to a river. Knowing the origin of the hazard helps, firstly, to prevent further disruption and mass destruction, and, secondly, to be prepared, which allows a fast recovery (Kent, 1994). This usually leads the discussion of these plans to the next level which is mainly about studying the urban area from various aspects. It usually covers topics such as building structures and vulnerability, economic and social structures, residents' surveys, etc. (*ibid*), which estimate the possible damage to the city. The damage estimation, therefore, is an important section, which might be a separate study and which uses various tools as discussed earlier in this chapter. It is useful to illustrate where and how the vulnerable elements are (Otani, 2000).

The other section of these plans are the recommendations to prepare the city for the worst, providing guidelines for relevant urban activities such as housing, open spaces, transportation, emergency services and management for the post-disaster period (Kent, 1994). Some advanced countries have taken drastic measures by strictly supervising building construction activities and placing flood/tsunami protection defences around their vulnerable built environment (Otani, 2000). However, for some, the disaster prevention plan is limited to a number of recommendations for certain organisations that are not even the controlling forces of urban development and activities (Kent, 1994). In Iran, for example, for the first time, JICA (2000) produced a study in partnership with Japanese experts to address the extent of damage that an earthquake could cause in Tehran, identifying the vulnerable areas of the city (JICA, 2000). It was prepared utilising the initial data provided by some local key organisations; however, what is important is the role and contribution of key local agencies in implementing the plan's recommendations. UNISDR (2008), in an interesting publication, "Indigenous Knowledge for Disaster Risk Reduction", has explained the use of good practices and local knowledge in mitigating the risk of disaster. In Nepal (2005), for example, using the community's capacity to plant shrubs and bushes around villages, rather than growing heavy trees, may protect their farms from landslides (UNESCO, 2006). This simple but effective use of local knowledge can be an effective tool in the hands of planners to make it a legal requirement for hazard-prone zones. The next part will focus directly on the main agencies that get involved in this type of plan.

3.8 Key Responsible Organisations

Due to the nature of the disaster preparedness plan, the main participative agencies vary from those which provide urban development plans. According to UNISDR and UNOCHA (2008), government, civil society, regional organisations and international organisations are the managerial teams that have to cooperate and have active interactions with each other to make the plan feasible. Table 3.8 is the summary of roles of professionals who are usually involved in disaster risk reduction and response.

Table 3.8: Roles of professionals (UNISDR, 2009:31)

Roles of Professionals			
Architects	**Surveyors**	**Planners**	**Engineers**
Review and revisit dwellings and other buildings, observing the way people are changing their lifestyle and habits in relation to the use of buildings. Ensure safe and sustainable adaptations	Review and revisit reconstruction sites and carry out condition surveys of key buildings, dwellings, understanding operational coasts and labour use	Periodically review the demand for infrastructure and its capacity. Review disaster preparedness plans in consultation with local communities, monitoring regulations and their compliance and revise if necessary	Periodically review the strength and stability of key buildings as well as dwellings and infrastructure services, carry out further training if required to build a skill base

Roles of Professionals			
Architects	**Surveyors**	**Planners**	**Engineers**
Undertake life cycle studies of reconstruction projects and plan for their eventual replacement, work with existing communities to design new developments that reduce their vulnerability to hazards	Explore the cost planning implications in life cycle studies of reconstruction projects and of new developments that reduce vulnerability of existing communities to hazards	Work with resident communities in reviewing and renewing plans for the long-term sustainable development of disaster-affected or hazard-prone settlements, develop renewal and regeneration strategy for the settlement as a whole	Undertake life cycle studies of infra-structure projects and plan for their eventual replacement, work with existing commu-nities to design new infrastructure develop-ments that reduce their vulnerability to hazards, carry out regular checks on safety of infrastructure, development and maintenance of management plans
Advise on reducing operational and management costs	Advise on reducing and servicing debt by utilising the value of land and building to the fullest	Advise on making safety regulations cost less to implement	Advise on cost-effective retrofitting, extensions and safe new construction
Identify regular housekeeping and maintenance procedures to avoid major repair	Ensure repair and maintenance are obligatory and cost-effective		Monitor any issues that are leading towards major repair of buildings or require addressing to stop unsafe construction
	Estimate operational costs and ownership of repair and maintenance	Raise awareness and education among general public and enforcing compliance where necessary	Carry out regular checks, monitoring and training of specialist workers, provide guidance on infrastructure main-tenance provision
Provide training in building design, construction and extensions for professionals as well as communities	Provide training in cost-effectiveness and responsibility for maintenance and management	Provide training in planning for profes-sionals in local authorities, covering future risk assess-ments and reduction when planning developments/ settlements	Provide training in safety and stability of the structures as well as understanding environmental risks and risks from construction practices

Contribution of research organisations is a vital part to provide the planning authorities with the independent and crucial information. The Hyogo Framework for Action (2005–15) is one of the foremost international documents in recent years (UNISDR, 2009). In this document, five strategic guidelines have again been highlighted, consisting of a combination of disaster planning theory, practice and management as follows:

- Making disaster risk reduction a national and local priority, with proven support from institutions;
- Working on an early warning policy by recognising, observing and analysing risks;
- Enhancing a culture of safety and hardiness by improving the basic understanding, culture and innovation of the public;
- Decreasing the potential risks;
- Empowering an effective and comprehensive response for every stage of a disaster (UNISDR, 2009:9).

The categorisation and use of the data obtained from leading statistical centres, the construction industry, councils and other geoscience centres is different, as it has to fulfil damage estimation purposes. Therefore, it utilises a specific way of organising information which is not well known within the traditional council-based planning system. Disaster management, emergency response organisations and charities are more active within this process. UNDP is one of the main investors in conducting research in disaster-related issues and development planning programmes, as well as providing relief and emergency services to regions affected by disaster. According to Siegel and Witham (1991) the United Nations Development Programme (UNDP) has been involved in disaster-related activities in four ways:

- as a funding source;
- as the field representative of the office of the United Nations Disaster Relief Coordinator (UNDRO);
- often, as the executing agent of disaster management projects through its office for Project Services; and
- because the UNDP resident representative is often called to assist in the coordination of disaster relief (*ibid:*297).

Based on the plan's approach, UNDP aims to identify the possible damage to supply lines and urban infrastructure, which is way beyond the physical, economic and social planning of master or regeneration plans (*ibid*).

Central disaster units, under the direct order of central government, are usually the leaders of the planning team (ALNAP, 2010). Every country has a different emergency response unit and these units work with relevant organisations including hospitals, police, building construction regulatory organisations, urban infrastructure management systems, municipalities, statistical centres and many more (*ibid*). If the importance of the plan for the region is fully accepted, then the number, extent of participation, and names of involved agencies vary. Preventing structural damage to buildings is encouraged and controlled by engineering and supervisory organisations that provide the building codes, control the building material quality, and check the construction process (Al-Ansari and Senouci, 2011). Lewis (2003) believes that, although within the last few decades all architects and engineers are keen to design earthquake-resistant buildings, “it is not only shortcomings in the application of building construction technology that is responsible for these circumstances; so are planning, management, administration and integrity” (p.35). He recommends regular inspection of the buildings from the underground foundation stage to the last coat of paint.

The plan evaluates the emergency facility and services and the management team who make plans for the pre-disaster period, check the equipment, places for providing temporary shelter, hospitals, and storage for food and water. These organisations usually have direct authority, especially in the event of an emergency, to act for the highest level of government (the presidential office, for example) (ALNAP, 2010). The extent of cooperation between the municipality, urban development planning authority and the disaster management team is also subject to many issues (Wolensky and Wolensky, 1990). Some plans aim to provide post-disaster services in order to save lives, help the area to get back to normal and recover fully (*ibid*).

Some plans target the preparedness measures which are about constructing disaster-proof buildings, facilitating emergency transport roots, providing canals to direct flood water or minimising the possibility of spread of the fire (Otani, 2000). The latter is about adequate infrastructure and safe buildings which includes government and private sectors efforts. However the former involves a limited number of organisations that can actually provide help. Many voluntary and charity groups fit within this category and act as they are needed. What this research aims to study and analyse is the gap in the disaster management team and disaster planning group. It will be exemplified in more depth in the last section of this chapter.

3.9 Examples of Disaster Preparedness Plans

In a region with a high chance of being hit by disaster, such as Japan or California, local and national governments have developed an experienced-based planning policy after years of loss (economic, supply lines, social, physical, environmental) to firstly be prepared to survive with minimum impact if disaster strikes, as they cannot predict and stop the disaster from happening; and secondly, to recover in a short period of time (Rubin and Barbee, 1985). The summary review of Tokyo's fire-stopping green spaces (Ishikawa, 2002) is a good example of combined planning for a city, whilst California's prevention plan (Topping, 2008) gives an insight into a more integrated approach for disaster prevention policies. These two regions also utilise the latest technology to predict earthquakes, which is a significant tool in their hands. However, this may not be available in many countries.

3.9.1 Japan's Disaster Prevention Plan

In Japan every year, a number of large- or small-scale earthquakes occur, which sometimes cause tsunamis, landslides or fires (Mendenhall, 1879). Therefore, the Japanese are keen to make their built environment more resilient to earthquakes and their consequences. Besides all the extensive knowledge and practical experiences of making their public buildings and high-rise buildings resistant to earthquake shake, Japanese planners have developed a combined planning policy to include safety measures when they provide urban development plans (Suganuma, 2006).

Ishikawa (2002) has pointed out the location of open spaces in the city plan and how different criteria have been considered to design green spaces for general use, as well as preventing the spread of possible fire in the city in the event of an earthquake. It is apparent in the city planning of Tokyo that "the park system [was] introduced as the infrastructure for a safe city” (Ishikawa, 2002:833). It was/is a cost-effective method in preventing the spread of fire, especially around densely-populated areas, and gives the residents a chance of escaping to the green spaces (*ibid*). The original idea of “park systems” founded in the US was adapted to the form of “3 parks, 52 children’s playgrounds and 52 streets” in Tokyo in the 1920s–50s (*ibid*:833). During the 1950s and 60s, the design of green spaces within the urban built-up area became part of city planning requirements, as Figure 3.6 shows. According to Ishikawa (2002:836), small parks and most of the green spaces around and within dense built-up areas were used by people as the refuge areas after the Hanshin-Awaji earthquake (1995) which proves the usefulness and importance of such integrated planning in a disaster-prone zone. Therefore, in a simple but important categorisation, open spaces are secured to function in a disaster scenario effectively (Table 3.9).

Table 3.9: Securing open spaces (Bureau of City Planning, Tokyo Metropolitan Government, 2004:2)

Type of open space	Role in disaster prevention	Direction of improvement
Large-scale parks (metropolitan etc.)	Refuge base, disaster, recovery base	Improvement and reconstruction of metropolitan parks
Smaller parks (ward, city, town etc.)	Disaster-resistant activity bases	Securing a park for every town block
Roads (city planning roads)	Firebreaks, refuge roads	Improvement of roads in high risk areas

Alongside consideration of open spaces in and around residential areas, after the Kobe earthquake in 1995, the Matsumoto Area Community Development Council helped the city’s reconstruction process and introduced a stream within the project area to reduce the possibility of wooden houses burning (Ishikawa, 2002:837). Table 3.10 also supports the above claim, where parks were made use of for emergency purposes after the 1995 Kobe earthquake.

Table 3.10: The use of parks in Kobe City after the 1995 Hanshin-Awaji earthquake (Ishikawa, 2002:837)

Parks		Surviving Parks	Parks used after earthquake	Purpose of usage				
				Refuge	Supporting Activities	Supporting centre	Shelter	Total
Small park	~1000 m²	151	47	23	13	1	0	37
	1000 ~2500 m²	95	49	31	26	0	0	57
	2500 m²	54	40	36	36	2	0	74
Neighbourhood park		31	24	17	33	6	2	58
District park		11	9	6	13	3	0	22
Comprehensive park		5	3	0	4	2	0	6
Others		20	4	4	0	1	0	5
Total		367	176	117	125	15	2	259

In a larger plan, the Matsumoto County Council, alongside the Tokyo metropolitan government, designated and constructed “Safe Living Environment Zones” as part of a comprehensive strategy for the region (Bureau of City Planning, Tokyo Metropolitan Government, 2002). In this plan the safe area was “surrounded by main roads and rivers” and then divided into smaller parts with the green space considered in the centre equipped by water tanks and food (Figure 3.9) (Ishikawa, 2002:838). With each disaster-proof residential zone there is a reduction of the possibility of fire spread; also, better use of the district planning system increases the capacity of dealing with post-disaster consequences (Bureau of City Planning, Tokyo Metropolitan Government, 2002). This indicates a valuable multi-purpose design for the urban area which was previously purely a land-use plan.

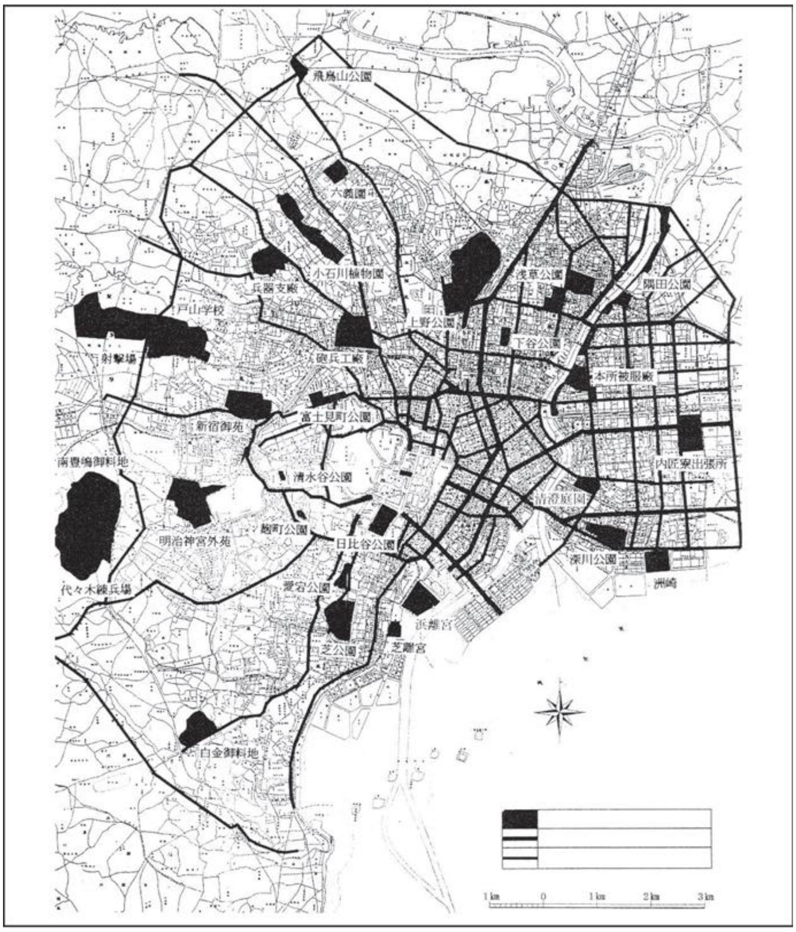


Figure 3.11: Reconstruction plan after 1923 Kanto Big Earthquake (Ishikawa, 2002:834)

Tanaka et al. (2008) also give examples of the lessons learned from the Kobe earthquake recovery and mitigation planning. They first point to the typical charrette plan which involves community, residents, local agencies, planning professionals and a large number of stakeholders, and how the initial ideas were generated (*ibid*). This involvement of local knowledge and multi-disciplinary planning has become popular within the Japanese planning system (Sutton and Kemp, 2006). Although Tanaka et al. (2008) believe that public meetings and consultation tend to build consensus rather than making the plans and decisions more democratically analysed, this research is interested in how, after the Great Hanshin-Awaji earthquake (1995), planning authorities in Kobe used the community's participation to reach a more effective, integrated and preventive earthquake plan.

The three selected case study neighbourhoods of Takatoriyama, Mikura and Shinyo were studied and the data regarding their population, building structure and use, as well as maps of their geographical situations, was collected (Tanaka et al., 2008). The regional proposed plan suggested gradual relocation of residents from the slopes to the safer areas of Satoyama's open spaces; these areas were still not far from dangerous zones (*ibid*). This did bring multiple advantages to the Takatoriyama neighbourhood by reducing the risk of landslip, restoring the ecosystem, improving access to the houses, etc. (*ibid*:4). The targets in the second appointed area of the Mikura neighbourhood were to:

- Recover human-scale streets while also considering disaster prevention;
- Recover diversity of land use;
- Connect residents meeting spaces, parks and river and connect Mikura with surrounding neighbourhoods;
- Revitalize Mikura's economy.

(*ibid*:4).

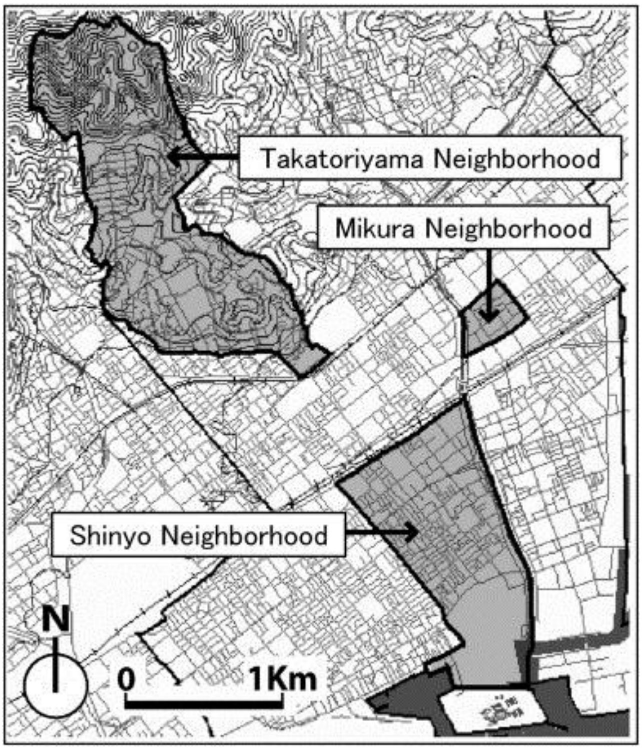


Figure 3.12: Focus neighbourhoods (Tanaka et al., 2008:3)

In this way, the plan made the streets more accessible for emergency vehicles (*ibid*). For the third case study, the plan points to the lack of open space and the high density of buildings and population. It suggests a gradual approach to include small and large open spaces in the area which would improve the quality of the urban environment, function for the emergency period, and reduce physical and social problems of the area (*ibid*).

The three examples tried to highlight how disaster prevention/recovery planning can become part of routine urban land-use planning, and fulfil both normal and emergency requirements. The next example is the California disaster-dominated planning process.

3.9.2 Highlights of Planning for Earthquakes in California, USA

There is consensus on the power of urban planning as a mitigation tool for earthquakes amongst Californian academics and government. However, creating a strong and useful link between them is a debatable context. The challenges in Topping's (2010) idea are:

1) The diversity and accuracy of knowledge to establish a strong base;
2) Illustrating a real picture of shortages, vulnerability and potentials;
3) Justification and consideration of economic supports and subsidies;
4) Placement of supportive legal regulations, accountability and practicality of plans.

In order to reduce or eliminate the risk of disaster in the urban fabric, the plan has included various measures such as:

- Strengthening structures to withstand earthquakes;
- Limiting developments in flood-prone areas;
- Clearing space around homes in wild land fire areas;
- Placing development away from geologically unstable areas.

(Topping, 2010:3).

Each important piece of legislation also aims to identify the disaster-prone zones, clarify the legal supportive grants, policies and criteria whilst also drawing maps of social, physical, geological and economic vulnerability (*ibid*). In some acts such as the 1968 National Flood Insurance Act, besides the usual terms and conditions, the pre-disaster flood hazard mitigation plans are subject to financial support, whilst in the 1988 Robert T. Stafford Disaster Relief and Emergency Assistance Act, the post-disaster recovery and strengthening plans to prevent future losses are subject to grants and support (*ibid*:7). In another radical legal act, the Disaster Mitigation Act of 2000 (DMA 2000), the hazard mitigation plans are subject to the preparation of Local Hazard Mitigation Plans (LHMPs), which emphasises the importance of multiple hazard mitigation plans, loss reduction and life-saving policies (*ibid:*4).

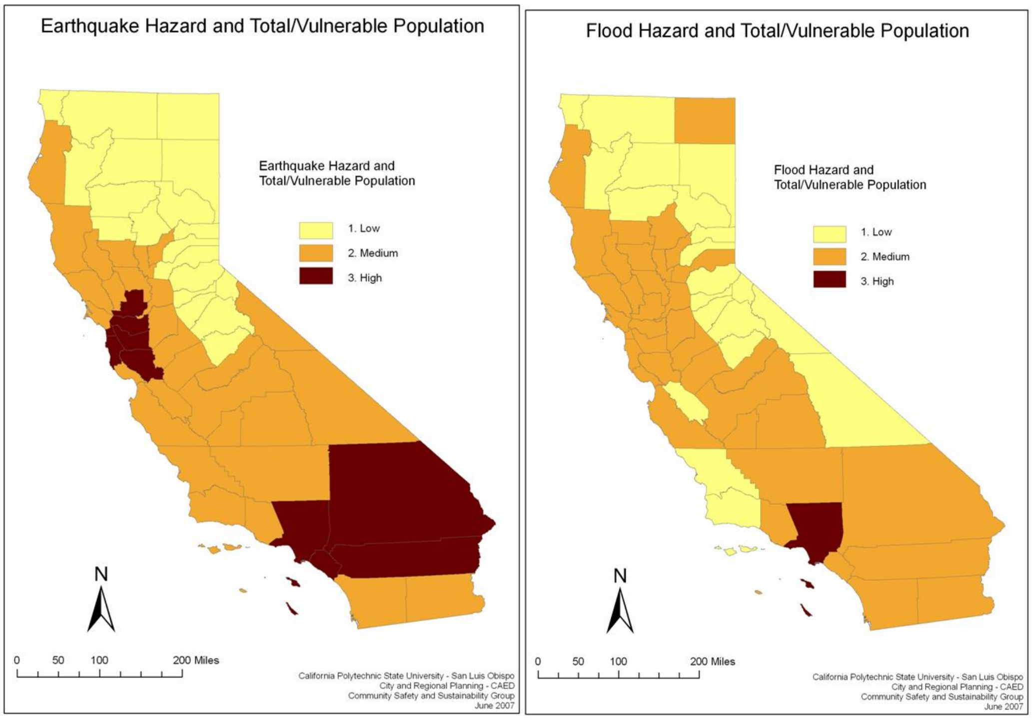


Figure 3.13: GIS hazard/risk/vulnerable population exposure: earthquake and flood (Topping, 2010:11)

Topping (2010) has discussed the context of the 2007 California state multi-hazard mitigation plan which was approved in 2008 by FEMA as follows:

- The plan recognises and follows the previous (2004) SHMP;
- This shows a constructive process which has been built upon the past experiences and policies;
- There has been a historical review of disaster hits in the region which gives an idea of the severity, sequence and causes of disasters. It also includes the impact of climate change in this process;
- The plan reviews the majority of FEMA local and regional documents and plans regarding disaster mitigation policies and recommendations. It is a

valuable process in studying, adapting and utilising the previous plans, which perhaps include aspects of analysis and lesson-learning.

Therefore the next section is the result of previous studies in the form of new legislation and hazard mitigation plan (Figure 3.11).

One of the requirements of building construction, insurance or transaction is to provide the proximity of the building to the fault zone; to do this, the Earthquake Fault Zone Mapping Act and the area that might be exposed to “ground shaking, landslides or liquefaction” (*ibid*:13) may be used. For the fire mitigation plan, some areas have been identified as vulnerable zones. These areas should have both the government and local community’s support in constructing fireproof buildings to lessen the possibility of spreading fire in the built-up areas (*ibid*). Therefore, a comprehensive plan for a city should “be consistent with others: land-use, circulation, safety, housing, conservation, scenic highways, noise” (Topping, 2010:18). Each section requires a separate study, but connectivity and coherence in targeting a balanced goal is the challenging element that planners and planning authorities should accept.

The study of the above examples revealed that the two countries have some factors in common: their high exposure to hazards, advanced technology, and extensive work on hazard mitigation policies and practice. However, this is not a similar practice in many countries, such as Iran, which does not benefit from an integrated planning system. The next section will highlight the main missing links, which will then be followed by the concluding part that prioritises the needs for multi-aspect urban planning.

3.10 Outline of Shortcomings

The above sections have highlighted a summary of the context of the typical disaster management plan in general. This category of the plan is prepared by a team of planning organisations, government agencies and research groups; but with a different approach, disaster-related plans could direct some of the physical activities to be more resilient to disasters by constructing stronger buildings or fireproof urban areas by designing open spaces and canals. Disaster mitigation plans are important documents that would suggest particular regulations for building in hazardous areas, green spaces, emergency services or roads. However, due to general government policy in the post-disaster period, concentrating on emergency and recovery services, this is not seen as an ongoing daily plan in many countries. This plan is studied and prepared in a different environment and by using different data from development plans. It might have some recommendations for road widths, public buildings, structural resilience or local parks, but it is not usually considered to be an active part of urban development planning. Creating a regular and permanent connection between development and disaster plans, and eventually combining them into one general city plan that considers safety as well as development, is the aim of this research. However, due to the variety of subjects that may be considered in a plan (hazard mitigation or urban development), the research will exclusively emphasise the role and nature of open spaces, their design criteria and the disaster management team's insight into them.

3.11 Conclusions

This chapter examined disaster damage estimation and planning via an assessment approach. First, the damage estimation method, as discussed in the chapter, plays an important part in the selection of the most appropriate method for this research which, to a large extent, was dependent on the available data, the context of the case study and the use of this data in future analysis. Therefore, the chapter had a short review of seismic risk evaluation, the most popular building damage methods and vulnerability evaluation. This helped in the selection of the simple analytical method as a tool for estimating building damage in the case study section. Then, the chapter looked at the disaster planning process in terms of its criteria and subjects, the professionals who are involved in the decision-making process and the key organisations responsible for its implementation. But the chapter also discussed how the urban built environment has a close relationship with disaster vulnerability, and that it is therefore a matter of necessity to consider disaster mitigation elements under a united development and disaster plan. The separation of these has cost many countries a lot when each urban development organisation has weak or no connection with other organisations and in some cases even act in opposition. The next chapter will contain a narrower study on the functionality and design of open spaces within the context of the city, which have been seen as a means of providing green space and refreshment points rather than safe refuge areas for vulnerable situations.

Chapter One................................ **Introduction**

Chapter Two............................ **Conceptual Framework**

Chapter Three.......... **Evaluation of Damage and Risk due to Earthquakes**

Chapter Four.................. Open Space and Diversity of Services

Chapter Five............................ **Research Methodology**

Chapter Six.... **Identifying the Spatial and Geographical Structure of Tehran**

Chapter Seven. **Use of Urban Risk Assessment Tool for Main Planning Resources**

Chapter Eight.. **Evaluation of Risk in the Study Area**

Chapter Nine.. **Open Space Design Criteria for Refuge Areas**

Chapter Ten..................... **Conclusions and Recommendations**

4.1 Introduction

Urban open spaces are an essential part of every settlement, which integrate with the elements of a city in many ways. They are defined and characterised differently in every context and give variety of services to the locality, region or city. As Figure 4.1 indicates, public spaces are, for example, one of the eight pillars of London's urban environment quality presented in Carmona et al. (2010:48).

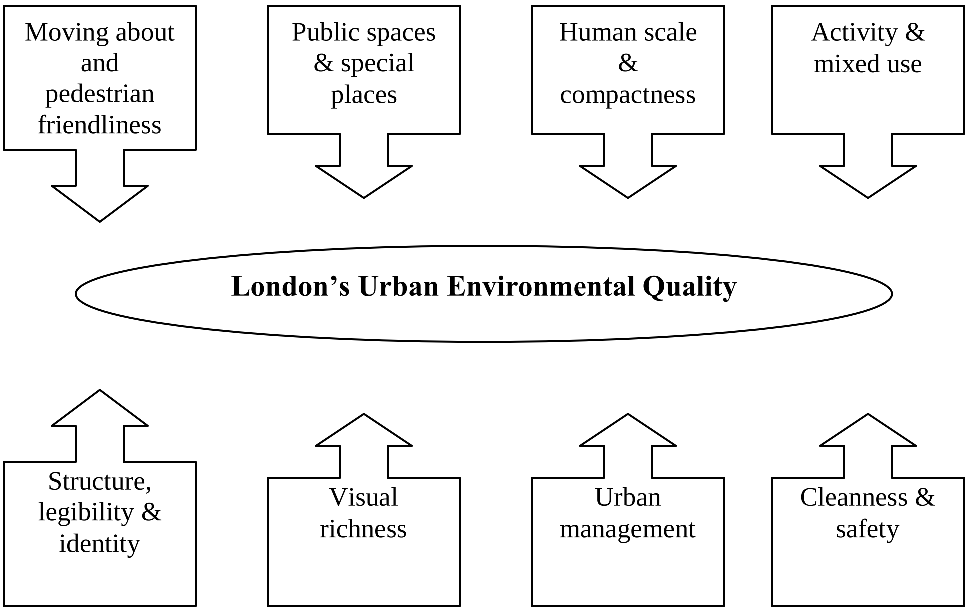


Figure 4.1:London's urban environment quality (Carmona et al., 2010:48)

In a similar approach, the city of Tehran's urban characteristics are summarised in Figure 4.2. There are certainly common elements in the criteria which describe or categorise the cities' identities, such as quality of visual richness in a positive to negative way, but open spaces in particular are one of the most controversial topics in Tehran. They can also have a variety of features and can be presented quite exclusively. The impact of tradition, religious ethos and cultural elements in their design is evident and characterise the area which is specific to that context. This chapter starts with the definition of open spaces, their use and services to the neighbourhood and the wider context. It then looks at the new usage of these areas for disaster-related services, which is the focus of the research.

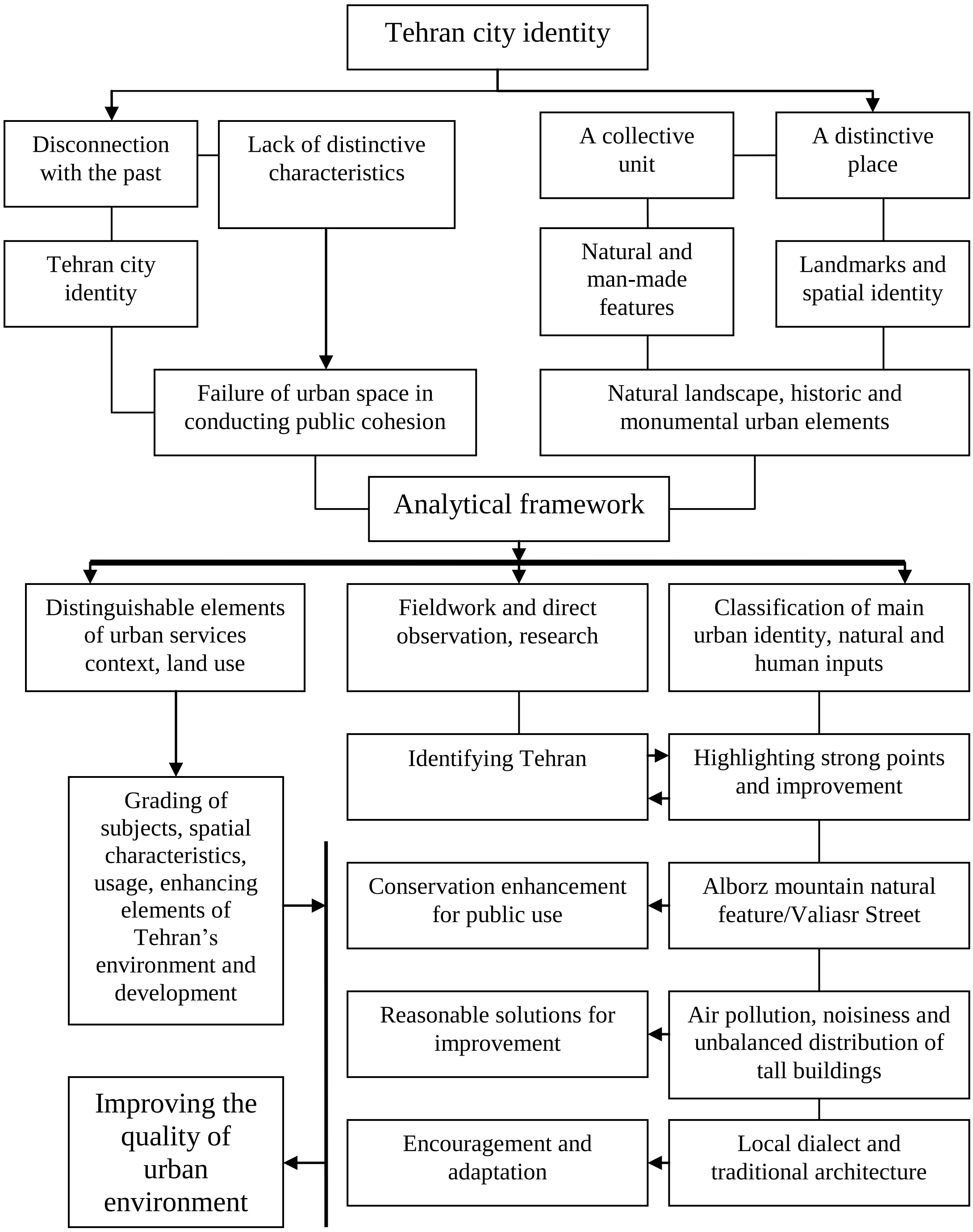


Figure 4.2:Tehran's urban characteristics (Behzadfar, 2008:71)

4.2 Definition of Open Space

"Urban texture integrated from mass and space" (Tafahomi, 2007:83). Their relationship is designated by architects and urban designers. In most cases, open spaces are a significant framework for urban fabric, featuring buildings within their surrounding environment whilst making connections with transport routes and promoting the quality of the neighbourhood. However, they can also attenuate the area by being poorly maintained and not making authentic communications with residents and general users. There are many scholars such as Madanipour (2003), Behzadfar (2008), Habibi (1996), Bahrainy (1996), Rapoport (1983; 1986; 1987) or Francis (1987a; 1987b; 2003) who have evaluated the meaning and usage of urban open spaces in various aspects, and from different points of view.

In terms of definition, urban open spaces are those which are part of the city without any building mass on it. One of the defining terms of open space can arguably be its ownership status, which underpins its accessibility by the public (Madanipour, 2003). This ownership can also be classified by who controls and authorises access to the open space and how they do so (*ibid*). Government authorities, in general, run and control the main public open spaces; they apply certain rules and conditions for people to use it. The private sector, in the form of inner-city landowners, is the second most important owner of open spaces (Fakoohi, 2008). Disregarding this categorisation, open spaces give service to the city, which makes them imperative and useful. In other words, open spaces have physical characteristics within their built environment which are fulfilled by social activities featuring their role in the community with residents and the city as a whole.

In the opinion of Carmona et al. (2010:3), designing urban spaces, despite the usual expectation of looking for a connection between solid buildings and their presence within the wider context of the area around them, should concentrate on more of a “sociological approach to the public places to create the sense of joy and activity along other elements of relation, social acceptance, economic activities or physical balance”. This develops the idea that urban open spaces are, in fact, a product of a trial or design process which can serve the majority of citizens at every level and be used for very different purposes. Simply, urban open spaces add to the quality of a city (Madanipour, 1996). The generalisation of open space to everywhere that can be seen from a window (Tibbalds, 1988) is a good definition for broadening its function, shape and design. However, it does not necessarily help to involve a group of professionals to maintain or design the space, as a public place requires a collaborative and multi-disciplinary design team.

In an interesting statement, Rapoport (1986:160) believes that the existence of open space within the urban context is important and useful in itself, even if it is not appropriately and accordingly used. This is, therefore, a different approach in defining the meaning of open space which is more related to its environmental quality and relationship with the city. Hence, the visual dimension of open spaces is part of a larger argument in traditional urban design thought.

Open space is a prominent strand of urban-structure-forming townscape, and it may contribute to the increase of the aesthetic quality of a neighbourhood (Cullen, 1961). It is the most common urban feature that can express the quality of a city. Locating landmarks and monuments within public open spaces has formed the context of many cities, expanding the definition of open spaces from plain spaces between the buildings to a contributor to the improvement of places (*ibid*). This approach thus compromises the definition of open space mentioned by Gold (1980) which describes undeveloped land or water as open space. Giving open spaces an exact definition is difficult as they can be viewed and used differently. In terms of location, they can be around buildings, between them, in the centre of a neighbourhood or anywhere in the city (Jacobs and Appleyard, 1987). Adding function to them makes their classification easier as they can be for the fulfilment of authenticity and meaning (*ibid*), or for pure vitality and meeting human needs (Lynch, 1981), giving choice to the public for the range of uses (variety) (Bentley et al., 1985), or for supporting the essential psychological, ecological, environmental and emergency needs of the city (Tibbalds, 1992).

The use of open spaces is usually accompanied by adding some features to them which opens up a series of discussions about place innovation and enhanced local distinctiveness (Tunbridge, 1998). This helps to define open spaces as part of the city structure and components aiming to create place differentiation and image-building (Carmona et al., 2010). This idea emerges from the culture of each context that involves a combination of traditional ideologies, globalised theories and the relationships between buildings and the surrounding environment (*ibid*). Their use as a public or private open space does also influence its definition as used by Light and Smith (1998). Many public open spaces are the backbone of the city, providing environmental and recreational services; however, their semi-public and private counterparts are also a large proportion of existing open spaces in every city (Newman, 1972). Whether they are open for public access or set restrictions in their use, many, such as Tibbalds (1988), have suggested some frameworks for design of an open space. These frameworks take into consideration many aspects of an open space, such as being on a human scale, providing access for all and integrating use (*ibid*). Each element, in some respect, has connections with various definitions of open space that have been pointed out above.

For an open space to be usable by humans, and have a suitable scale, there are assorted definitions discussed by Lynch (1981) and Carmona and de Magalhaes (2008) which is about the degree of functional support and capacities. Being accessible to people requires debate about ownership (Madanipour, 2003) and control. Simultaneously, other factors such as permeability and freedom make an open space a public place with a degree of effectiveness and inspiration (Bentley et al., 1985). One of the most important factors in defining an open space is the accessibility and range of services it can provide to the city and its citizens. In the majority of cases, open spaces provide limited services, which are perhaps controlled by public authorities or the private sector (Madanipour, 2003). However, a mixed use, which concerns their robustness and diversification, has widely been encouraged by many planners (Lo and Yiu, 2003). This automatically leads to the group of people who use the place, their involvement in decision-making and management and social interaction debates. The community, as the prime target of a designated open space, is the first user to influence its definition (*ibid*). The public realm, in general terms, is used to describe non-privately-owned spaces, including open spaces.

The physical components of open spaces, to a large extent, define the social activities and opportunities that shape the built environment (ALR, 2010). Lynch (1981) points to the range of choices that an open space can give to the community, whilst Carmona et al. (2010) describe them as part of a wider context of public life. The nature of interaction and connection made in these spaces by the community varies. It can be socially driven, politically empowered, or it can simply deliver prospects for recreation and sport. Rapoport (1986) has emphasised the importance of availability of social opportunities to actively form and reform public open spaces, which is part of the process of urbanisation. The symbolic influence of open space that has become the national identity of many nations (Picture 4.1) is also part of its social and cultural definition.

Picture 4.1: 1) Grande Arche, La Défense, Paris[5] **2) Azadi Monument, Tehran**[6]

How we define or categorise open spaces only helps to describe an essential part of a city which can bring liveliness and quality to the urban environment. The next part will have a more in-depth review of the functionality of open spaces in a typical urban area.

4.3 Use of Open Spaces

As discussed above, open spaces include public, semi-public or private spaces of a city comprising diverse functions. The nature and extent of their services vary and is largely influenced by their size, location, proximity to other urban features and many others (Landcom, 2008). Open spaces have become one of the most important dimensions of our social life, which gives different meanings to the space and "reflect[s] the way places are socially constructed" (Knox, 1995:165). If the quality of an open space is fully looked after, it can promote the social capital of that specific neighbourhood. It is a place where connections are made, many political discussions are sown, and personal, physical and psychological stimulation is developed (Madanipour, 2003). In an era of electronic technology and privatisation, the role of open space in improving social life and reducing undesirable impacts of modernisation is becoming increasingly important (Al-Hagla, 2008). This goes beyond its traditional

[5] http://inarchitecturalterms.blogspot.com/2010_10_01_archive.html
[6] http://www.iranianhotline.com/IranPhotos1.cfm

functions, which used to be only as a public gathering place or for city monuments. Giving certain functions to open space by citizens, planners and government agencies is an acceptable approach. These range from cultural activities to environmental and uplifting places. Hence, adding emergency relief functionality to the open space, which has previously been tried in some cases, cannot be a new idea. The following paragraphs concentrate on identifying the most common functions of open spaces in urban areas, followed by the disaster-related uses that have been added to them.

4.3.1 Open Space as a Recreational Place

Parks, squares, gardens and fields are the general features of open spaces that include recreational elements. The location of the space, seasonal conditions and initial facilities are some of the crucial factors in encouraging people to come and use the area (Plummer and Shewan, 1992). A degree of organisation can enhance the quality of use for users. How people use the places is largely dependent on how these facilities are organised and how people are guided to actively utilise them. There are parks in Tehran that facilitate their use as public (long or short) walks. There are also small parks that are equipped with simple mechanical machines in order to encourage people of all ages to exercise (Pictures 4.2 and 4.3).

Picture 4.2: Recreational spaces of the city:

1) Vali Asr Park, Tehran[7] **2) Laleh Park, Tehran**[8]

This is one of the points mentioned by Woolley (2003); it enriches the individual's experience and increases and decreases the value of open space and the extent of its

[7] http://t3.gstatic.com/images?q=tbn:ANd9GcQRmRIzFfR-gsowIzRrRhpRxOiNvRSRTFasC85OPRBQlkcldCaSN0b6GVXQ

[8] http://tehrandaily.files.wordpress.com/2011/06/playing_volleyball.jpg?w=497

contribution to social life. One of the influential factors in the encouragement of recreational use of these spaces is their size, which provides enough space for every taste and becomes the home of integrated recreation (ALR, 2010). This also opens up another debatable context about the kinds of users. The more spacious, safe and dedicated the space is, the more attractive it will be (Lo and Yiu, 2003). Having said that, for many users the availability of communal facilities and the distance from residents or their social activity centres are other factors which contribute to the enhancement of its recreational purposes. The low number of parks in many neighbourhoods puts additional pressure on larger parks in many areas of Tehran. This is apparent in the southern parts of the city.

In business areas, the open space can gather many people for short midday/end of day breaks, which are beneficial to them (Carmona et al., 2010). In an environmentally well-presented and green space, the number of users increases, which is a good opportunity for physical and mental recreation and social relations. This is one of the controversial issues in Tehran's green space management (Bahreiny and Aminzadeh, 2006), which largely depends on the mayor's policies, priorities and budget. The impact of seasonal weather conditions can change the number of people making use of open spaces (Thompson and Travlou, 2007); however, their existence as the centre of sociability and recreation has not been reduced. Whether they are private and within the boundary of someone's property, or belong to a wider group of people, open spaces still have a sense of locality and limitation or are located and designed for a larger group of people at city or regional scale (Woolley, 2003); they have increasingly become part of civic life and rights due to the criticism of planners and planning authorities. Those functions are not in conflict with them being safe spaces for emergency situations, especially if they are designed appropriately.

4.3.2 Open Space as Cultural Manifestation Place

Separating cultural elements from many socially-dominated activities is a difficult distinction to make; however, open spaces are the backbone of cultural display and traditional religious festivals (Thompson and Travlou, 2007). In some rich, culturally-based cities such as Edinburgh (Picture 4.7), open spaces are famous for hosting some of the internationally-known festivals that attract thousands of tourists every year. In societies with a rich cultural history, open spaces are the place for exchanges of social experience (Worpole, 2000) and facilitate the theme of dialogue and devotion.

Picture 4.3: **Cultural use of open spaces:**

1) Abyane, Isfahan, Moharam Ceremony[9]

2) Sizda Bedar, New Year, Tehran[10]

Identities are formed and developed in society by the presentation of cultural values in open public spaces (Carr et al., 1992), whether they are an internationally accepted principle or supported by various ideologies (see Picture 4.3). Open spaces have been the centre of influential pressure in presenting public ceremonies in every nation. In a country such as Iran, they are widely used for public ceremonies influenced by religious demonstrations. The dominating role of the government (local or national) varies between democratic and undemocratic contexts. Rapoport (1986) stresses that cultural features partly originate from religious values, and have an impact on people's lifestyles, which ultimately become part of the local culture. Activities performed in these places, according to Rapoport (1977), are not limited to major programmes or influential aspects. They are associated by meaning, need, communication and identity (*ibid*). Each is the touchstone of a group or community's culture. The cultural range of activities within an open space conceptualises (Carmona et al., 2010):

- *Time*, by inviting and gathering people in a public place to share their feelings and make use of their time;

9 http://www.spiritsofadventure.com/journal/iran/abyaneh/Abyaneh-ceremony-3.jpg
10 http://www.payvand.com/news/07/apr/Sizdehbedar86-Iran16.jpg

- *Lifestyle*, by giving the opportunity to the community to be represented and their thoughts to be conveyed;
- *The built environment*, by providing them with various spaces to use;
- *The choice* to choose the audience, the place and the nature of activity;
- *The purpose of urbanisation*, by enriching values, changing beliefs and doing away with prejudice.

The variability of culture can be a problem for design and investment in open spaces as they dictate the use, the size, the characteristics of groups, and the setting (*ibid*). However, in a mutual relationship between cultural activities and the availability of open spaces, they can compromise or be influenced to fit the purpose. That is why Rapoport (1986:161) argues that “generally, characteristics such as the overall culture, membership in various sub-groups, stage in life cycle, age, gender, role, education, occupation, ethnicity and other demographic cultural and socio-economic features need to be considered”. Culture is the latest outcome of lifestyle as a specific time and specific place (*ibid*). Open spaces, throughout history, have been the stage for displaying the lifestyle of a population, in the form of cultural performances and activities. Lifestyle is the outcome of environmental conditions and modernisation (*ibid*). This leads us to one of the first elements in the design of an urban open space.

4.3.3 Open Space as Environmental Quality

Parks and plazas are common typologies of open spaces aiming to promote the environmental quality of urban areas (WHO, 1997). Planners have always tried to bring the natural richness of trees and water to the polluted urban built environment; for example, in design theories such as the garden cities of Ebenezer Howard (1898). Ecologically they can create a healthy environment for citizens to breathe and live (Thompson, 2002), whilst creating a pleasant and refreshing environment for the fulfilment of spiritual needs. The green coverage of many parks and fields also helps reduce general urban pollution such as sound pollution, carbon dioxide pollution, and visually poor solid walls and buildings. In many urban planning recommendations, Iranian development plans have a specific emphasis on their location, size and proximity to each neighbourhood (Fakoohi, 2008). Although the concentration of a population in an urban area is accompanied by various forms of pollution, there has been consensus amongst government agencies, citizens and planners over the necessity of the inclusion of open spaces within the urban fabric to:

- Minimise the side effects of urbanisation in terms of pollution (Sadgrove and Voller, 2000);
- Make visual and mental connections with the natural and green environment (O'Sullivan, 2001);
- Enhance the aesthetic quality of cities (DTLR, 2002);
- Freshen the air and create cooler weather conditions;
- Help the natural ecosystem to produce a sustainable and comfortable working environment (Thompson, 2002).



Picture 4.4: Parks and plazas, green spaces:
1) Ferdousi Park, Tehran[11] **2) Mellat Park, Tehran[12]** **3) Darake, Tehran[13]**

Each of the above-named factors has been discussed thoroughly by many scholars such as Woolley (2003), Lynch (1992) and Cranz (1982). Rapoport (1986) discusses different aspects of environmentally active open spaces in a very particular way. In his argument, the "characteristics of the environment", "safety", "the quality of the built environment", its "finishing, ownership" rights, and the desirability and "human-scale" form are the main influential factors, instrumentally and conceptually, in making an open space a highly pleasant environment (p.166). Some of them might not be

[11] http://i59.photobucket.com/albums/g320/alitezar/A1/parke-lale.jpg
[12] http://i59.photobucket.com/albums/g320/alitezar/A1/bourj-milad-viewed-from.jpg
[13] http://i59.photobucket.com/albums/g320/alitezar/A1/bourj-milad-viewed-from.jpg

considered for every space; however, the safety aspect, in terms of crime or disaster-related refuge areas, is what this research will study for Tehran in the case study chapters.

In many dedicated parks, and in order to prevent disconnections of human from nature, zoos and bird sanctuaries are two types of wildlife habitat which strengthen urban environmental quality. They have been described as a way of keeping in touch with nature within an extremely manmade context (Woolley, 2003). There are dis-similarities in the design process and the presentation of green spaces derived from the personal opinions of planners; whether to make the place a work of art, or simply leave it to the art of nature. However, this results in one important conclusion which is a combination of the natural environment and man-made buildings. The fewer buildings or heavy objects exist in an open space, the safer it would be to accommodate people in an emergency situation. There will be more discussion in this regard later in this chapter.

4.3.4 Open Space and Monuments

Many countries are identified by their famous public open spaces with monuments. Although they might include sculptures or symbolic elements, their sophisticated open spaces are their frame. They represent culture, history, technology and identity and also build the social characteristics of the city or country (Carr et al., 1992). The efforts of designers in achieving a perfect physical monument has improved over the years and has been appreciated by visitors ever since. Their role as landmarks has been mentioned by Montgomery (1997) and has dominated a range of activities (Rapoport, 1986). Monuments are symbolic characteristics which contribute to the enrichment of the cultural perspective of the city (Ulrich, 1979). The impetus of religious ethos, for example, appears in the shape and physical characteristics of monuments. They sometimes bring to mind memorable and distinctive historic events in certain places (Taylor and Coalter, 2001) in order to keep good and bad memories alive. These values, in the opinion of Carr et al. (1992), can have roots in ideologies, or the nationalism and patriotism of a group of people or individuals. The monuments also help keep connections with present and future communities, as do many ancient sites. In other words, they are the language of past, present and future generations in a symbolic way without needing any translation (*ibid*). Within a rich cultural background like Iran, these monuments represent the country's pride.

Picture 4.5: Monuments and open spaces:

1) Emam Square, Iran[14] **2) Speke's Monument, London**[15]

Arguably, Knox (1994) believes in the dominating role of power, and particularly ideology, in personifying monuments and their physical environment. However, generalising this opinion can be challenged by the simplicity of recent public art exhibitions within open spaces which are not claimed or manipulated by political, religious or market forces. This is another acceptable role of open spaces in the past and present.

4.3.5 Open Spaces and Economic Qualities

It is an established fact that market and economic forces directly and indirectly influence the physical aspects of many urban activities. However, open spaces that serve the economic development of an area are interestingly exempt, as they are the prime locations that create opportunities for trade and economic activities. Many Sunday markets, for instance, take place in an existing open space which gathers tradesmen and buyers from various locations. In many Iranian cities, traditionally open spaces adjacent to city centres accommodate day-markets and assist the economic activities of the area. As well as theme parks in which to have fun, there are open spaces that are used by commercial workers and staff (Carmona et al., 2004).

[14] http://saridailyphoto.blogspot.com/2009/08/emam-square.html
[15] http://www.superstock.co.uk/stock-photos-images/4124-3763

Picture 4.6: Economic activities in open spaces:

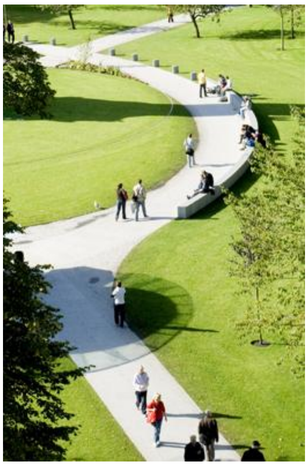
1) Day-market, Sari, Iran[16] **2) Grand Bazaar, Istanbul[17]**

In the past, many marketplaces were located in public places, in the centre of settlements, and were the focal point of commercial interactions. However, this role has gradually transferred to enclosed shopping centres, which has consequently reduced the size of cities' core open spaces that could potentially be economic centres (Madanipour et al., 2000). However, the proximity of the location of a well-presented open space can increase the value of the surrounding environment and create a better commercial market (*ibid*). This can add to the types of users from purely shopping to tourist or leisure purposes (ALR, 2010). Therefore, this opens the door for integrated markets and different types of users. At the macro-economic level, designated valuable open spaces form parts of tourist attractions, which bring large economic benefits to the region, especially in countries like Italy and Turkey. This may not be an active and accepted idea in Iran in the current political atmosphere, but has certainly proved to have a more positive impact on the city than any other functions of open spaces. This benefit trickles down to the local people and government, whilst returning the open space to one of investment, maintenance and expansion (Carmona et al., 2010). In terms of safety measures, having an open market space in an open space does not interfere with its use as a refuge area. Real examples of this in Tehran will be looked at in Chapter 7.

[16] http://www.iranonline.com/iran/iran-info/economy/bazaar-Sarri.JPG
[17] http://traveldk.com/istanbul/bazaar-quarter-and-eminonu/category/places-of-interest/all

4.3.6 Open Spaces and Social Qualities

Social values are presented publicly in open spaces by social groups and individuals (WHO, 1997). There may be overlapping discussions between social entities and other discussions mentioned above. However, the prime psychological role of open spaces is to feed the social appetite of the community in a way that promotes acceptable values, tailored to the present identity and common needs, and enhancing cultural enrichment (Lynch and Hack, 1994). Social learning in social science theory and practice is a complicated and involved issue, but in the context of this research, open spaces are places with the ability to facilitate this learning, whether it results in political revolution, the confrontation of cultures or dialogue.



Picture 4.7: Social activities in open spaces:

1) Figgate Burn, Edinburgh[18] **2) Sanje Park, Isfahan[19]**

Also, within this context, people learn about each other, how to communicate, make friends, be part of a group and appreciate the natural environment (Childs, 2004). Although cities are the places for working relationships between human beings, however, private houses create distance in social relations; open spaces are the first to break through this gap by bringing people into a place with fewer physical boundaries (Madanipour, 2003).

Since 1898, when Howard developed the idea of garden cities, followed by other theorists and designers such as Raymond Unwin (1996), open spaces have been

[18] http://88.208.222.252/website/plans/eclp/chap5.htm
[19] http://t3.gstatic.com/images?q=tbn:ANd9GcSECTwTa7EBRC-84Sa9neKejORcMPT8tfR3TYBGkXeR5GSZIeUumspepk-8

socially communicative places. A city with a socially supportive and strong background can lead to an economically robust community, and this is partly sustained by decent open space (Alexander, 1987). In the Iranian context, where every social communication is controlled by government power, open spaces are not exempt. Nevertheless, in disaster management systems, the socially improved quality of open spaces can promote the quality of disaster rescue operations. This will be discussed under public knowledge in Chapters 7 and 9. Colomb (2007) also emphasises reconstructing urbanisation through social cohesion and communication. Many of today's technologies, especially in the communication and transportation field, reduce face-to-face contact and direct social interaction (Mitchell, 2002). Therefore, many critics such as Fishman (2008) or Colomb (2007) seek alternative forms of cultural and social attractions and opportunities. Open spaces are the realm in the public domain that have the area for building social relations (Worpole and Knox, 2007).

Yet, despite all the diversity of functions that an urban open space can offer to the city and its citizens, it is hardly mentioned in planning literature that an open space can be a place of refuge for the community and provide emergency services in the event of a disaster. The next section will discuss more about the specification of an ideal open space beyond its traditional use.

4.4 The Dimensions of a New Design Paradigm

Approaches to neighbourhood- and regional-scale open spaces are derived from many background forces such as urban design theories, proposed functions and an area's ecological and environmental conditions (Trancik, 1986). Green and open spaces create urban structure and a public realm; however, years of dealing with hazardous events have allowed disaster management teams to appreciate how open space could also be employed serving cities and their citizens as refuge areas. As discussed in Chapter 3, the complexity of urban issues and the unexpected features of disaster appeared to fail to make connections between urban planning theory, practice and urban disaster management. From the beginning of the 21st century, the social economy and public health became important issues in urban design (O'Sullivan, 2001). New and modern technology has created numerous practical ideas in order to solve the problem, but the position of urban open spaces and safe open spaces has still not found its rightful place in planning debates. The following paragraphs will contain discussions regarding the dimensions of a safe open space in the literature, which will later be used in the case study discussion in Chapter 8.

4.4.1 Open Space: A Fireproof Approach

One of the common consequences of disaster is fire. It spreads quickly from one building to another and from one area to another, which is extremely dangerous. In order to reduce this effect, the government of Japan, for example, has produced some planning measures such as the Land Readjustment Law (Olshansky et al., 2006), the Park System (Ishikawa, 2002), reconstruction plans for affected areas, the road network configuration, evacuation routes to open space, etc. The common subject of all these policies is the use of safe open space to:

- Prevent the spread of fire from the affected area to others;
- Deliver initial services to victims of fire;
- Readjust land to create open spaces within densely built-up areas;
- Widen roads and create boulevards for fast connections;
- Add canals to the structure of the area as firebreaks;
- Modify the urban landscape in accordance with public safety principles.

Each item will be individually discussed under different subheadings, and the experiences of other countries will be presented, to become the foundation of this research proposal. Small or large parks can simply be used as firebreaks. Hazard Mapping, which is a method to identify the main vulnerable objects and areas, and also estimate damage, is a useful tool in the hands of planners to update seismic safety elements and relocate open spaces on their general map (French and Isaacson, 1984). In a densely-packed urban area, an organised evacuation plan using safe evacuation routes which end at a safe open space with no possible means of spreading the fire is the common and acceptable mode of action in the US and Japan (Kanamori et al., 2007). “The fire expansion speed depends on the wind velocity, spatial distribution of fireproof structures and open space boundaries including streets and roads having fire protecting width” (*ibid*:1). The width of open spaces is as important as their accessibility and the distance from densely-populated areas, particularly for disabled or elderly people without help.

In an interesting discussion, Beall (1996:290) has mentioned the occurrence of 175 fire incidents within ten days after the Hanshin earthquake of January 1995 which burned 10,000m² of the urban area.

Table 4.1: Proportion of fire break factors along fire spread boundaries for ten major fires, Kobe, Japan (Beall, 1996:300)

First Stop Factor	Road, railway		Open space		Fire-resistant bldg.		Suppression		**Row total**	
Major Large Fire Sites	Length (m)	Ratio (%)	Length (m)	Ratio (%)	Length (m)	Ratio (%)	Length (m)	Ratio (%)	Length (m)	Ratio (%)
1) Ohta school north	110	31.4	145	41.4	30	8.6	65	18.6	350	100.0
2) Ohta school south	165	38.8	75	17.6	55	12.9	130	30.6	425	100.0
3) Ohta 4 chome	55	48.9	25	22.2	33	28.9	0	0.0	113	100.0
4) Near Yokozuna bldg.	25	12.3	25	12.3	87	43.2	65	32.1	203	100.0
5) Near Chitos park	298	46.9	58	9.1	142	22.4	138	21.7	635	100.0
6) Near Takahashi hospital	812	64.6	298	23.7	124	9.9	23	1.8	1,258	100.0
7) Near Nishidai market	280	23.4	295	24.7	337	28.2	282	23.6	1,195	100.0
8) Near Mizukasa nishi park	985	42.0	539	23.0	626	26.7	195	8.3	2,345	100.0
9) Hiyoshi 2 chome	143	58.8	82	34.0	17	7.2	0	0.0	243	100.0
10) Shin-nagata sta. south	625	59.1	119	11.3	262	24.8	50	4.7	1,080	100.0
11) Kobe department south	262	24.3	170	15.7	365	33.8	283	26.2	1,080	100.0
12) Hosoda 4 chome	117	39.8	97	33.0	50	16.9	30	10.1	295	100.0

First Stop Factor	Road, railway		Open space		Fire-resistant bldg.		Suppression		**Row total**	
13) Mihune-dori 2.3.4 chome	480	71.1	0	0.0	90	13.3	105	15.5	675	100.0
14) Kawanishi 1 chome	135	49.0	43	15.5	48	17.3	50	18.2	275	100.0
15) Mikura-dori 5.6 chome	234	24.1	242	24.9	370	38.0	124	12.8	973	100.0
16) Near Sugawara market	528	40.0	442	33.5	350	26.5	0	0.0	1,320	100.0
17) Higashi-shiriike 7 chome	197	61.7	37	11.7	0	0.0	85	26.6	320	100.0
18) Egeyama south	624	23.4	942	34.3	686	25.0	472	17.2	2,745	100.0
19) Nakamichi-kita 6 chome	178	58.7	40	13.2	53	17.4	32	10.7	303	100.0
20) Uozaki-kita 5.6 chome	170	35.8	93	19.5	123	25.8	90	18.9	475	100.0
21) Ogi sta. south	235	49.2	38	7.9	107	22.5	97	20.4	478	100.0
Summary of the above fire sites	**6,676**	**39.9**	**3,805**	**22.7**	**3,955**	**23.6**	**2,316**	**13.8**	**16,752**	**100.0**

This figure indicates the irregularity of the fire ignition pattern, which was dependent on the building structure material, road width and building coverage of the area. In Table 4.1, the fire break factors are compared in order to figure out the role of each element in saving lives and minimising the possibility of fire spread.

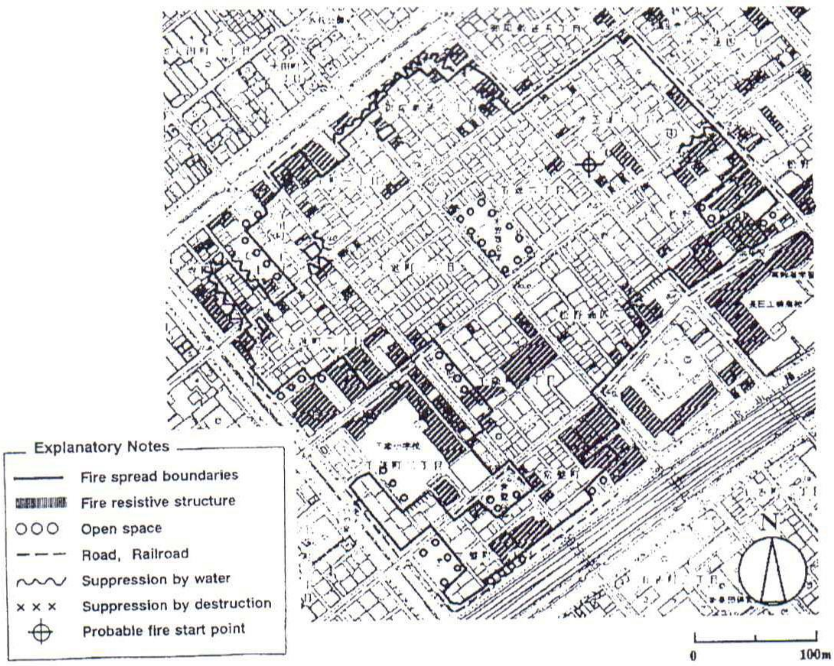


Figure 4.3: Fire spread boundaries and fire break factors of the fire site near Mizukasa Park, Kobe (Beall, 1996:297)

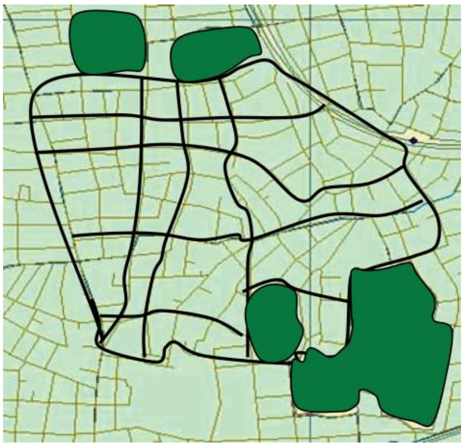
Open spaces, although they are not the first referral points of citizens, provide a significant proportion of places of safety and refuge. Whether the fire brigade responds to the emergency calls or try to stop the actual fire spread, the open spaces, with fire hydrants or a lake, are focal points for many people. Responding to an open fire (which cannot be extinguished by local or prefectural fire brigades) requires acting appropriately in a densely-populated area, based on “open space ratio” as well as “road ratio” etc. (Tanabe and Kumagai, 2005:51). The probabilistic approach used by Kanamori et al. (2007) was “taking to simulate the evacuation scenario along all the streets which are crowded” and includes elements of fireproof structure ratio and open space ratio (p.1).

Figure 4.4: Schematic example of urban area in Tokyo (Kanamori et al., 2007:2)

Table 4.2: Statistics of Setagaya community (Kanamori et al., 2007:2)

Item	**Unit**	**Amount**
Population	Persons	**5622**
Area	Ha	**30.7**
Population density	Person/ha	**183.4**
Building density	No./ha	**49.1**
Fire resistive structures ratio	%	**46.7**
Road occupancy rate	%	**14.8**
Open space	**m^2**	**6047**

In an attempt to draw up an evacuation plan for a congested modern city, the authors used the 1994 Northridge and 1995 Kobe earthquake investigation data and a basic model of a city area of a 0.5 km × 0.5 km grid (Figure 4.4). In this way, open spaces are allocated and escape routes are designed.



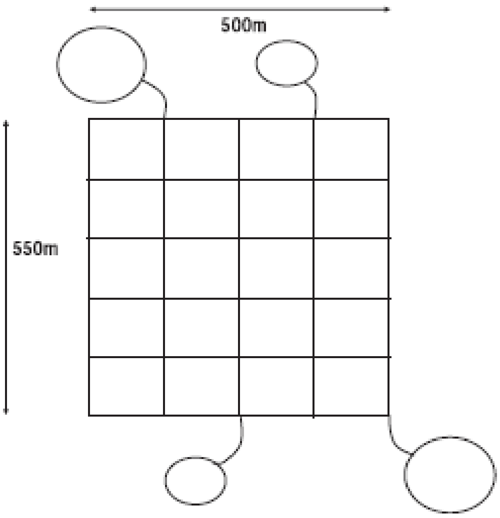


Figure 4.5:
1) GIS map of Setagaya ward, Tokyo

2) Simplified road network model (Kanamori et al., 2007:3)

Ignition of fire is largely triggered by:

- Wooden houses of poor resistance;
- Densely congested housing;
- Non-fire-resistant buildings;
- Widely allocated residential housing.

(*ibid*:2).

The study chose the Setagaya ward of Tokyo, which is one of the most populated areas with approximately 6,000 people (*ibid:*2). Based on past experiences and the spatial structure of the area, with narrow roads, the study suggested four possible locations for open spaces inside and around the outer boundaries of the ward (Figure 4.5). With factors such as humidity, wind speed, building structure, open spaces and trees as the main driving forces of the speed of the fire spread (Figure 4.6), the direction of the routes to guide people (whether they are familiar with the area or not) to the designated open spaces are shown in Figure 4.7.

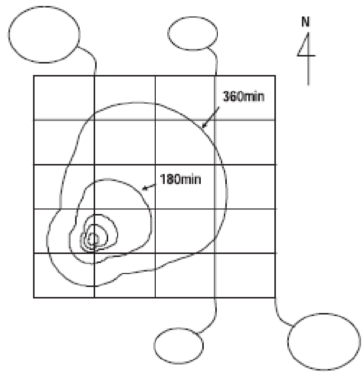


Figure 4.6: Schematic example of fire growth (Kanamori et al., 2007:3)

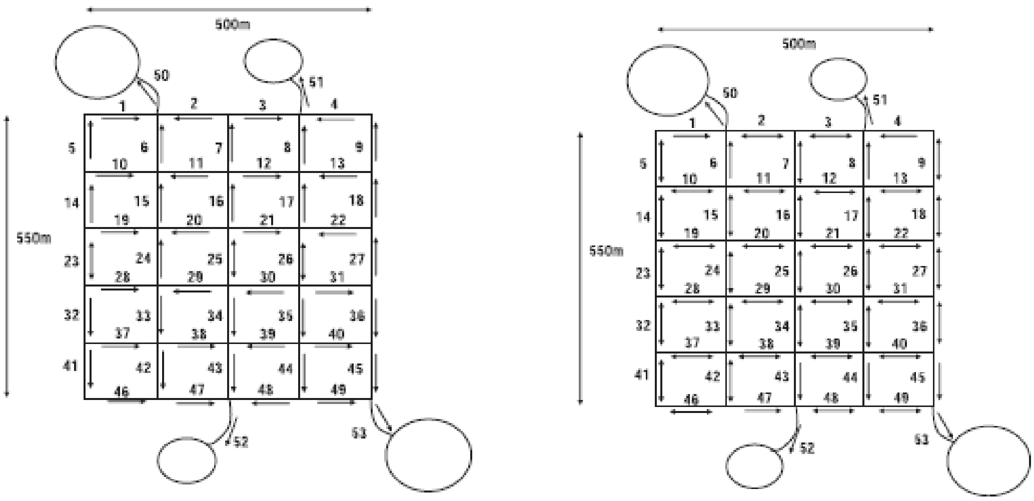


Figure 4.7: 1) Analytical model assigning a single direction of an evacuation route
2) Analytical model assigning dual directions of an evacuation route (Kanamori et al., 2007:5)

Considering many parks and open spaces, instead of only one or two, in a congested, vulnerable area:

- Can save more lives and evacuate a larger proportion of people;
- With signposted evacuation directions, gives choices to people and lessens the congestion of the routes in the peak time of the hazard;
- Alongside more fire-resistant buildings, provides time for people to move away from danger;
- Softens the impact of slow-moving and disabled people on the evacuation routes.

This assumption will be fully discussed and studied in the case study chapters.

4.4.2 Open Spaces and Accessibility Approach

Assessment of hazard damage in an urban area illustrates the estimated pattern of damage in urban areas (Reichle, 1990). This can then be used to map the major corridors for pedestrian and car access to the safe open spaces. Available literature with a unique focus on this subject is very limited, as the majority of plans are post-disaster-defined. However, the first natural reaction to any disaster-affected area would be to relocate people to an accessible place for further rescue action. The routes, whether for pedestrians or cars, are required to have fewer possible building damage obstacles nearby. Signposting them for local people is necessary as it makes them recognisable. In a broader context, the hierarchy of these routes has to be considered in accordance with their degree of contribution in providing safety.

4.5 Land Readjustment to Create Open Space

Land readjustment or land pooling is fairly new to the western literature, but has been an effective tool in Japan for the purpose of improving and decreasing the congestion of densely-populated areas, in order to build a seismic-proof urban context. According to Sorensen (2007), the use of this law has not been limited to earthquake-related planning but, as an extraordinary tool, has been used for all urban development and management purposes since the 1920s (p.89). The strong Japanese culture of “collaboration and consensual decision-making” has supported institutions to change the attitude of government and citizens from “town planning by public authorities” to “town planning through cooperation” (Nishiyama, 1992:90). In general, land readjustment is a technique used to reduce plot size and simultaneously create wider spaces for public use (roads, open spaces, services, etc.) (Hein, 2010). In Tokyo, implementation of this policy not only helped to reconstruct a better environment to resist disaster, but was widely used to develop the city and modernise its streets, connections and buildings (*ibid*). In a simple figure, Aoki (2007:3) shows how exercising land readjustment can improve the quality of urban fabric and organise a connectivity pattern, whilst considering adequate open space for recreational, environmental and, most importantly, functional determination.

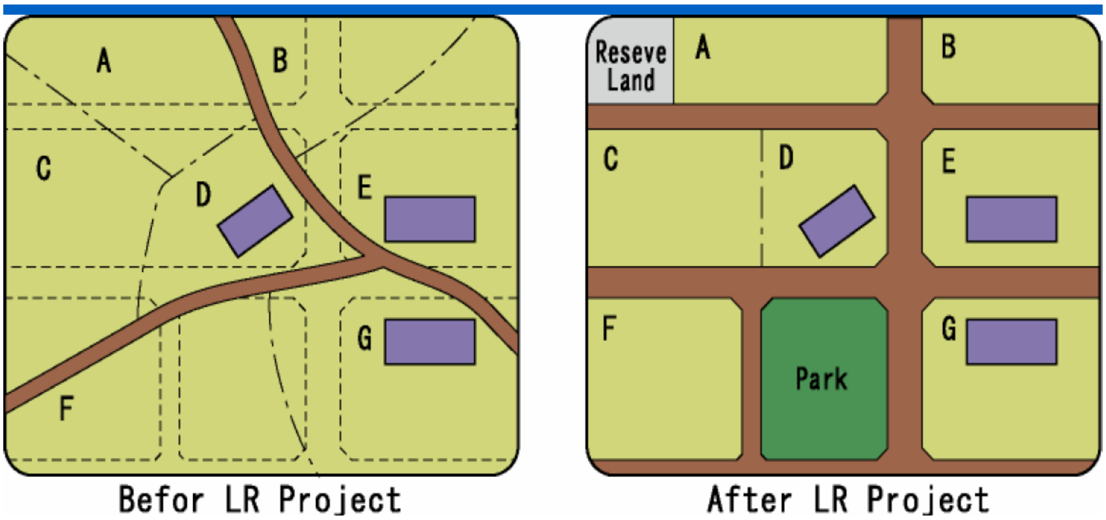


Figure 4.8: Land readjustment system (Aoki, 2007:3)

Aoki also summarises the characteristics of LR (Land Readjustment) projects as follows:

- Comprehensive urban development (in infrastructure development and increase of land use);
- Participation of public and private sectors;
- Wide applications;
- Fair procedure and distribution of development benefits and costs;
- Presentation of land titles before and after the project.

(Aoki, 2007:4)

By using such a law, according to Aoki (2007:5), Japan has doubled the number of its parks and open spaces since 1954 and comprehensively assisted the government to rehabilitate the affected areas of citizens after the disasters, such as the Hansin-Awaji earthquake.

Table 4.3: International experiences of land readjustment or associated techniques (Blanco, 2006:1)

Country		Legal origins	Period	Term/technique applied
		Related regulations	Years	
1	Japan	Introduced through agricultural land consolidation and then through the former land readjustment law	1899 ,1954	Kukakuseiri
2	Germany	Former Lex Adickes, Land Consolidation Act (LCA), also referenced Baugesetzbuch (BauGB) and law on adjustment of agriculture (LAA)	LCA 1902 BauGB 1986, LAA 1990 (post-reunification)	Baulandumlegung
3	India	Bombay Town Planning Act	1915	Plot reconstitution
4	Australia (Western)	Western Australian Town Planning And Development Act (TPA)	Framework from 1928, current TPA of 1984	Land pooling
5	Turkey	Municipal Expropriation Law 2497 (1934), current 2942 (2005), Building Amnesty Law 2981, Reconstruction Law 3194 (1985)	1934, 1983, 1985, 2005	Land readjustment
6	South Korea	Introduced through the City Planning Act and recently through the Residential Land Development Promotion Act	1934, 1980	Land readjustment
7	Taiwan	Indirectly in the republic's constitution and the agrarian land consolidation programme	1949, 1958	Land Consolidation
8	Spain	Land Use Law	1956	Reparcelation
9	Indonesia	Basic Agrarian Law no. 5, Spatial Use Management Law, Law on Housing and Settlement	1960, 1992	Land consolidation
10	North Korea	Five lines of nature remodelling, nature remaking policy and agricultural law	1976, then late 1990s	Land realignment
11	Canada (some provinces)	Local Government Act (Chapter 323)	1983–7, later update	Replotting schemes
12	Colombia	Urban Reform Law, Territorial Development Law	1989, 1997	Reajuste de tierras
13	Nepal	Land Acquisition Act, Town Development Act	1976, 1988	Land plotting
14	Thailand	Land Readjustment Act BE 2547	2005	Experience with land sharing before land readjustment

Although the notion and culture of participation and collaboration amongst citizens and government has been the main guidance for moving forward in LR projects, the commitment of the government alongside the people in reducing the impact of the consequences of earthquakes and improving the quality of urban resilience has been the prime approach in all examples. Many countries such as Thailand, China and Colombia have recently joined the list and translated this law to be used in their context (Table 4.3).

However, uncertainty remains around this model's "application purpose", the "consensus achievement process", the "legal strengthening" and "financial valuation" (*ibid*:1). What this research is concerned with is the wide and successful implementation of LR in Germany and Japan to regulate unorganised urban development structures which could cause problems in emergency evacuation and service provision after a disaster. Each landowner in the project area contributes part of their land to the public services (Sorensen, 2000:52), and in this way, everybody can benefit from such services in the event of a hazard. Land readjustment is, indeed, a powerful tool in the hands of the government (local and central) to rebuild the city and its neighbourhoods as part of a post-earthquake sustainable reconstruction plan. The next section is dedicated to a brief review of the characteristics of a reconstruction plan, using a few examples.

4.6 Reconstruction Plans and Open Space

In a reconstruction plan model, there are always some criteria which target hazard mitigation tools: the redevelopment of urban areas, the strengthening of infrastructure, evacuation pattern and routes. However, economic, cultural and environmental consequences put restrictions on building construction and standards (Opricovic, 2002). The criteria of each reconstruction plan, derived from local and national legal systems, targets public safety in many ways. The main approach used in this plan is the "reassessment of natural hazards" and the modelling of the "geographical distribution of industry, residential buildings and land development" (*ibid*:211). Open spaces are considered to be the principal location of "safe and serviceable operations alongside the other necessary supply line factors such as gas, electricity, transportation and communication networks" (*ibid*). It has been emphasised by many scholars[20] that the level of achievement of reconstruction largely depends on the performance of local

[20] See Hein (2002); RMS (Risk Management Solutions) (2005); Emergency Operation Board, (1994), Ying, (2009).

agencies, citizens, national government and other voluntary groups in action before, during and immediately after the recovery period, which requires the correct measure of compromise within their policies and practices.

In the recent reconstruction plan of the Great Wenchuan Earthquake in May 2008, Chinese authorities had special focus on involving the public and a number of local authorities during the decision-making process, as 28,000 km² of land and built-up area was affected and destroyed (Ying, 2009:27, 29). One aspect of the Chinese reconstruction plan was/is migrating people from the most devastated regions, especially in rural areas where there are no economic means and lack of “state of the art technological services” (Donner and Rodriguez, 2008:8). Figure 4.9 summarises the overall restoration and reconstruction planning system of China after 2008. The figure indicates land-use plans, with special interest on LR policies, consisting of networking, open spaces and connectivity-related decisions.

In the US, the government’s planning policy is slightly different from what many southern countries are hoping to achieve. The city of Los Angeles, for instance, has targeted disaster preparedness plans by launching an innovative pre- and post-disaster planning approach. After the devastating earthquake of 1971 in San Fernando, California, the government of Los Angeles adopted a “pre-earthquake planning for post-earthquake rebuilding (PEPPER) study” which targeted “the structural and non-structural mitigation projects and programmes and … assessment of various economic recovery” (Emergency Operators Board, 1994:1, 3). The revised draft of the Recovery and Reconstruction Plan of 1994 still follows past policies and recommendations in five categories, as follows:

1) Organisation and authority;
2) Residential, commercial and industrial rehabilitation;
3) Public-sector service;
4) Economic recovery;
5) Land use/reuse.

(*ibid*:4)

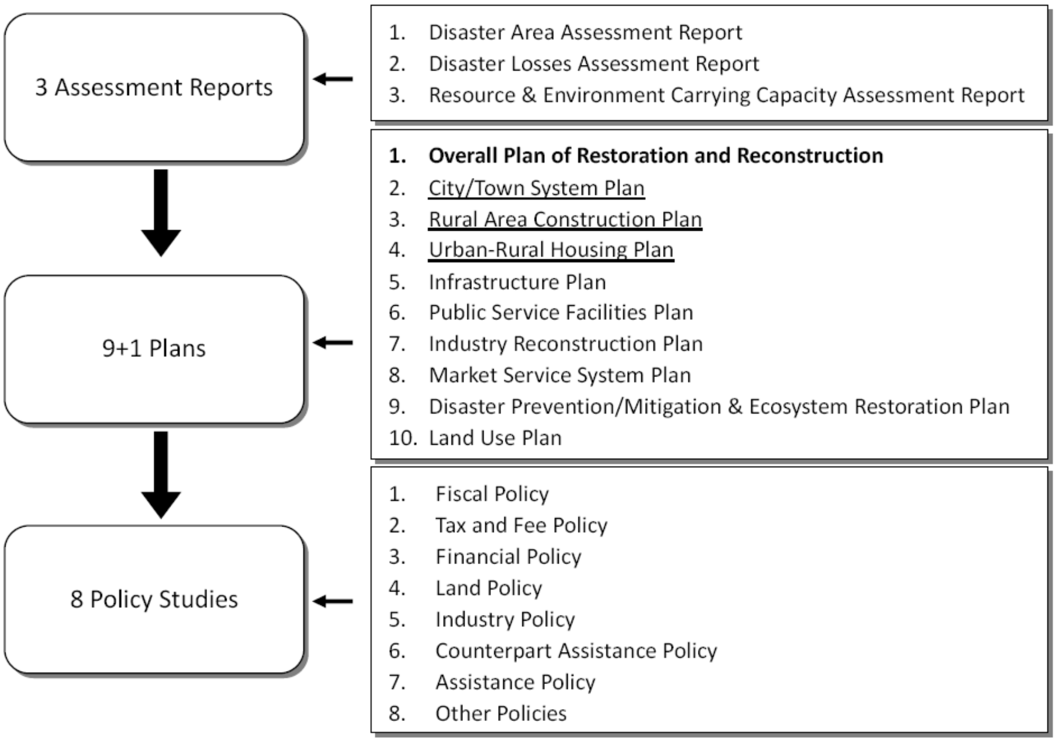


Figure 4.9: The overall restoration and reconstruction planning system in China (Ge, 2010:12)

Equipping possible shelter sites such as open spaces, schools, etc. is part of a larger pre-event context, whilst their normal use is not compromised (*ibid*). Florida's pre- and post-disaster redevelopment plans are similar to California's, in addressing the community and government as the main actors, establishing models for future recovery and emergency operations ordinance and many others (Johnson and Olshansky, 2007).

Despite the dissimilarity of the American and Japanese approaches in categorising open space functions and management in their planning documents and policies, there is consensus on the requisite of improvement of the quality and quantity of open spaces and the nature of their connections with other urban areas (Hein, 2002). The final part of this chapter outlines the main lessons learned by rebuilding policies, and actions for the future use of the research.

4.7 Lessons from Disaster Planning

The extent of damage caused by earthquakes is the driving force of reconstruction, with lesson-learning policies of many governments to mitigate the losses and costs of recovery in every aspect. For those countries with a more organised and advanced planning system, this lesson-drawing process is as crucial as initial investment, whilst also helping the government and citizens prevent possible mistakes and build up their knowledge of a reliable context. The simple figure below presented by JICA (2008) depicts how the Kobe city reconstruction plan was reviewed and its progress examined in various workshops consisting of local and central governments, various agencies, residents and voluntary groups. The reviews were obviously for improvement purposes, followed by the previous general aims which were:

- Reconstructive land readjustment projects (5 districts, 143.2 ha),
- Reconstructive urban renewal projects (2 districts, 26.96 ha),
- New eastern city centre (120 ha) (*ibid*).

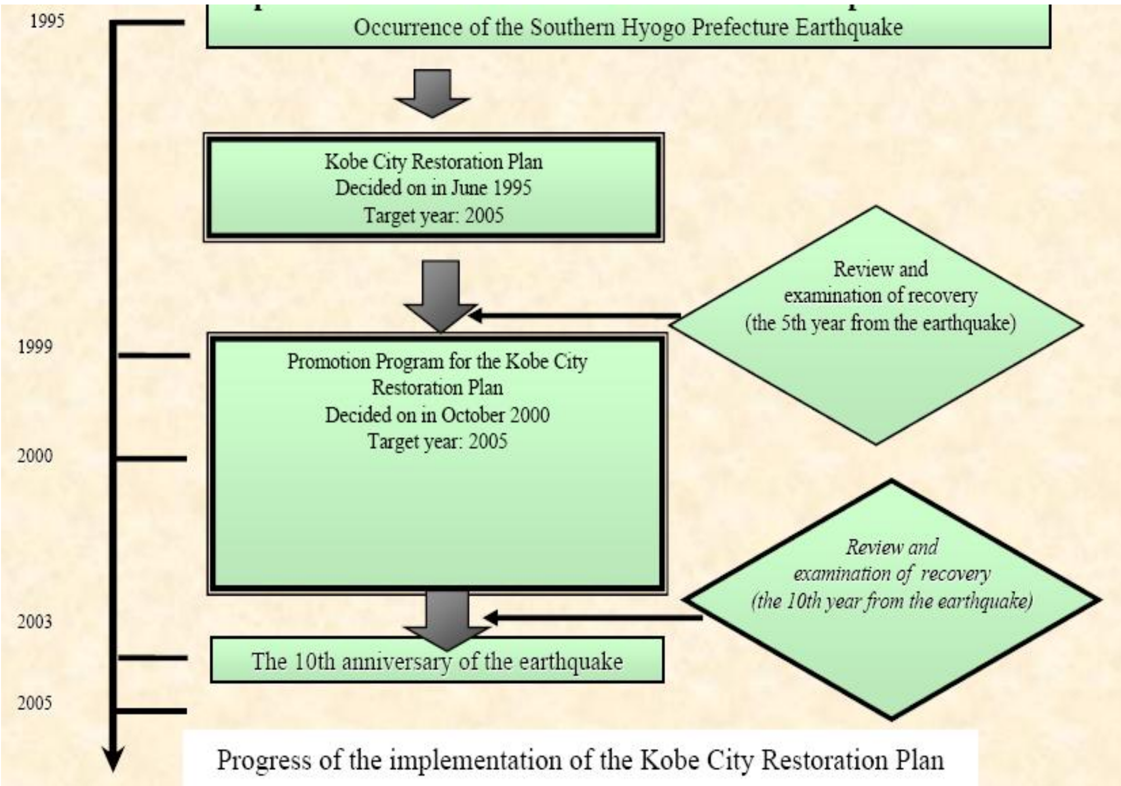


Figure 4.10: Progress of the implementation of the Kobe city restoration plan (JICA, 2008:31)

In another study conducted by Risk Management Solutions in 2005, it was pointed out that:

- There is demand for further research programmes related to "earthquake engineering, seismology and disaster management";
- The complex nature of the urban environment requires a multi-criteria approach targeting "transportation, communication and infrastructure system";
- The Japanese 1981 building code should be reviewed, although the "ductile reinforced concrete structure" should be encouraged;
- "Seismic evaluation and retrofits" for public buildings' safety improvement are required;
- "Moving from safety-based design guidelines" to "performance-based design";
- A completed and enriched active fault map is needed for the region.

(Risk Management Solutions, 2005:10–12)

It is hard to get access to the more open space-related documents as it is seen as part of the land readjustment process in a secondary grouping system; however, Olshansky et al.'s (2006) article is a unique discussion on drawing lessons from Los Angeles and the Kobe reconstruction plans, based on the data collected from the January 1994 Los Angeles earthquake recovery process and the January 1995 Kobe rebuilding planning activities. They put the post-disaster recovery efforts into three main overlapping categories of "process and timing, physical conditions and finance" (p.359). It might still be too general simply to include a wide variety of decisions and actions in these categories; however, their subcategories are inclusive enough for discussion in this chapter.

4.7.1 Process and Timing Lessons

1) "*Planners can take advantage of the disaster, in order to further pre-disaster goals*" (*ibid*:369): they can be a loud wake-up call for the government at a higher level to diagnose the problems and to start to cure them.
2) "*The cases confirm the delicate nature of the trade off between speed and deliberation*" (*ibid*:369): the government agencies have to act fast, and act according to

the local needs. Having this in mind, an underdeveloped plan expanded in a glaze of time, can be quite dangerous and invalid in the long term.

3) "*Citizens' involvement is vital, especially in the face of significant reconstruction of land-use change*" (*ibid*:369): involving residents can create a valuable context for temporary or permanent shelter, business recovery and services.

4) "*To work most effectively after disaster, community organisations should already be in place and have working relationships with the city*" (*ibid*:369): in reality, this is very difficult, but if developed it can stabilise the recovery process in financial terms and possible oppositional movements.

5) "*Governments can improve the effectiveness of neighbourhood planning circumstances and in the event of post-disaster*" (*ibid*:370): this can facilitate a better mutual relationship between people on the ground and the government at every level.

6) "*Condominiums and other co-operative or joint housing schemes will pose challenges to governments in future disasters*" (*ibid*:370): cooperative ownership should be equally noted and their problem should be solved whether by involving a neutral group or legal support.

4.7.2 Physical Planning Lessons

1) "*It is better to repair buildings than to re-build them*" (*ibid*:370): it is understood from the past that repairing partly-damaged buildings has many advantages such as preserving the neighbourhood fabric, costing less, being more convenient and retaining historical accuracy, as well as being quicker.

2) "*Disaster can lead to physical betterment of neighbourhoods*" (*ibid*:370): rebuilding may require major intervention in the urban context but helps to improve the environmental quality of the area, injection of open spaces and wider roads to the neighbourhoods, and increasing the safety of buildings and streets.

3) "*Betterment comes at a price, however, as reconstructed properties in damaged areas often cost more than before*" (*ibid*:370): it can change the residents' social status by enhancing the quality of buildings and the built environment.

4) "*Providing temporary and permanent housing following a catastrophic disaster is a major challenge*" (*ibid*:371): this is short-term and does not have a strong study

background. Temporary and permanent accommodation can cost local agencies a lot. It is harder to manage within a densely-populated area.

4.7.3 Financial Lessons

1) “*Local flexibility is important, in order to provide finance mechanisms appropriate to the situation*” (*ibid*:371): like other urban development projects, the reconstruction process can not follow a rigid rule as the condition, time and unexpected situations would require a flexible and adaptable decision and action.
2) “*Insurance is the fastest and most equitable means of financing reconstruction*” (*ibid*:371): the role of the government in informing and encouraging people to insure their properties is a worthy tool in the hands of owners to recover from the loss fast.
3) “*Public funding though neither as fast nor as equitable as insurance, can more readily promote community betterment*” (*ibid*:372): this is a common and inevitable source of reconstruction process that is used for rebuilding homes, roads and urban improvements.
4) “*Redevelopment is a useful funding concept following disasters but … ambitious redevelopment plans diverted resources away from other needs*” (*ibid*:372): there should not be an inappropriate amount of focus on single projects as it would be an unfair way of dealing with problems.
5) “*For redevelopment, it is necessary to have different procedures during disaster times and these must be established ahead of time*” (*ibid*:372): public consultation would diversify and direct the redevelopment strategies, whilst the government should value the financial redevelopment policy before disaster.
6) “*Condominium owners need technical and financial assistance following an earthquake”* (*ibid*:373): the situation for this group of owners should be paid attention to and regarded as a priority for advice and help.
7) “*The earthquakes produced both winners and losers*” (*ibid*:373): those who could not obtain the equivalent of their lost assets and businesses are the “losers”, whilst, in contrast, many owners of newly built-up buildings or reconstruction companies are among the “winners”.

Although economic and social scares following an earthquake cannot be avoided, they can be mitigated. Open spaces are part of the rescue and recovery process of every neighbourhood; they can save lives, which are priceless, and reduce building damage and fire damage, which is valuable.

4.8 Conclusion

This chapter started by looking at various definitions of open spaces within the city context and undertook a broader study into the field of disaster planning and management. It has achieved the aims of the study by looking at various possible uses of open spaces and how they can be adapted to meet earthquake-related requirements. However, the general lessons drawn from the reconstruction experiences of Japan and America showed how a multi-disciplinary approach can be employed for and by every part of the city management team to fulfil the main goal, which is to recover from a devastating event. The next chapter will illustrate the methods used for the review and the analysis of the case study: Tehran’s development and disaster management plan.

Chapter One................................ **Introduction**

Chapter Two............................. **Conceptual Framework**

Chapter Three......... **Evaluation of Damage and Risk due to Earthquakes**

Chapter Four.................... **Open Space and Diversity of Services**

Chapter Five............................ Research Methodology

Chapter Six.... **Identifying the Spatial and Geographical Structure of Tehran**

Chapter Seven. **Use of Urban Risk Assessment Tool for Main Planning Resources**

Chapter Eight.. **Evaluation of Risk in the Study Area**

Chapter Nine.. **Open Space Design Criteria for Refuge Areas**

Chapter Ten...................... **Conclusions and Recommendations**

5.1 Introduction

This thesis is divided into two main parts: a literature review, which has enriched the general background information for the set of data that was gathered for the case study; and a case study, which describes, assesses and analyses the elements of urban design, disaster planning and open spaces, highlighted in the literature review. Although the gathered and analysed literature review creates the base for further discussion in Chapters 6–9, this research methodology focuses on data collection and field study analysis methods. It is worth mentioning that the structural characteristic and the context of discussions in this study is designed to target the research problem and questions, getting assistance from the research aims and objectives.

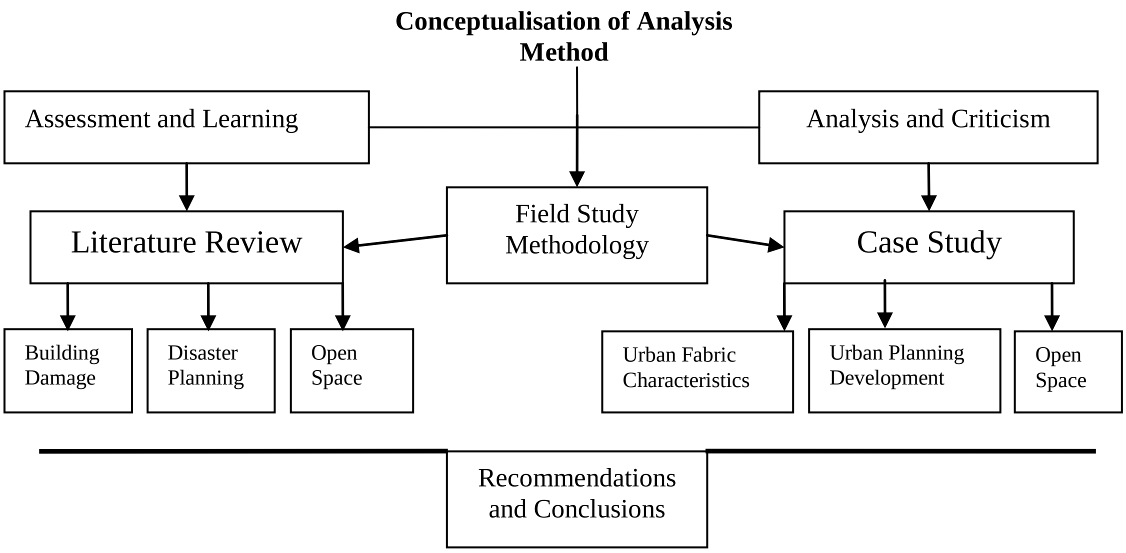


Figure 5.1: Research methodology chart

Having to answer the research questions by conceptualising the assessment tools has produced a logical and reliable method to target certain points within the pool of information and discussions in the field of the Tehran/District 17 urban planning system. Also, the clarity of research objectives has facilitated the selection of a decent research strategy which is based on both a qualitative and quantitative approach. Utilising a combined[21] methodological approach is necessary for the nature of data required to be collected and analysed in the case study section. The unique

[21] "Combined" in terms of methods used during the field study. A variety of methods, such as interview, local documents review, observation, questionnaire etc. were implemented.

characteristics of the study has positioned the literature review after the conceptual framework of the research (Figure 5.1). In this way, there is a clear method to browse the relevant literature and select the items that can guide the researcher to analyse the case study for vulnerability and capacity.

As explained in the first chapter, Tehran is the prime target of this research study, where, unlike many Iranian cities, there is a more organised urban planning and management system. This chapter starts with an overview of research aims and approaches, followed by the general features of the research design, the context of the thesis chapters, case study selection, and the data collection and analysis methods.

5.2 The Research Problem and the Relationship with the Aims

In order to develop an adequate assessment tool, the research focused on:

- The research objectives;
- Sub-questions raised from the literature;
- The extent of the practicality of similar solutions;
- The contextual characteristics of the area spatially, physically, socially, etc.

The aim of this research is to *minimise the effects of an earthquake by providing a network of safe urban open spaces*, which are manifest in the existing urban fabric and can be developed and redesigned accordingly. In fact, this is in response to the problem that exists within *the quality of the urban built environment of Tehran in terms of safety, structure, quality and accessibility*. Therefore, the general research objectives are set around three series of discussions, in light of the literature review chapters (3–4) and the field study (6–9). The following are the developed objectives:

- Knowledge expansion and building the foundations;
- The practicality of the plan;
- Future adaptive response.

The following figure illustrates a clearer picture of the series of questions, and the area of study to fulfil them.

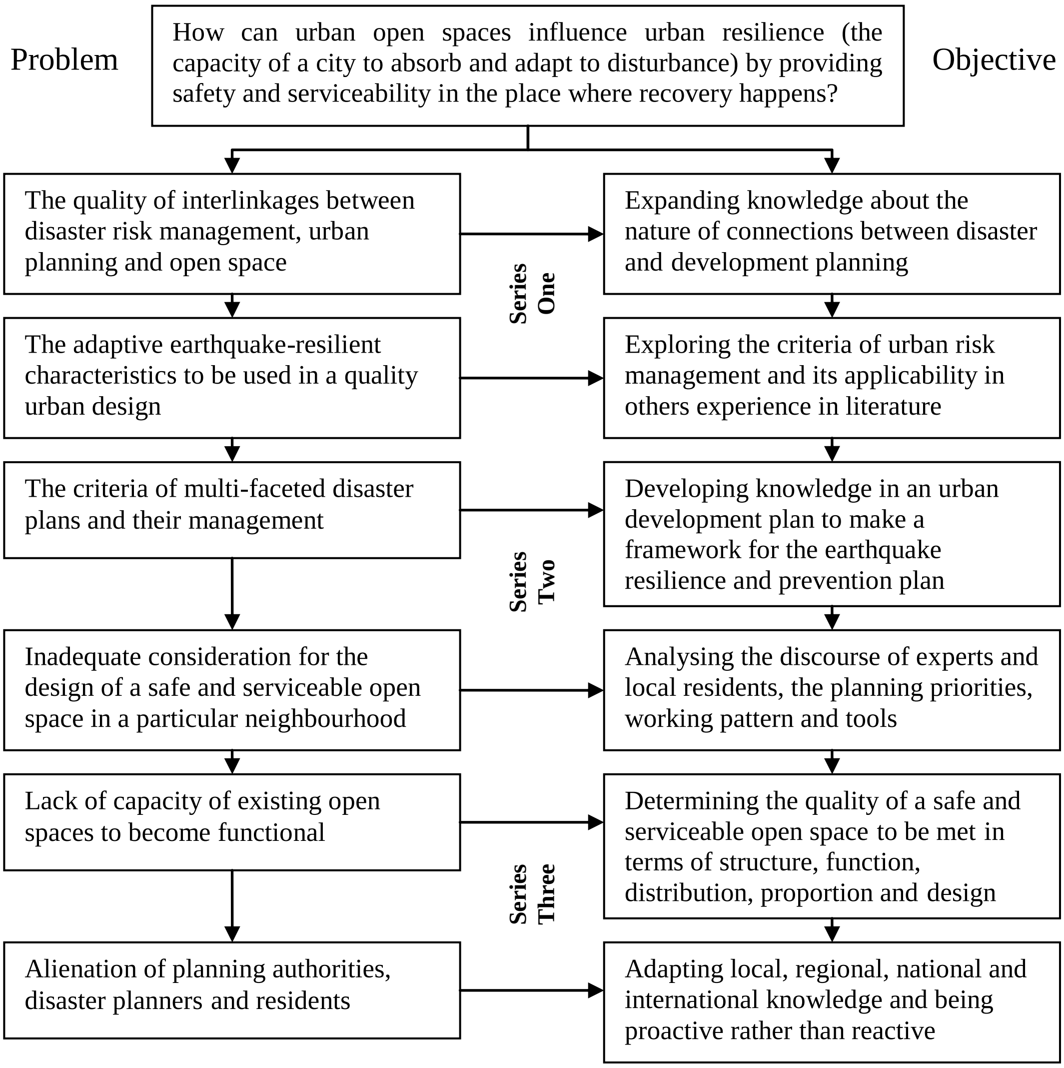


Figure 5.2: The relationship between research problems and objectives

5.3 A Combined Methodological Approach

Having a wide range of issues on shaping a safe open space in mind, the research focuses on how urban planning (development and disaster), in a vulnerable situation for buildings, can promote the quality of open spaces in the Iranian context of Tehran, in the densely-populated and highly-at-risk area of the Khazaneh neighbourhood. It concerns the planning tools, which are in the hands of the local government, the localities' experiences, and people's living experiences. Furthermore, the research studies the capacity of public buildings (Chapter 8) and residential building structures (Chapter 9). Therefore, exploring these two features can be achieved through both a qualitative and quantitative methodological approach.

The diverse nature of the data required has been challenged by a variety of scientific calculation methods in Chapters 3 and 4. This is carried out in Chapters 7, 8 and 9. The analytical base has been defined involving both a simple mathematical calculative approach, for a naturalistic approach to the matter; and a qualitative interpretive approach, to discover the meaning of safety. This means having to use them both in collaboration, and interactive methods have created an inclusive environment for the main discussion (open space, planning, disaster management and vulnerability). In this way, with the help of previous research, direct observation and close interaction, the quality of a neighbourhood's open space could be questioned and improved. From a planning point of view, the balanced qualitative and quantitative approach should result in a realistic and useful disaster plan, and will be useful to local authorities, planning organisations and the people of the area. Such a method is the most appropriate one for this research, as it looks through the Iranian disaster and urban development planning context, which is not advanced (in being multi-sectoral, scientific or proactive).

In a complex situation, like Iran/Tehran, each section of urban management works independently, inspired and dictated by the bureaucratic system of the country. Therefore, transferring the quantitative results of numbers in designing or reorganising a qualitative urban space is the best practical tool. This also creates the opportunity for the researcher to interpret the data into design parameters, a meaningful process which has traditionally been used independently by planning authorities. Applying this knowledge into the development plan, a formal guide of Tehran's urban activities, might not be new in the single-approach planning system of Iran, however it is certainly new in:

- Using experts' opinions;
- Adapting the real experiences of others;

- Assessing local residents' knowledge;
- Importing disaster-related discussion into a master plan.

The above initiation required a dual-direction data collection approach. One, as discussed before, was having the best of both qualitative and quantitative research methods in the context of social science. The other was a wide variety of data collection methods ranging from reviewing literature, planning documents, and the reference hazard mitigation documents; interviewing key actors, asking local residents, in-site visits, and direct observation. Consolidating the approaches created a holistic approach and gave the researcher the opportunity to suggest a meaningful and integrated design insight, which retrieved the social, spatial, physical and practical elements of a neighbourhood. In other words, it is a way in which to learn from deficiency, design for safety, and increase the collaboration amongst key actors.

It is also important to mention how the nature of disaster planning, which requires the use of quantitative and qualitative research methods, has left the field of discussion and the direction of the research open. By "open" is meant having an in-depth study and assessment in a variety of subjects, such as building damage, structural vulnerability, management, the design of roads, public buildings, etc. However, in this study, the research questions took the lead and directed the discussion. It was the research questions which narrowed the field of study, and then the research objectives that specified the focus of the research. In this way, the research structure avoided confusion, and prevented the overflow of data and time wasting. Knowing the characteristics of the research method allowed me to design the foundation of a safe and serviceable open space in Chapter 10.

5.4 The Research Design

There are key rules in the development of the research design. First, the openness of the research aim in the way that data was collected. This is reflected in the variety of methods used in the literature review chapters generally, and the case study section specifically (LeCompte and Preissle, 1993) (Figure 5.3). Second is the smooth but directed change of the research focus from a broader and, in some sense, unrelated discussions in the field of planning, disaster management and urban design towards the design of safe open space (Mason, 2002) ,which shaped the structure of the research. Third is the inclusion of various points of views (interviews, questionnaires, literature and documents) to avoid being influenced or brainwashed by a single ideology or discussion (Kleining and Witt, 2001). The former, then, has strongly dominated the discussions presented in Chapters 7–9 of the thesis. The research design facilitates the flow of information assessment and analysis within the entire research. This also makes sure there is cohesion and connections between each chapter and the next, or the previous one, using research objectives in answering the research questions.

Each set of questions, in other words, creates a strategic framework for each chapter to be answered (Yin, 1994). As demonstrated in Figure 5.3, there are four sets of development frameworks in this research, derived from the aims and the approaches to meet objectives. The first set is the introduction and opening chapter. When the problem, research questions and objectives, were clearly defined, the second set of research commenced. In this section, starting with the conceptualisation of the research theory, a clear strategic framework for both the literature review and empirical chapters were introduced, which was followed by other chapters' contexts. Although the third set, exclusively the case study section, concentrated on the quality of regional and local urban disaster planning, it still utilised one of the four main concepts of the research (Chapter 2). The concluding part, which again highlights the research questions, aims and conceptual framework, is the fourth set, helping to put an end to the discussion and research findings (Figure 5.3).

5.5 The Research Strategy Development

For such a complex issue within the context of urban planning, and to some extent urban management, taking different voices into consideration is important. Undoubtedly, the research should apply an appropriate strategy which is based on both theoretical material and practical experiences. Hence, the stakeholders' fundamental information must be obtained, different voices heard and personal experiences applied in the study. The last was especially developed through the case study and fieldwork where the spatial characteristics of the neighbourhood could be felt directly. In this way, not only did the research fulfil the exploratory phase, which was about the literature and the review of the planning system, it achieved the explanatory phase target by interviewing some of the key actors in the planning and decision-making process, as well as including local residents' participation by questionnaires, whilst also viewing the area in person. Together this enhanced the accuracy and quality of the research findings and discussion.

This strategy has followed a path to include all three aspects of disaster definition and damage estimation, planning for urban development and disaster management, and open spaces and their functionality. Table 5.1 shows the thesis chapters' strategy and context. As the table indicates, each chapter is part of a chain to make connections with other discussions in the field of urban planning: first, to clarify some debates around the subject; second, to evaluate its validity; and, third, to assess the possible connection between that particular subject and others with which it may have connections.

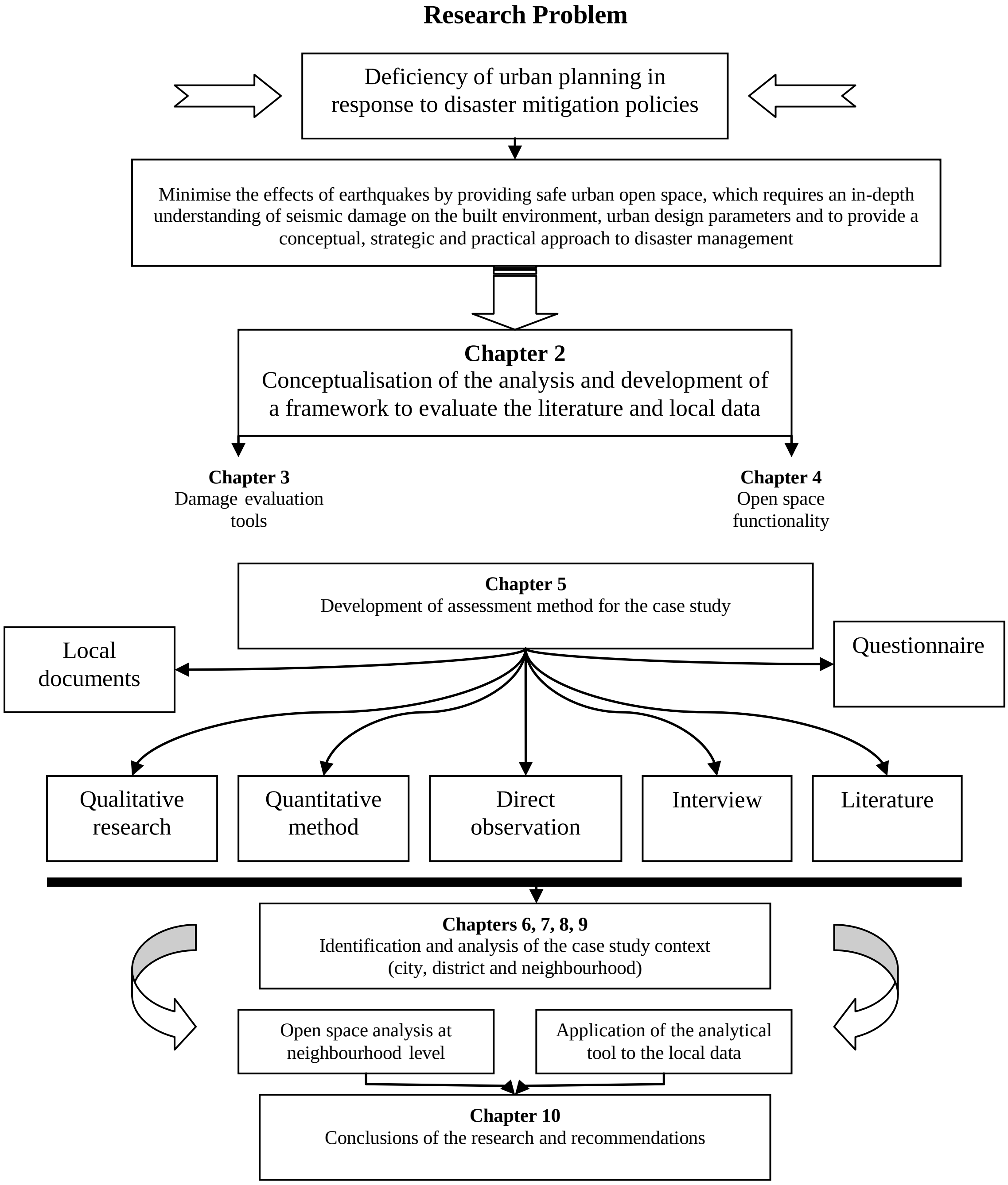


Figure 5.3: Research design diagram

Table 5.1: The relationship between chapter subject, methodology and research procedure

Chapters	**Methodological theme**	**Main subjects and analysis**	**Main sources of evidence & techniques**	**Main focus**
Chapter 1	Introduction of the research scope	Presenting the research aims, objectives and questions	Review of literature, personal experience	The development of the research concept, directing the research
Chapter 2	Conceptualisation of the research structure	Identifying the relationship between components of the subject and its assessment tools	Literature, documents, personal understanding	Risk, hazard and vulnerability components, assessment tool and conceptual framework
Chapter 3	Evaluation of existing risk estimation tools and disaster plans	Estimating building damage, reviewing the methods of vulnerability assessment and assessing various aspects of disaster mitigation plans	Literature, documents, personal experience	Reliable risk assessment tools, disaster profile. The feasibility and connections within disaster planning
Chapter 4	Descriptive and analytical approach to open space use and diversity	Reviewing and assessing open space in urban context from functional to environmental uses	Literature, documents, internet	The use of open space in urban context and adaptive design
Chapter 5	Justification of use of a combined method in the research	The quality and practicality of using research methods for the subject of this thesis	Literature, personal ideas, practical experience	The use and validity of certain collection and analytical research methods for the subject of the thesis
Chapter 6	Description of the urban structure of Tehran	Studying how natural and man-made elements form Tehran's urban fabric	Local documents, personal experience	The influence of roads, water and other natural features in shaping Tehran's development
Chapter 7	Identification and assessment of the vulnerability and capacity of case study area	Using VCA as an assessment tool to analyse Tehran and pilot study area potentials and structure	Local documents, interviews, questionnaire, personal experience	The extent of Tehran's vulnerability and capacity and case study area for disaster
Chapter 8	Evaluation and analysis of risk and damage in the study area	Buildings and social vulnerability of the context	Local documents, interviews, questionnaire, personal experience	Assessing the extent of possible damage to the selected area physically and socially
Chapter 9	Analysis and design of safe and serviceable open space in the study area	Review and analysis of four open spaces in various aspects of safety, accessibility and capacity	Personal knowledge, interviews, questionnaire	Creating a safe and serviceable open space for the most vulnerable urban area in the study area
Chapter 10	Analysis and conclusion of the discussion over vulnerability criteria	Drawing lessons from analysis and design for future use	Personal experience, previous chapters	Learning from the discussion and creating links between urban planning components

In doing so, the research chose common but fundamental features in the field of disaster planning, having reviewed the present structure of land-use planning, disaster planning, vulnerability assessment practices and the inclusiveness of open spaces;

whilst, in the second part, it evaluates and analyses each of the above items in the context of Tehran, District 17 and the Khazaneh neighbourhood. In this way, the potential and shortcomings of each element in a real case is studied, which has led to the drawing of some lessons for future reference.

The awareness raised from the literature review created a clear strategy for the case study section to be focused on certain subjects and in the carrying out of the analysis.

5.6 Case Study Selection and Design

Selection of the case study was, in fact, influenced by previous neglect and problems identified by myself and other parties. In this case, it was derived from the ever-increasing concerns raised by scholars, especially after the 2003 Bam earthquake that created a sense of vulnerability amongst the people in Tehran. There have been scattered attempts to deal with the problem in theory by some organisations producing study papers, as mentioned before. However, this research has specifically found the deficiencies in creating connections between theory and practice amongst components of urban planning in Tehran. This became the case study area of this research, to examine and analyse the present structure and propose a new design paradigm.

The initial steps taken by the Tehran municipality and other local organisations towards a wider disaster mitigation policy and practice are essential; however, they are relatively small advances. The case study has been chosen based on the above attempts, and the lack of comprehensiveness and inclusiveness appears only to make the plans part of the municipality archive. Although there might be a wide range of choices for the study, considering certain aspects of the research process may reduce the number of choices. As a person who lived in Tehran for years and worked closely with the municipality in various projects, I found District 17 a good place for the research case study as:

- First, it was the place that I lived in for many years and I am therefore familiar with its urban fabric;

- Second, it has been highlighted to be one of the most vulnerable areas due to its quality of buildings, population density and narrow roads and alleyways.

Besides, having to interview government agencies required a familiar face who knew the area. Working and living in the area was an advantage for me to have a more friendly relationship with local government officers to collect data, which supported the choice of District 17 to be the selected case study. The other advantage of choosing District 17 as the main case study area was having easy access to local resources, which facilitated the acquisition of comprehensive background information to the diversification and accuracy of the research. In terms of questionnaires and interviews with local stakeholders, again, I was quite comfortable to communicate with people as I knew their culture and likes and dislikes. These all influenced the design components of the case study in terms of its procedure, structure and analysis. The impact of the research questions and assessment tools is also important in formulating the discussion, especially in Chapters 7, 8 and 9. These included four major discussions for hazard mitigation planning, whilst having open space as the pivotal point, derived from vulnerability and capacity assessment criteria:

1) The evaluation of demographic, spatial and natural components of the area;
2) The physical assessment of damage to the buildings, infrastructure and local urban life from documents and residents' points of view, from city to neighbourhood level;
3) The analytical review of the local planning resources and residents' knowledge about the subject of disaster;
4) The critical but constructive approach towards design of open space at neighbourhood scale.

Each section contained one or more conceptual framework concepts, which shaped the thesis discussion and strategy from the beginning, and was followed in every chapter. The independence of each chapter's discussion did not compromise the cohesion and consistency of the thesis, as each was built on the knowledge and discussion gained from the previous section, and each became the foundation for the next chapter.

5.7 Methods for the Case Study Research

The case study is not only a data collection chapter conducted by myself, but consists of a discussion around why and how decisions are taken or implemented (Yin, 1994). This was the case in the research as the examination and assessment of the literature review chapters, in the field of land-use planning, hazard mitigation documentation, damage estimation techniques and open space design, became a familiar route for the case study chapters. The evaluation of risk to determine the vulnerability and capacity of a selected urban context was followed by a critical analysis of the planning documents in the district and neighbourhood. This background study and analysis was necessary for the analysis of quality, capacity, connectivity and covering area of open spaces in the Khazaneh neighbourhood.[22] Despite the long history of earthquake devastation in Iran, there is hardly any catalogued research or study in this regard. Thus, the literature review created the opportunity for the study to learn how to analyse the case study data. The literature review also relatively directed the most appropriate evaluation technique. Consequently, the case study was identified, assessed and analysed according to social, physical and spatial criteria using the most relevant but internationally proven assessment tool. Figure 5.4 summarises the case study chart.

There is only one case study in this research. The process of data collection was based on the research questions and concepts. They are based on three main methods; interviewing, observation and sampling (Yin, 1994). Interviews were conducted with officials and those who have input into decision-making and planning for the area. This includes the management system, municipality officers and disaster management organisation team members.

Iranian urban planning is conducted and prepared by the Ministry of Housing and Urban Development (MHUD), municipalities, private consultants and some less effective organisations. In terms of emergency management and planning, the main organisations involved are the municipality, the provincial governor, the Red Crescent and some voluntary organisations. The role of planning and research in this area is

[22] Amongst all the 11 neighbourhoods of District 17, Khazaneh neighbourhood is located in an especially strategic location. It consists of a high-density residential area with a few typical green spaces, and is suitable for further analytical discussion in the case study chapters.

distributed amongst a variety of organisations which are not particularly involved in emergency action. This group consists of the Seismic Centre of Iran, the Housing and Urban Development Organisation Research Centre, the Statistical Centre of Iran and the municipalities (Greater Tehran and District 17). Therefore, I included at least one interviewee from each main category in my fieldwork. Table 5.3 is a list of officials who were interviewed.

The other set of interviews, in the form of questionnaires, were conducted by me in the neighbourhood with the people who live there, use the place, and are in touch with public buildings management every day. I intentionally interviewed an equal number of men and women. I tried to include all age groups representing the wider society. Also, I included people who were employed, self-employed, homeowners and tenants, local residents and visitors. Table 5.2 has more details in this regard. In this way, real public opinion and knowledge was collected. The focus of the questions, as well as the interviews, was around the four concepts of the research as follows:

- *Integrated disaster risk management*: focusing on policy documents and approaches to land-use planning and disaster mitigation planning, and evaluating them. This was supported by the interviews;
- *Open space and its usefulness for disaster management*: identifying the notion of the use of open space in the literature and in people's opinion via the answers to the questionnaires;
- *Learning from earthquake and building improvements*: evaluating building damage and vulnerability assessments though a variety of sources, including interviews, engaging with people and direct observation;
- *Open space design criteria*: a multi-disciplinary approach generating ideas for creating safe and serviceable open space, based on the literature, interviews and direct observation:

  Phase 1: exploratory: a) reviewing safe open space literature;
  b) reviewing the planning documents;

  Phase 2: observation: observing every relevant subject in the site, roads, buildings, capacity and connection of open spaces;

  Phase 3: interviewing: a) local people;

b) planning officers and staff.

The purpose of using a variety of methods in the case study is to generate more data, for greater accuracy, reliability and validity of the research.

5.8 Direct Observation of Neighbourhood Open Spaces in the Selected Area

Direct observation in the planning process is a longstanding tradition which helps planners to see the result of a design concept, evaluate the impact of the changes, assess the requirements, and record user behaviour. In this research, and due to the importance of studying the spatial characteristics of the selected case study area, and studying the local people's pattern of use of space, direct observation played an important role in the assessment and justification of recommendations in Chapters 9 and 10. This visual observation of certain public spaces and the urban built environment became an important part of the research in inspiring the ideas and comparing the written documents with the reality of neighbourhood life. They helped the research to critically analyse the quality of open spaces in the study area against the VCA criteria. In Chapter 9 specifically, the direct observation (photos and other documents) helped the assessment of each selected open spaces, their capacity, distance and serviceability for emergency situations. Assessment also became deeper when the open spaces were examined in terms of their locations and interaction with the surrounding built environment.

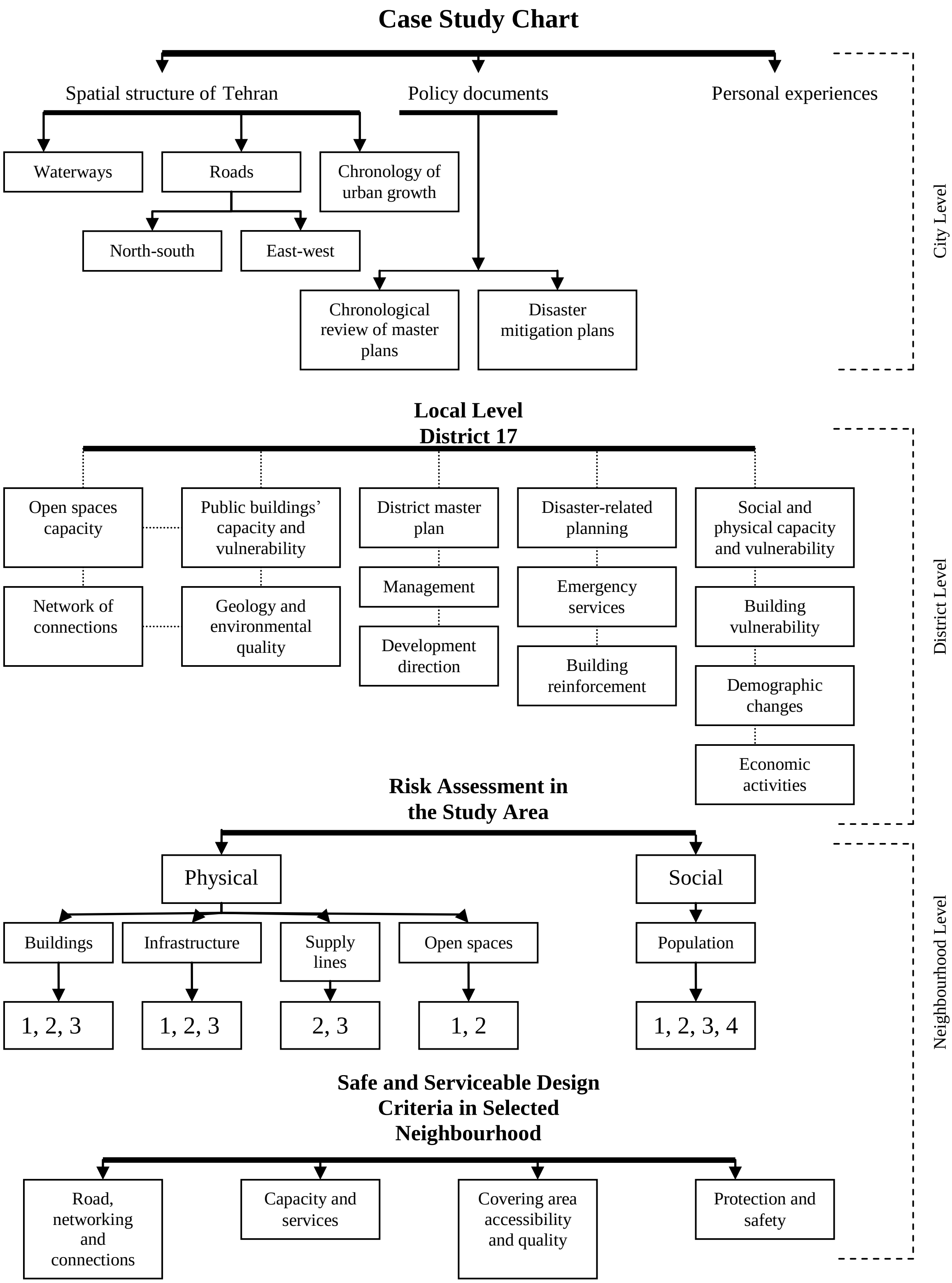


Figure 5.4: Case study chart

Key: 1: Direct observation, 2: Documents, 3: Interviews, 4: Questionnaire

5.9 Public Awareness Assessment: A Residents' Survey

The design of a safe and serviceable open space is for the benefit of the people who live and work locally in the study area. This certainly requires evaluation of their capacity and awareness about disaster, its planning and operation. Thus, the researcher carried out inclusive interviews in terms of diversity, sex, age, social group and exclusively in terms of the type of questions to help the research context. Each will be discussed later in this chapter. The survey further enhanced appreciation of the observation method, which is valuable in its nature. It examines local knowledge in the field of open space and disaster planning, which is a relatively new subject in the field of planning. The questionnaire also gathered information about the locality's demographic situation, which can have an impact on the size and location of safe open spaces.

Tools to address these types of questions were derived from the VCA assessment criteria, which include both physical and social vulnerability and capacity assessment. My personal experience and understanding also played a role in raising some of the questions. From a technical point of view, giving multiple choice answers to the participants speeds up the answering process, whilst also making further discussion and analysis of the results easier. This method may limit the openness of the research to the variety of possible opinions, if one wants to give more chance of expression to participants, but on the other hand, it targets the main purpose of the research precisely and quickly. Residents' opinions on the subject of this research might not be of the most influential power in shaping open spaces as this requires planning authorities' collaboration and a wider range of action at local, regional and city level; however, local residents' training and participation is important in the quality of accessibility, increasing safety, fast reactions and saving lives in the event of a disaster. In order to fill the gap between local people's perception and direct observation by myself, the third form of case study strategy focused on interviewing some of the key actors and decision-makers in this field.

5.10 Case Study Selection

In this research, Tehran became the larger context consisting of many study area choices. Tehran, a city with a high earthquake risk potential and accommodating over ten million people (SCI, 2010), has been subject to some reports and studies, criticising its spatial structure and service distribution (Bertaud, 2003), but also has the ability to put things right due to its financial capability and stronger research background. The above points made Tehran the best choice for the case study, compared to other cities. After the choice of Tehran as the case study city, the selection of the best pilot study area was carried out. At this stage, there were other criteria that influenced the selection process:

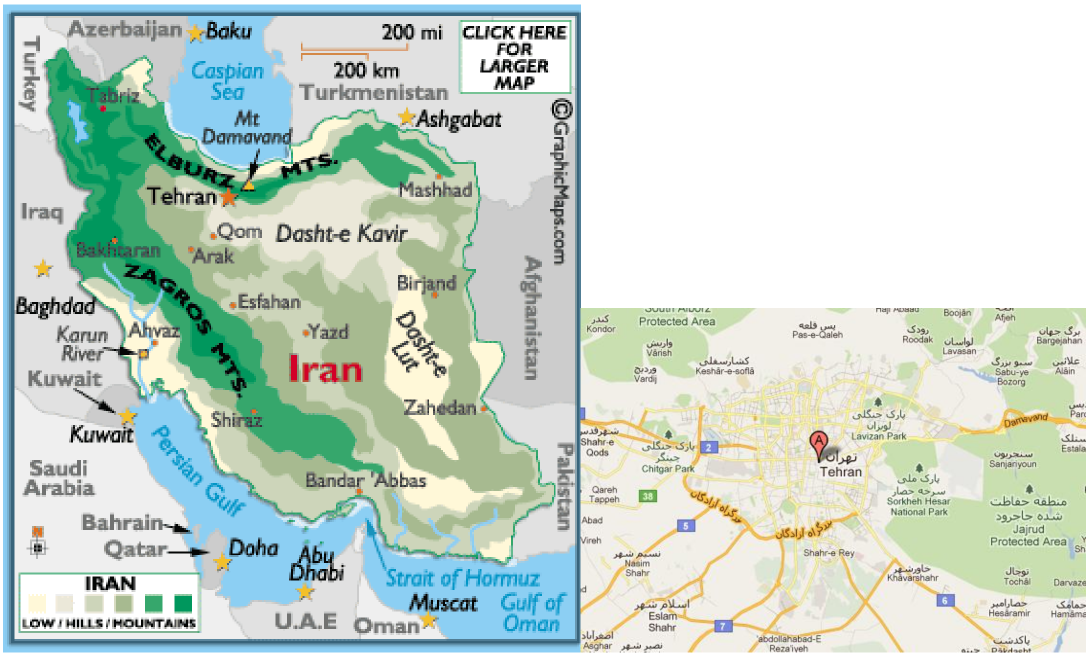


Figure 5.5: Tehran and its surrounding settlements[23]

- There were some areas that were more vulnerable to disaster than others, due to the quality of their urban fabric, their population density, spatial distribution of services, connectivity and many other factors. District 17 was amongst the most vulnerable areas, as the analysis of Chapter 8 reveals.
- Familiarity with the context of the study area is an advantage for the researcher, which was the case in this research. It not only prevented time-consuming

[23] Taken from **www.worldatlas.com** and **www.maps.google.co.uk**.

familiarisation with the spatial characteristics of the area, but allowed the opportunity to discover the study targets easily.

- From a social and behavioural point of view, there are some parts of the city where the making of connections with public and government agencies is easier, due to their cultural and social connections. People in this part of the city, unlike the northern districts, are more open in communicating with others, perhaps even with strangers. Hence, this created a better and more familiar working environment, especially during the direct observation and piloting processes of the research.
- The above, coupled with my previous experience of living in the neighbourhood for a few years, gave me more confidence to carry out the pilot study. The Khazaneh neighbourhood was a good option, having both advantages and disadvantages of the district in terms of moderate building damage, a number of small parks, a few public buildings, and a mixture of narrow and wider roads.

It is in fact a typical southern area of Tehran; promoting its open space quality could be a good example for designing safe open space in other parts of the city.

5.11 Sources of Information

The validity of the research depends on the diversity of sources and the method of using and analysing them. In a simple statement, Mason (1996) stated that the validity of research can be achieved by:

- Going through a process of exploring different parts of a process, or phenomenon;
- Answering different research questions with different methods and sources;
- Answering the same research questions but in different ways and from different angles;
- Analysing something in greater or lesser depth or breath and using different methods accordingly;
- Seeking to confirm one source and method with another.

Mason (1996:52)

Therefore, in this research, various methods were used to generate accurate data and analysis. The data was collected from relevant literature, in the hope of fulfilling research questions and in line with research objectives; it was also collected based upon VCA criteria in order to facilitate a directed and accomplished analysis. The reviewed literature consisted of the local documents which were exclusively prepared for the city and case study area, local urban planning publications and websites, and, most importantly, through personal visits and interviews. The data is therefore specific to the locality, and needed some adaptations if it was to be used for other areas. It focused on the research subject, disaster planning, land-use planning, open spaces and the social character of the neighbourhood under the VCA framework.

The data covered several subjects:

- Approaches of master plans as a means of development policy and practice in Tehran and its surrounding area;
- Damage estimation techniques, mathematical calculations and structural specifications in general, and at a city and neighbourhood level in particular;
- The structural relationship between the city and a disaster in the context of Tehran.

For each set of data various methods were used which have limitations and variations in time and gaining expected information. Each is discussed in the following paragraphs. They were then analysed in terms of their vulnerability and capacity to hazard. Vulnerability assessment was carried out by looking at:

- Building structures;
- Population density;
- Road networks and public routes;
- Land-use planning.

The capacity of the city, district and neighbourhood was evaluated by looking at:

- Capacity and accessibility of main city networks and axes;

- Widths of roads;
- Public buildings (schools, fire stations, medical centres, etc.);
- Open spaces’ and parks’ capacity;
- Planning documents;
- Disaster mitigation publications; and
- Many other factors.

Each vulnerability’s and capacity’s impact on that specific subject (e.g. building) was then compared and analysed to discover the city, district and neighbourhood risks. Chapters 6–9 each constitute part of this analysis from the city level to a very specific neighbourhood level.

5.11.1 Local Documents

One of the methods typically used for data collection is the use of published data by local organisations, including the municipality and research organisations. They are, in Tehran’s case, mostly plans with a less critical view of past development or management experience. This set of data created the basis for the main guidelines of local authorities’ development policy and practice. Presentation and classification of the data in these documents follows government guidelines, which does not necessarily fit within the structure of this research. Therefore, I only chose and organised relevant data, which was more useful for the subject of research. This clearly appears in Chapters 6 and 7 where the city’s spatial and physical specification is described and analysed. The master plan of Tehran, published by Tehran’s municipality, and JICA’s disaster preparedness plan for Tehran are the two main local documents, which many authors worked on concerning the subject of damage estimation in Iran.

In Chapter 6, the spatial characteristics of the city and the main transport arteries are identified. This was part of the capacity assessment process and how the city is situated for fast and emergency accessibility. In the second part of the chapter, the planning documents of the city, as the main guidelines for the city’s growth and management, are analysed in terms of their disaster preparedness, inclusiveness and possible encounters with risk. This is done simply through looking at their contexts and recommendations for urban development activities.

Chapter 7 analyses both vulnerability and capacity of case study in detail by looking at the data, fieldwork and local documents. The VCA criteria were the main approach to assess the extent of the damage to the physical and social structure of the city.

Chapter 8 looks at building damage exclusively, and shows how vulnerable the study area is to earthquake damage. In Chapter 9, the quality and accessibility of selected open spaces are analysed to see how functional they can be in an emergency situation. Vulnerability was the basis for damage estimation during the course of analysis. The most vulnerable area was identified in terms of its physical and social risks which assisted in evaluating existing capacity and shortcomings in an emergency situation. The criteria for the elements evaluated were chosen from the VCA model, and were selected based on available data from the literature and local documents, including development plans, and interviews.

5.11.2 Interviewing of the Public Sector

Having reviewed local documents, interviewing local authority officers was the next step, which required spending an extensive portion of time in arranging appointments and steering the discussion in the right direction. The national and local urban or disaster management structure in Iran is specific to the country's administrative system. I am familiar with this system. Hence, selecting key actors to be interviewed was not hard, but finding the opportunities to meet them to be interviewed was difficult and extremely time-consuming. The main body in charge of dealing with emergency situations is the Provincial Natural Disaster Committee, located in the provincial governor's office under the direct order of the Home Ministry. Therefore, the first people who were interviewed were the chief executive and two officers from this committee (Table 5.3). Due to the spatial bureaucratic system which exists in Tehran, and the power of the municipality in dealing with the municipality's issues, the principal consultant of the Tehran mayor, the disaster management executive and one officer from the section within the Greater Tehran Municipality were interviewed. At district level, again there is an office within the District 17 Municipality, which has to deal with natural disasters and emergency situations, acting separately from the fire brigade. The interview with the head of this office played an important part in the research to illustrate how local-level knowledge and facilities are identified and evaluated for an emergency situation. This office was also extremely helpful in providing me with invaluable local documents and quantitative data which were used in the case study. As well as interviewing the local and city level fire brigade, the officer from Tehran’s Statistical Centre were approached to obtain the numerical data which was used in the case study. Tehran’s Seismic Centre staff (two officers from the research department), one lecturer from the University of Tehran, who runs the course in disaster management, the officer at the Tehran office of HUDO (Housing and Urban Development Organisation), and the head of the urban design section of the Boom Sazegan consultancy, who is in charge of Greater Tehran’s master plan, are amongst those who participated in interviews (Table 5.3).

Their opinions might not be of importance as regards numerical data, but they were a good resource in terms of urban planning management and obstacles in the way of possible future reorganisation of open spaces. Their positions and working experiences were two dimensions in addressing government policy, the nature of collaboration, and the background to disaster mitigation in a practical sense. Therefore, the nature of the questions designed for this group was open, and in an explanatory form (Appendix 1). This gave the officials and myself more room for discussion. The language they used was interesting for me, as from one side it was strong and optimistic in facing the challenges of designing a safe city, but on the other side, it did not have any tendency towards:

- Being organised and academically proven;
- Enhancing collaboration with other national and local actors; or
- Seeking public participation and potential.

The interviews revealed that if the design of safe open space becomes a priority one day, then, with a major shake-up within the council and disaster management system, hopes of mitigating risk and managing disaster at city level may be raised.

5.11.3 Structured Interviews with Local Residents

Table 5.4 indicates the sample of interviews for the pilot study stage. This technique, in my experience, was the most interesting one as it was flexible, accurate and low-cost. Interestingly, the result of sampling was close to the demographic survey of officials in terms of population specification (Chapter 9). The questionnaire (Appendix 2) included both simple general informative questions and more fundamental questions, such as people's personal knowledge about disasters, their surrounding facilities and environment. This method, in a sense, helped the flow of conversation. I personally preferred to sit with the participants to fill in the questionnaire rather than post them or leave them to be collected later. This gave me peace of mind in making sure that residents understood the questions, and if they had any problems I was there to clarify matters. The other advantage was that on a few occasions, I managed to gather more information than what the questionnaire aimed to achieve. The number of interviewees was 60.

Table 5.2: Breakdown of the people participating in the questionnaire

Number	**Sex (no.)**		**Age group**				**Living in the area**	**Working in the area**	**Studying in the area**
	Female	Male	0–17	18–29	30–54	55–90			
60	29	31	2	17	26	15	51	16	12

Key: F: Female; M: Male; R: Resident in the area; W: Working in the area; S: Studying in the area. Numbers represent the age of interviewee

In quoting the interviewees' opinions in the next few chapters, I used a coding system to avoid distraction and keep things simple. For example, (M.R.57) means (Male, Resident in the area, 57 years old) and (F.W.29) means (Female, Working in the area, 29 years old).

This method could give expression to various factors in the area, as it is relatively populated. The guidelines for the type of questions asked in the questionnaire were inspired by the research done by the UN in Uganda (2000) to assess the vulnerability of the area against drought. It was helpful to use the VCA tool in a situation for which the government has made plans, but has not been implemented fully. As mentioned before, the questionnaire aimed to examine the data collected via local documents and interviews. In my opinion, this was fulfilled to a large extent.

5.11.4 Observation

Site observation became the most useful tool in the assessment stage of the research. Chapter 9 uses this method exclusively for the physical analysis of open spaces and their surrounding environments. This proved how the points mentioned in studies, such as the incapability of narrow (under 6 m) roads, can cause rescue operations to break down. Scholars such as Sanoff (1991) and Whyte (1980) have also used direct observation as a means of evaluation and context analysis. This tool:

- Became essential in the recommendations section of the research (Chapters 10) by facilitating visualisation of the space;
- Compared the context of documents with the reality of the built environment in the neighbourhood;
- Improved the practicality and quality of any design suggestion.

5.12 Limitations of the Fieldwork

At the literature review stage, as was expected, finding authentic research and studies in the field of safe open space, or even disaster management and planning, was difficult. This limited the number of references to be used for this study. Even gaining access to the so-called disaster plan was difficult, as it was not in the municipality's possession. However, even the data that was prepared or held by the municipality was not easy to access. Finding parallel information to increase the accuracy of some of the data was also an obstacle. There was sometimes a difference in the amount of similar data, such as population growth or earthquake history. This can be exemplified by the data recorded for the severity of earthquakes in Tehran in the past by the officials of the Seismic Centre of Iran, Tehran Province Natural Disaster Committee and JICA. During the site visits, there were no major problems, apart from finding volunteers who fitted the criteria as participants and who were willing to spare their time to fill in the questionnaire. However, being able to interview the relevant officers in the Tehran municipality, the provincial governor's office, the Seismic Centre of Iran, the fire brigade, local schools and the District 17 Municipality was not an easy task. Having a friendly relationship background with the municipality facilitated the interviews with its officers. However, on some occasions, such as at the Seismic Centre of Iran, officers were not willing to be interviewed, pass on any information or even help to obtain other resources. Therefore, I had to use informal requests from other organisations on my behalf to do so. Despite my initial plan, it took me over four months to do the fieldwork and gather the case study data.

5.13 Conclusion

The chapter highlighted the main points and procedure of this thesis's research theme, method and strategy. They were inspired by reviewing research methodology texts such as Yin (1994; 2004), and Groat and Wang (2002); nevertheless, the chapter aimed to avoid being a textbook and focusing more on the methods used in this research. It was explained how a combined qualitative and quantitative research method was used, with more use of primary materials, whilst obtaining guidelines from secondary materials, in order to create a framework for the case study. The next chapter will demonstrate the use of the above method in analysing the case study data.

Table 5.3: List and details of interviewees

Position	Duty	Place of Interview	Subject of Interview	Means of Interview
Chief Executive, Tehran Province Natural Disaster Committee	The second-in-command, responsible for the committee's equipment, cooperation with other organisations, reports and action plan	Tehran Home Ministry office	Their approach to post- and pre-disaster management and planning, the history of the committee and key role players	Answers to structured questions tape-recorded
Officer A, Planning Department, Tehran Province Natural Disaster Committee	General planning and report preparation for the other departments	Tehran Home Ministry office	Previous and existing planning documents, the improvements made in the past and general pre-disaster knowledge	List of questions was handed to the interviewee just before the session. Answers tape-recorded
Officer B, Management Department of Tehran Province Natural Disaster Committee	Preparation of training courses for the staff, organising the committee's action plan, collaboration and team-working	Tehran Home Ministry office	Key involved actors writing the plan and its priorities	Answers to structured questions tape-recorded
Principal Consultant of Greater Tehran's Mayor	Giving advice to the mayor and his office on various issues	Tehran Municipality office	Duties of municipality to deal with emergency situations, available plan's subject, nature of cooperation with other organisations, future planning and management aims	Key questions posted to interviewee prior to interview. Interview tape-recorded
Head of Natural Disaster Management, Tehran Municipality	Conducting office activities, planning, logistics	Tehran Municipality office	Tehran's latest planning approach, documents for disaster preparedness, intra-organisation collaboration	Prepared questions, giving the choice to the interviewee to direct the discussion

Position	Duty	Place of Interview	Subject of Interview	Means of Interview
Officer C, Office of Natural Disasters, Tehran Municipality	Preparing the plan and organising general public awareness process	Tehran Municipality office	Available documents, local surveys and knowledge, training workshops	Prepared questions, giving the choice to the interviewee to direct the discussion
Chief Urban Planner, District 17 Municipality	Approving and putting into practice development and detail plans, coordination amongst different departments	District 17 Municipality office	The recent development plans for the area, the role of disaster plans and hazard mitigation in decisions and local designs	Subject of interview given to interviewee in advance. Handwritten notes of interview taken
Officer D, Office of Disaster Management, District 17 Municipality	Preparing disaster plans, training of local residents	District 17 Municipality office	Disaster mitigation policies and action, outline of municipality's future policies	Subject of interview given to interviewee in advance. Handwritten notes of interview taken
Chief Executive, District 17 Fire Station	Action plan, equipment advancement	District 17 Fire Station, Tehran	Priorities, equipment and arrangements in the event of disaster	Structured questionnaire, tape-recording of answers
Officer E, Tehran Municipality Central Fire Station	Coordinating and planning for emergency situations	Fire Station office, Tehran Municipality	Main data and planning objectives for emergency action	Structured questionnaire, tape-recording of answers
Officer F, Statistical Centre of Iran	Preparing and conducting reports, data collection process	Office of Statistical Centre of Iran, Tehran	Criteria for data collection, social and physical elements, disaster-related data	Structured questionnaire, tape-recording of answers
Officer G, Seismic Centre of Iran	Laboratory research on building seismology resistance	Seismic Centre, Tehran	The main damage estimation methods, pre/post-disaster	Open discussion, as the interviewee was also involved in directing the questions
Officer H, Seismic Centre of Iran	Team member on disaster-related research	Seismic Centre, Tehran	JICA's main approach, impact on Tehran's plans, municipality's plans and disaster management office	Open discussion, as the interviewee was also involved in directing the questions

Position	Duty	Place of Interview	Subject of Interview	Means of Interview
Lecturer I, School of Engineering, Tehran University	Teaching in building resilience subjects	University of Tehran	The approach to physical vulnerability assessment, the role of social vulnerability and capacity in traditional disaster assessment methods	Set of questions posted to interviewee prior to interview. Handwritten notes of the discussion taken
Officer J, Office of Urban Planning, Ministry of Housing and Urban Development	Team member in research group in urban planning subjects	MHUD research centre, Tehran	The framework used for urban planning in Iran/Tehran; traditional role of disaster mitigation in HUDO publications and approaches	Subject of interview given to interviewee in advance. Handwritten notes of interview taken
Officer K, Boom Sazegan consultancy	Part of design team of Tehran's 2006 Master Plan	Main office of Boom Sazegan consultancy in Tehran	The nature of information collected and used in the plan, use of disaster-related data and plans	Subject of interview given to interviewee in advance. Handwritten notes of interview taken

Chapter One................................ **Introduction**

Chapter Two............................. **Conceptual Framework**

Chapter Three......... **Evaluation of Damage and Risk due to Earthquakes**

Chapter Four.................... **Open Space and Diversity of Services**

Chapter Five.............................. **Research Methodology**

Chapter Six… **Identifying the Spatial and Geographical Structure of Tehran**

Chapter Seven. **Use of Urban Risk Assessment Tool for Main Planning Resources**

Chapter Eight.. **Evaluation of Risk in the Study Area**

Chapter Nine.. **Open Space Design Criteria for Refuge Areas**

Chapter Ten...................... **Conclusions and Recommendations**

6.1 Introduction

Tehran is a city of culture, history and entrepreneurship which manifests a variety of knowledge, contradictions and activities. The vulnerability of the structures and infrastructure of many central urban areas in Tehran is quite considerable. Weak buildings, old structures and vulnerable supply lines,[24] insufficient emergency infrastructure and roads, a lack of sufficient evacuation places in some districts, etc., are some of the key parameters of the city's vulnerability to earthquakes. By looking at the characteristics of the urban built environment, the context of urban land use and how the physical spaces (housing, public buildings, open spaces, etc.) and the morphology of the street pattern, one develops an understanding of how the city has been formed.

In summary, during the Safavid dynasty (1502−1722), Tehran was a small village outside the ancient city of Ray, which lay at the foot of Mount Damavand, the highest peak in Iran (Tehran City, 1930). But as time passed and it became the capital of Iran in the Gajar dynasty (1985−1924) it had grown into a large city. De Clavijo (1928) describes the city as follows:

> The town of Tehran is a very large place. No city wall surrounds it and it is a delightful abode furnished with every convenience. Its climate however is not healthy and the heat here is very great in summer.
>
> (De Clavijo, 1928:167)

The modern Tehran of the 20th century has often been described as the product of Reza Shah's (1925−1946) ambiguity and western ideology, the economic prosperity derived from oil revenues and a contradictory approach[25] in the urban management organisation process (Takeyh, 2006). Today, Tehran is the major political, economic and cultural city of Iran, the largest metropolitan area of the country and one of the fastest-growing cities in terms of population and urban expansion in Iran. With its

[24] "Supply lines" here refers to urban amenities such as water, gas, electricity and sewerage.
[25] It will be discussed later on in this chapter that how government policies in housing, land distribution, urban growth and municipalities' management changed from time to time and how this affects the way Tehran's urban activities operate.

current rate of population growth and urban development, in about 20 years it will become the fifth most populated city in the world (SCI, 2006). A bird's eye view of Tehran shows how the city stretches upwards (with ever-increasing numbers of high-rise buildings, illustrating that modern architecture has changed the skyline and general image of the city) and outwards (towards the west, south and even north) oscillating between clearly planned geometry and fragmented sprawl.

In order to study and analyse its characteristics it is required to set certain criteria and define them through studying the context of city as a whole. Due to the complexity and variety of notion of city, this chapter's criteria are classified as follows:

- Natural environment and location of the city
- Historic background of the city
- Functionality, socio-economic processes and urban activities' guidelines (plans)

This chapter briefly gives an overview of the historic development of the city of Tehran in three periods of urban modernisation, rapid urban development and more recent years. In each era, the impact of different economic, social and political impetus will be highlighted. The natural geology and land structure of the city will also be explored. It is essential to understand how the fault lines under the city increase the possibility of a moderate earthquake, which would have a destructive impact on the city. The historical expansion of the city during the 20th century is then reviewed. Various functional and structural parameters of the city will be explained, leading us to the city's structure, with a specific focus on the city's natural axes and axes of activity. These axes are the main lines on which urban activities and transportation take place. They will be used later on in the research to identify and propose emergency routes in the event of a natural disaster. The chapter also contributes an explanation of the main development plans and spatial structure of the city, with specific focus on the existing use of inner-city land and property. The purpose of this section is to illustrate the overall picture of the urban built environment of the city for future development and perhaps relocation of services.

6.1.1 Geology

The geological map, which focuses on Cenozoic sediments in the Tehran region, was prepared by the Geological Survey of Iran (GSI, 1979). This geological map basically presents the distribution of the Pliocene and Quaternary alluvial and glacial deposits in the Tehran plain between 51°00'–51°44'E and 35°28'–35°22'N (GSI, 1979). The classification of alluvial deposits according to Rieben (1966) is used as the basis for mapping different lithologic units of the study area. The Greater Tehran region, underpinned by the alluvium, is classified into four distinct types as follows (*ibid*:62):

1. class D: recent alluvium with a thickness of up to 20 m;
2. class C: Tehran formation with a thickness of up to 100 m;
3. class B: heterogeneous formation with a thickness of up to 300 m;
4. class A: Hezardarreh formation with a thickness of up to 500 m.

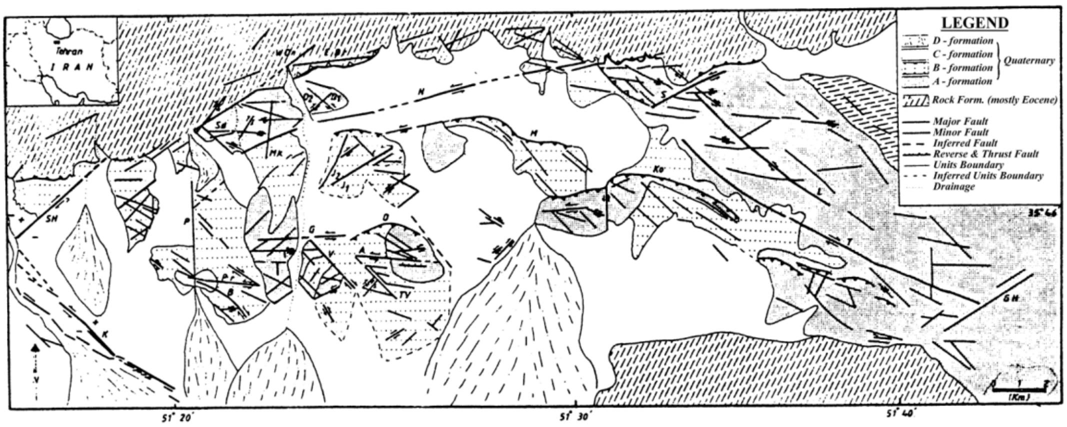


Figure 6.1: Geological map of Tehran area and faults (Rieben, 1955; 1966)

More on the geology of the region can be found in Rieben (1955:62). Based on the explanation of Figure 6.1 by Ghasemi et al. (2009) and the result of the geological investigation of this study, the geological conditions of the study area can be summarised as follows:

1) Bedrock: Rock units older than ***A*** formations in the map area are designated as “bedrock” (Ghasemi, 1999). In northern Tehran, where the Alborz Mountain Range is located (above the North Tehran Fault zone), this unit is basically composed of Eocene pyroclastics (green tuff) and volcanic rocks that form high outcrops north of the Tehran Plain (*ibid*).

2) A formation (fm.) (Hezardarreh formation): The name of this formation originates from the geomorphic nature of outcrops of the formation. Northern outcrops of ***A*** fm. are limited to the south of the 35°43' latitude; however, some outcrops of this unit are present in southern hills of the Tehran plain (south of the Kahrizak fault) (*ibid*).

3) B formation: This formation was first named and described by Rieben (1966) as Kahrizak fm. The formation is divided into a northern and a southern facies (*ibid*).

*3a**) Bn formation (North Tehran inhomogeneous alluvial fm.):***
The ***Bn*** fm. overlies uncomfortably on the eroded surfaces of the ***A*** fm. and forms old alluvial fan topographic units in the north of the city of Tehran.

*3b) **Bs formation (South Tehran clay silt or Kahrizak fm.):***
The ***Bs*** fm. is widely distributed under the topographical plain unit. Outcrops of the ***Bs*** fm., which are exposed as a result of faulting, form the badland scenery in the southern parts of the Tehran plain (Ghasemi, 1999). However, the soil condition of this area is not so strongly consolidated, and, from the engineering geotechnical point of view, these outcrops may belong to the ***C*** formation (*ibid*).

4) C formation (Tehran alluvial fm.): The ***C*** fm. includes conglomeratic young alluvial fan deposits. Lithology of the formation includes homogenous conglomerates, composed of grey to brown coloured gravel and pebble-sized clastics, which have a silt and sand size matrix (Reyhani, 2007).

5) D formation (Recent Alluvium): The ***D*** fm. is the youngest stratigraphic unit within the Tehran region and is present as alluvial and fluvial deposits. In this study, the ***D*** fm. is subdivided into two different stratigraphic units, named ***D1*** and ***D2*** units (Reyhani, 2007).

6.2 Fault Lines

The distribution of active faults in and around the city of Tehran was originally and systematically compiled by Berberian et al. (1983). The different types of alluvial formations deposited along the southern flank of the Alborz mountains were first studied by Rieben (1955). Many active faults affect the Alborz, most of which are parallel to the range and accommodate the present day oblique convergence across it (*ibid*). Almost all reports and research papers refer to this early report. CEST (1998) and Ritz et al. (2003) later compiled detailed maps of fault distributions. Figure 6.2 shows the distribution of faults in and around the city of Tehran. After studying the folded and faulted alluviums of Tehran, Tchalenko (1974) has proposed a stress direction of N–S to NE–SW responsible for the deformation in the post-Pleistocene period. These natural features of the city have always been a threat for the inhabitants. The most important of these are: the North Tehran Fault (NTF), the Mosha Fault and the Ray (or Rey) Fault in the south and north; there are also other active faults such as the Niavaran Fault, the Lavizan Fault and the Tarasht Fault. The list of the main active faults of Tehran and its vicinity is shown in Table 6.1.

Table 6.1: Main active faults of Tehran and its vicinity (Mozaffari et al., 2008:12)

Fault	Type	Length (km)	M_{max}
Mosha	Thrust-Inverse	200.0	7.5
North Tehran	Thrust-Inverse	75.0	6.9
Garmsar	Thrust-Inverse	70.0	6.9
Kahrizak	Thrust-Inverse	40.0	6.6
Pishva	Thrust-Inverse	34.0	6.5
South Rey	Thrust-Inverse	18.5	6.2
North Rey	Thrust-Inverse	17.0	6.1
Niavaran	Thrust-Inverse	13.0	6.0

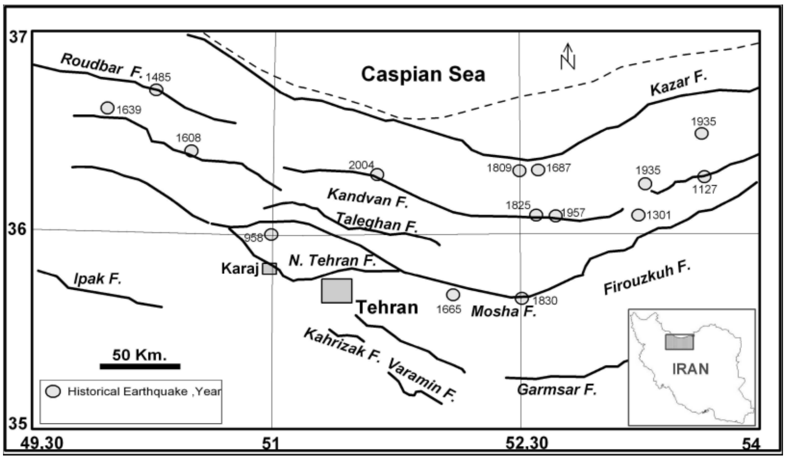


Figure 6.2: Main major faults in the study area. Locations of historical earthquakes caused by the Mosha Fault are also shown (Mozaffari et al., 2008)

Several of these faults have been mapped, but their geometry at depth, their associated seismicity and their kinematics are not precisely known (Ambraseys and Melville, 1982; Kehl, 2006).

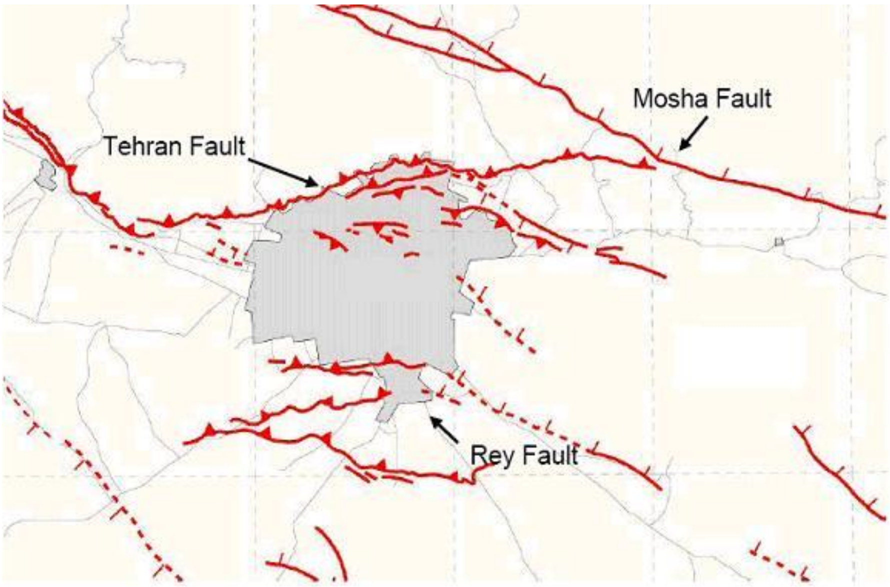


Figure 6.3: Main faults of Tehran Province (Jafari and Amini Hoseini, 2005:12)

Based on these reports, the features of the main active faults in and around Tehran can be summarised as follows:

1) Mosha Fault: The Mosha Fault is one of the fundamental and major active faults of the central Alborz mountains and is situated to the north of Tehran (Berberian, 1994). The fault is concave towards the north and extends from the edge of the mountain range in the west to the eastern Alborz. This ~150 km long ~N100E trending fault represents an important potential seismic source that threatens the Iranian metropolis (Nazari, 2007; Berberian, 1994). It is also believed that two large earthquakes in 1665 and 1830 are connected to the Mosha Fault (Ritz et al., 2006).

Its trace has a sinuous pattern, with an E–W strike in the west, and a WNW–ESE strike in the central sector, gradually bending to E–W in the east. Dips occur everywhere to the north, varying between 35 and 70 degrees (Shahpasandzadeh and Djamour, 2006). The thrust movements on this fault were initiated before the Jurassic age, and cumulative displacements amount to at least 4 km (*ibid*). The fault can be considered an upthrust in some places and an overthrust in others (Ambraseys, 1982).

2) North Tehran Fault: The North Tehran Fault is about 108 km in length, and is immediately to the north of the Tehran megacity and extends further west along the southern edge of Central Alborz (Mozaffari Amiri and Dowlat, 2008) (Figure 6.4). The North Tehran Fault is the most prominent tectonic structure in the immediate vicinity of the city. It can be followed almost continuously at the foot of the Alborz Mountains for about 35 km, from Kan in the west to Lashgarak in the east (Shahpasandzadeh, 2006). The fault trace is E–W to ENE–WSW and slightly concave to the south, whilst west of Kan, several NE–SW and E–W faults interrupt its continuity (*ibid*).

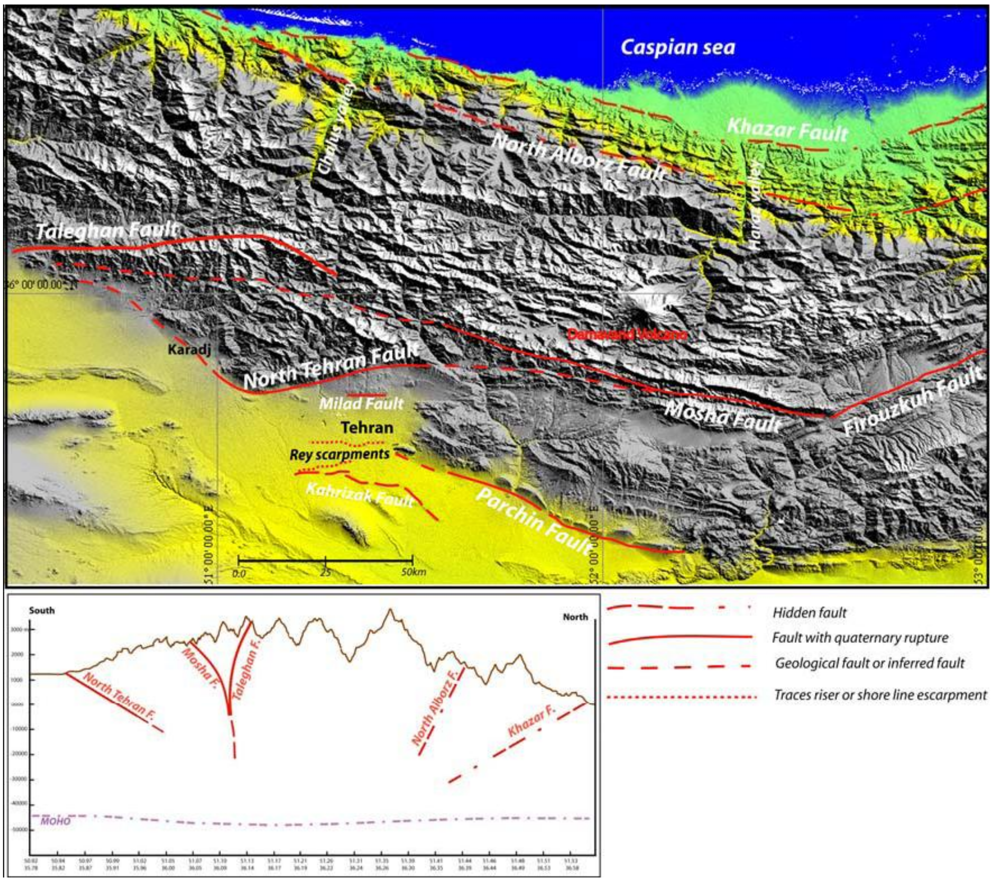


Figure 6.4: Faults map in central Alborz (Nazari, 2007:10)

East of Lashgarak, it enters a complex tectonic region where it joins with the Mosha–Fasham fault. Through its central section, between Kan and Lashgarak, the North Tehran Fault forms a well-marked boundary between the rocks of the Karaj Formation of the Border Folds and the alluvial deposits of the Pediment Zone, up-thrusting the former southwards over the latter (*ibid*). A number of localities along this central part have been previously described by Rieben (1995) and by Engalenc (1968); they were re-examined by Tchalenko et al. (1974). The date of the most recent fault movement for the North Tehran Fault is difficult to establish, due to uncertainty about the age of the rock beds that underlie the thrust plane. West of Darabad, the North Tehran Fault is typically a reverse fault, despite local thrust structures of the type seen in Kan; east of Darabad, it is more clearly a low-angle thrust fault.

3) South and North Ray (Rey) Faults: The South and North Ray Faults are the most prominent faults in the southern plains of Tehran (Nazari et al., 2007). These faults are distributed throughout both sides of the Ray depression.

6.3 Historical Review of Tehran's Urban Growth

In the late 19th and early 20th centuries, Shemiranat[26] was the centre of focus as a summer holiday resort. Because of Tehran's specific geopolitical situation (its central position and distance from the borders), in 1785 Aga Mohammad Kan Gajar chose the city as the permanent capital of Iran (Marefat, 1988). Tehran's basic urban structure, except for the city wall and gateways, which were a defensive element, can be characterised by four basic elements which give Tehran much of its character as an Islamic city (Grabar, 1973:22):

- The royal citadel;
- The religious structure;
- Residential quarters;
- The bazaar.

As indicated, in this most typical Islamic city, the main city mosque, the bazaar and other public institutions were located mostly in the centre of the city. Tehran's residential areas surrounded these public structures, and they were divided into quarters or Mahaleh. Later, Nasserdin Shah (1848–1896) created the Great Royal gardens such as Ferdous, Kamraniyeh, Saltanat Abad, Niyavaran and Sahebgharaniyeh and they became the summer quarters of his government (Oleg Grabar, 1995). In this way, the expansion of the city towards the north was greater compared to other directions.

6.3.1 The Modern Urbanisation Period (1922–1956)

Since the beginning of the 20th century, the urban areas of Tehran have undergone great social and economic transaction. With the rise to power of Reza Shah, the founder of the Pahlavy Dynasty, in 1925, a new chapter was opened in the social transformation of Iran (Fardust, 1999) and Tehran.

[26] Shemiranat was a suburban village in the vicinity of Tehran to the north.

Figure 6.5: Tehran in 1857 – Krziz's Map (TGIC.CNRS, 2004)

Reza Shah suppressed the autonomous regional forces and created a strong centralised state apparatus in the capital. He was the first person who attempted to change the features of the city based on academic plans when he introduced assorted government acts which encouraged rapid modernisation (Razaghi, 1988). These efforts were mostly concentrated on physical changes to the city, including widening the roads, constructing new buildings, using the international style of building, streets and squares on a grid pattern, and providing vehicle access and adequate spaces for vehicles to manoeuvre in the historical parts of the city. The Tehran municipality was given the responsibility of imposing urban policies. In this period, urban policy was in fact used as a practical mechanism for controlling and directing urban development without any plan or policy, to deal with the rapid growth of population, immigration and land-use planning (Clark and Jones, 1981).

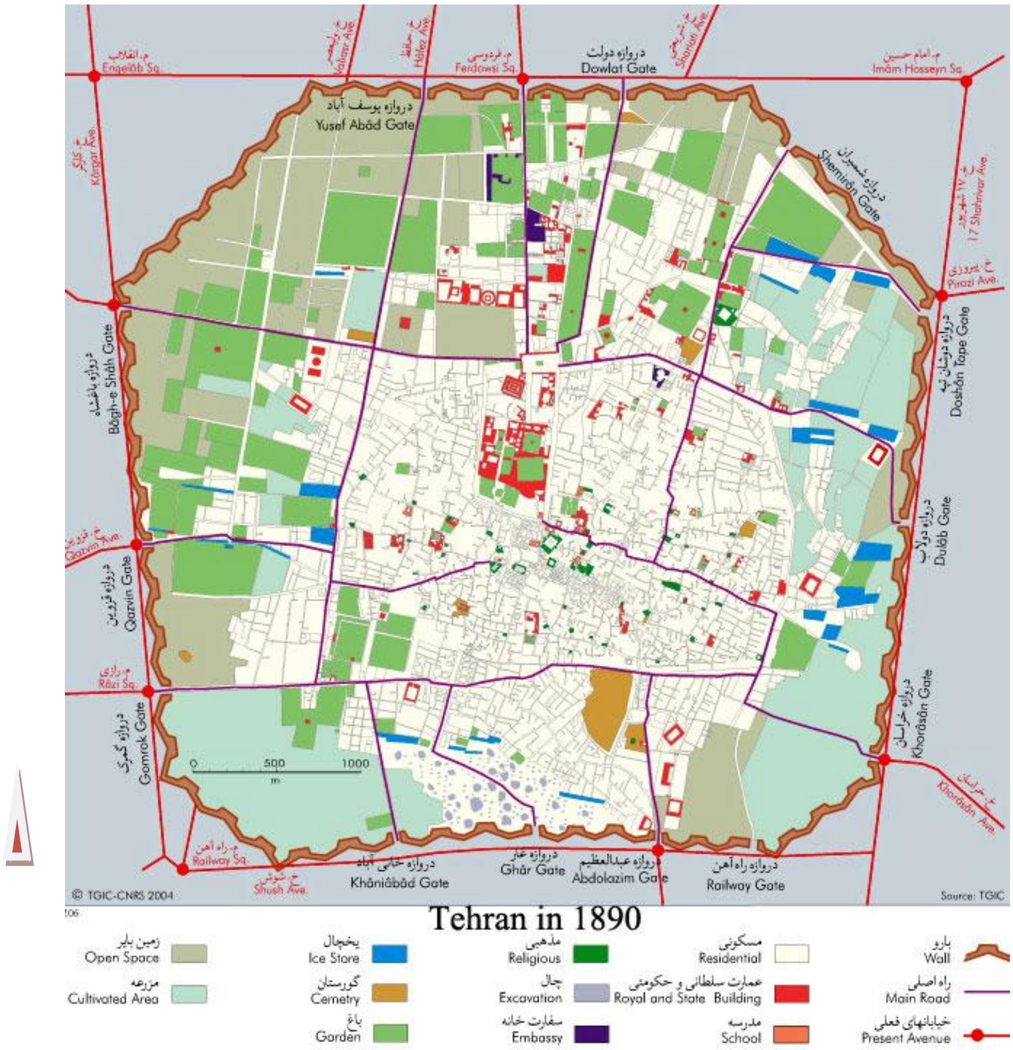


Figure 6.6: Tehran in 1890 (Tehran Municipality Website, 2012)

Arguably, as Madanipour (1998:177) believes, government policy, which included "investment of public money, introduction of development policies, control of the planning system" and dramatic changes accompanied by the modern lifestyle imported into the country, caused rapid and, to a large extent, uncontrolled development of the city. Major military bases, industries, trade centres, public buildings and an extensive road network were constructed in Tehran; the first university in Iran was also founded there (Ferdowsian, 2002). Economically, the country was beginning a transformation to a dependent capitalist economy, with Tehran functioning as the core of extraction of surpluses from the peripheries (Amirahmadi, 1990). Industrialisation based on import substitution reinforced the process of concentration of activities and led to more rapid expansion of the urban population in the largest cities, particularly the capital city, Tehran.

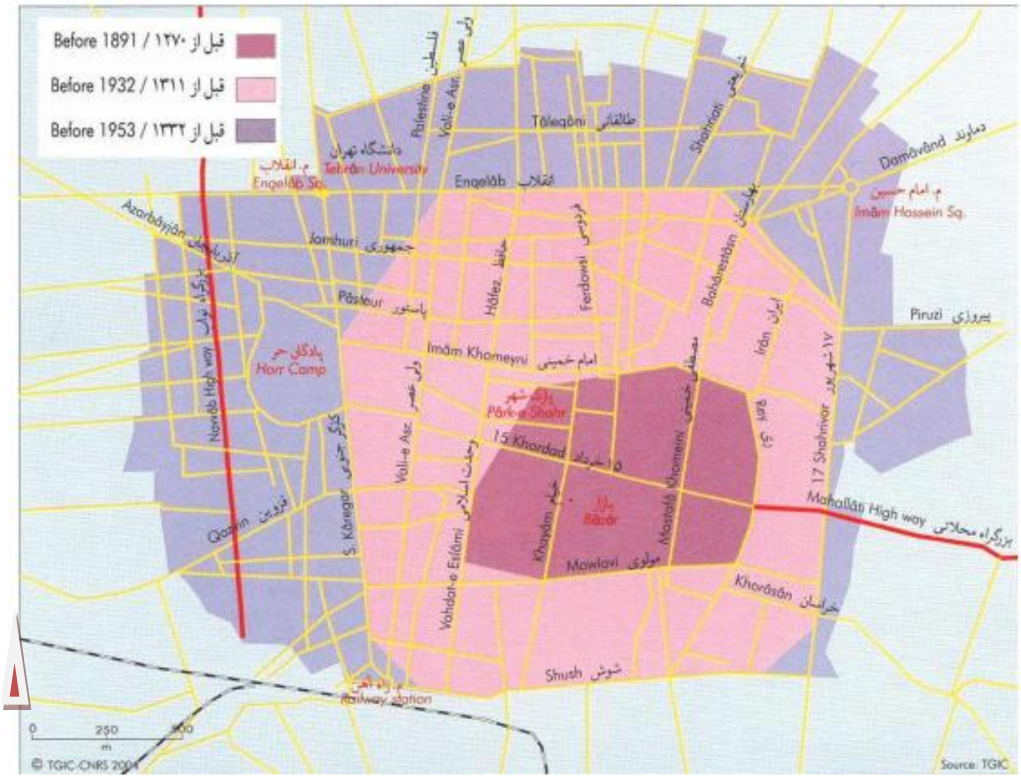


Figure 6.7: Map of Tehran until 1953 (Municipality of Tehran, 2004:59)

In this period, the city's infrastructure was founded and also advancement and promotion of international styles in architecture and city's high-rise building took place. Two important roads, Engelab and Valiasr, the major extensions of the eastern-western and northern-southern axes, created a new structure for the skeleton of Tehran. The city's old fabric was subject to major changes and the general image of the city was altered by the introduction of modern office buildings, asphalt and paved roads and many more improvements. Old gates and alleyways were replaced by grid-form avenues. The development of urban communication and the creation of new streets as well as the popularity of motorists' vehicles brought about the process of the expansion of the city towards the north.

6.3.2 Rapid Expansion towards a Megacity (1956–1978)

In Tehran, migration did not appear to be the major factor of population growth as the natural rate of growth has been more significant. According to Messkoub (2006), natural growth accounted for 65% of the net increase in the urban population between 1956 and 1966. Opportunities which attracted migrants were not evenly distributed amongst the city's regions. Building-related activities (whether private houses or government buildings) were more apparent in the northern districts than the southern ones.

As a result, in 1956 the boundary of the city was set at a 10 km radius from Toopkhane Square and its area increased to 100 km² (Madanipour 1998). Between 1961 and 1966, the city developed dramatically and with regard to the necessity of a development plan to control and guide the expansion, the first master plan of Tehran (1968) was created (MHUD, 2006). The plan proposed the pattern of development in an east–west direction for the city's expansion, and as a result the area of the city reached about 250 km² (*ibid*). The dominating forces in the evolution of the city in this period contributed to it being the centre for government offices and economic activities, initially up to Taleghani (Takh-e-Jamshid) Avenue and then to the KarimKhan, Shahid Motahari (TakhteTavoos) and Shahid Beheshti (Abbas-Abad) avenues (*ibid*). In this period for the first time, residential areas on a pre-planned pattern were created, such as Narmak and Chahar sad Dastgah, in the east of the city (Madanipour, 1998).

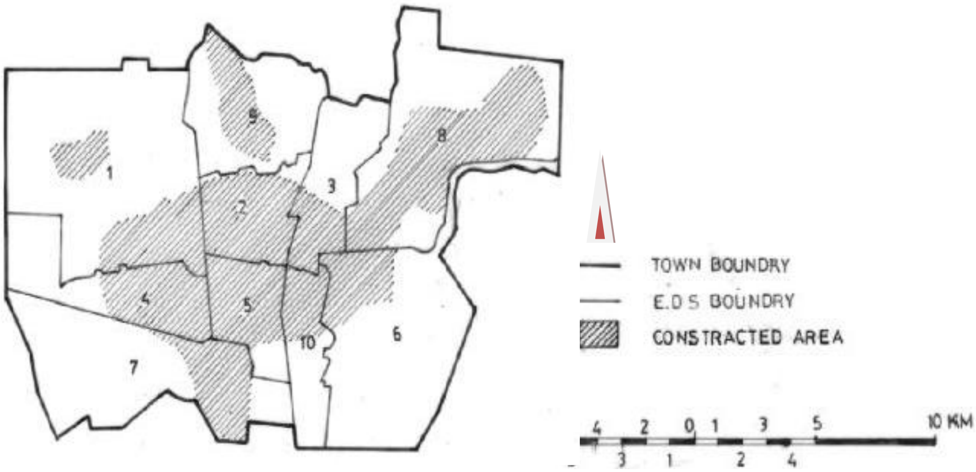


Figure 6.8: Map of Tehran in 1966 (Ohadi, 2000)

6.3.3 The Revolution and its Impact on the City's Development (1979–present)

After the Islamic Revolution, Tehran City was under enormous economic and social influences and the resulting pressure from the war. Religious thinking dominated the economy, and eight years of war with Iraq made the words restriction, protection, isolation and obtaining economic independence the central tenets of economic policy. Demand for decent housing for everyone was one of the reactions to the urban land speculation which had aided the economic boost of the 1970s (Madanipour, 1998). The Urban Land Law (1980) replaced previous laws, and ownership of urban land became limited in the number and size of plots allowed to be held, whilst government took control of vacant non-agricultural lands both within and outside the city to direct capital investment and industry (*ibid*). In the early aftermath of revolution, during this period of social upheaval and largely because of the breakdown of government control, a large number of plots in Tehran and its suburban areas were occupied by illegal settlements. They simply occupied the land, marked it out and started to build housing without fear of any observation or control, resulting in a chaotic appearance of some parts of the city. In addition, the government endeavoured to satisfy low-income people in the urban areas by allocating land to landless people, which caused a big wave of migrants towards Tehran.

The expansion of Tehran City reached the level of 720 km² and the number of city‘s districts increased from 12 to 20 in the early 1990s (Gharagozlu, 2004). In 1992, according to the Tehran development plan and in order to lessen the concentration of economic activities and traffic in the city centre, four centres of social, administrative and economic activities were suggested in four corners of the city. But, in practice, this plan was not executed and the city centre development, based on various attractions, continued. A high volume of building construction, as well as the creation and improvement of a road network, made accessibility to most parts of the city and its suburbs, in particular Shemiranat and all of the southern slopes of the Alborz, quick and easy. Therefore, the growth of the city towards the north, north-west, west and north-east increased. From an economic point of view, the core of the wholesalers’ sector has traditionally been the centre of the city (the bazaar area), and this has also spread to the north. The city centre played a dominant role in attracting activity as the economic core and focus of development within the same area. This has caused shortages of space for the creation of logistic support for wholesalers’ businesses and has persuaded general opinion to destroy the historical areas around the bazaar, and instead create warehouses, parking areas and docks. Although there are still a limited number of open spaces within the heart of the commercial area, in general a lack of designated public space exists (Salehi-Isfahani, 2005).

6.4 Government (Central, Regional and Local) Characteristics

The distinctive role and size of Tehran as the capital of the country and centre of administration has characterised the governance of the city in a specific structure. Locating all the ministries, main governmental offices and government's administrative centres in Tehran has created a situation in which most provincial and city offices work from the same building. However, the scale and power of Tehran municipality, with its extensive sub-offices, has made this local authority one of the most influential powers and decision-makers in Tehran and even in the country.[27]

Table 6.2: General characteristics of political territories and local management (Akhoundi et al., 2006:9)

Territories	Division Units	Governing authority	Appointing authority	Type of Institution (Governmental/public)	Type of Relations
Political Divisions	Province	Governor-General	Cabinet	Cabinet	Governmental
	County	Governor		Interior Minister	Governmental
	District	District governor		Governor general	Governmental
	Parish	Reeve		Governor	Governmental
Managerial Divisions	City	Mayor		City council	Public
	Village	Reeve (Rural district)		Village council	Public

In terms of spatial territories and the relations between them, as Figure 6.9 shows, there are three distinctive levels that put Tehran City in the geographic centre, working closely with other sections. Table 6.2 also indicates the general characteristics of political territories and local government in general.

[27] On several occasions, Tehran's mayor was subsequently elected as the country's president.

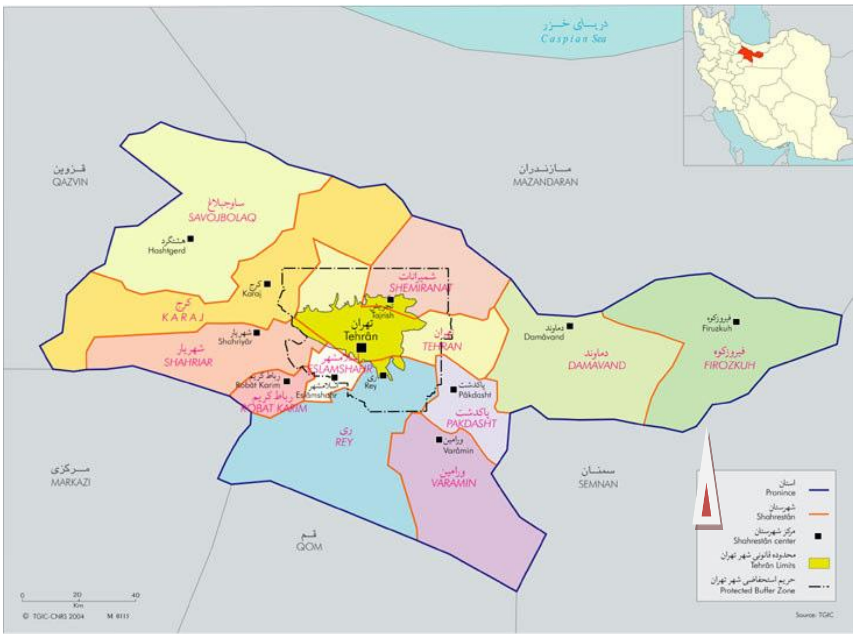


Figure 6.9: Tehran Province (Akhoundi et al., 2006:8)

Table 6.3: Information about Tehran (Akhoundi et al., 2006)

Tehran Area: 700 km²
Population: Approximately 7 million
Districts: 22
Tehran Municipality
22 District Municipalities
Tehran City Council
Tehran Metropolitan area: 17,000 km²
Metropolitan Population: 12,300,000
50 City Municipalities

Based on this hierarchy, the state (government) has two sectors with overriding power of political structure on institutional players. The state government forms and reforms the country's policies and divides into executive, legislative and judiciary branches (Akhoundi et al., 2006). But what concerns this research is that the governmental public institutions consist of ministries under the jurisdiction of the president and the elected government including city councils. The former element of government is responsible for decision-making, inter-organisation coordination, planning and management. As well as regulating and executing acts and plans, there are financial matters that the government has to deal with. This involves many resources nationally, regionally and locally. The best-known resources are oil revenue, taxes on property and land, revenue from fines and compensation (GFS, 2002). According to Akhoundi et al. (2006), the Tehran municipality's share is 88% of the total provincial income. The political and administrative division of the case study area is similar to the rest of the country and consists of the following:

Country → Province → County → District → Parish → Area → Neighbourhood

Figure 6.10: Administrative divisions (Amiri et al., 2010:125)

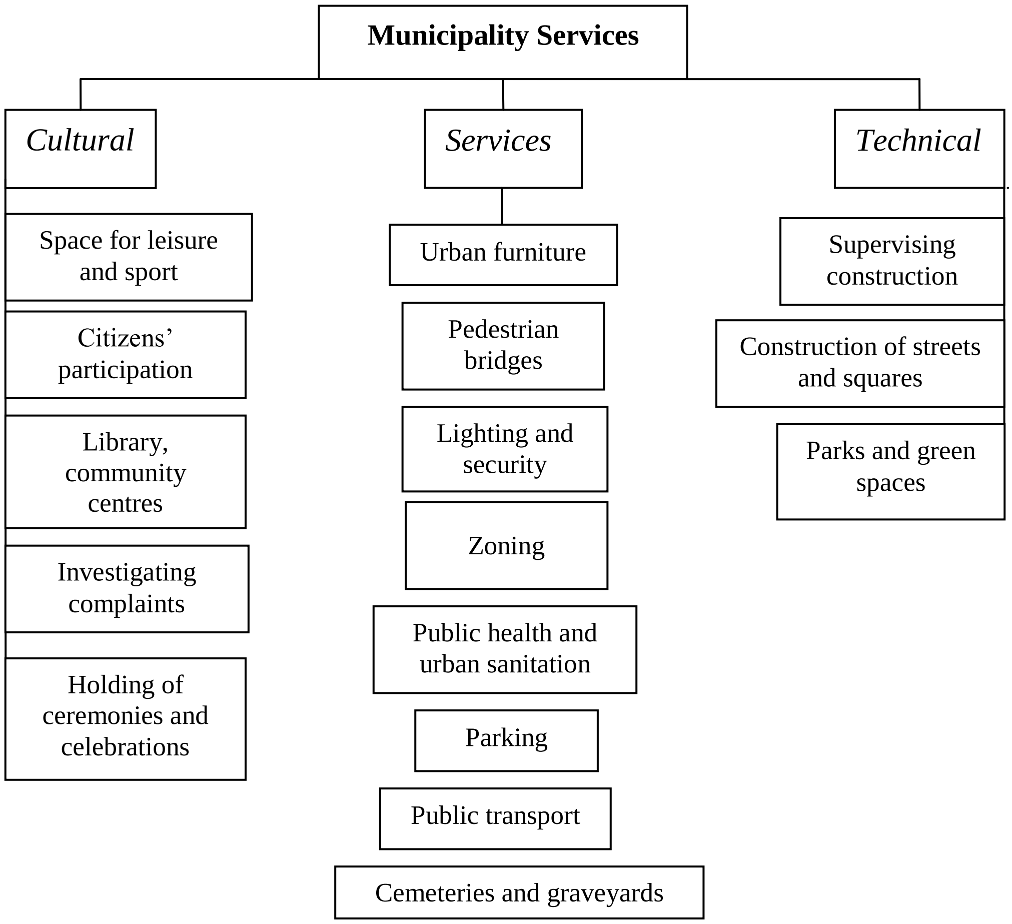


Figure 6.11: Municipality services (Goharipour and Karimi, 2011:73)

There are different divisions for rural areas. Each unit works under the administrative authority of a higher division. There are parallel elected and appointed representatives in these categories. Councillors at city and provincial level are the most locally elected governmental bodies. Tehran's municipality, under the supervision of Tehran City Council, holds the obligation for providing typical services like other municipalities (Figure 6.11).

But the scale of the city and required services has imposed changes in its management mechanism. It has resulted in vast usage of the private sector as well as privatisation of many services such as traffic management or maintenance of the city's public green spaces and parks. The role of provincial authorities is more apparent at the provincial level and in other cities rather than Tehran. However, the influential role of central government is stronger in nature in the city's affairs and management. This applies to the main ministries such as the Ministry of the Interior, the Housing and Urban Development Ministry or the Culture and Tourism Ministry. Figure 6.12 illustrates the relation between Tehran's local government and other governmental institutions.

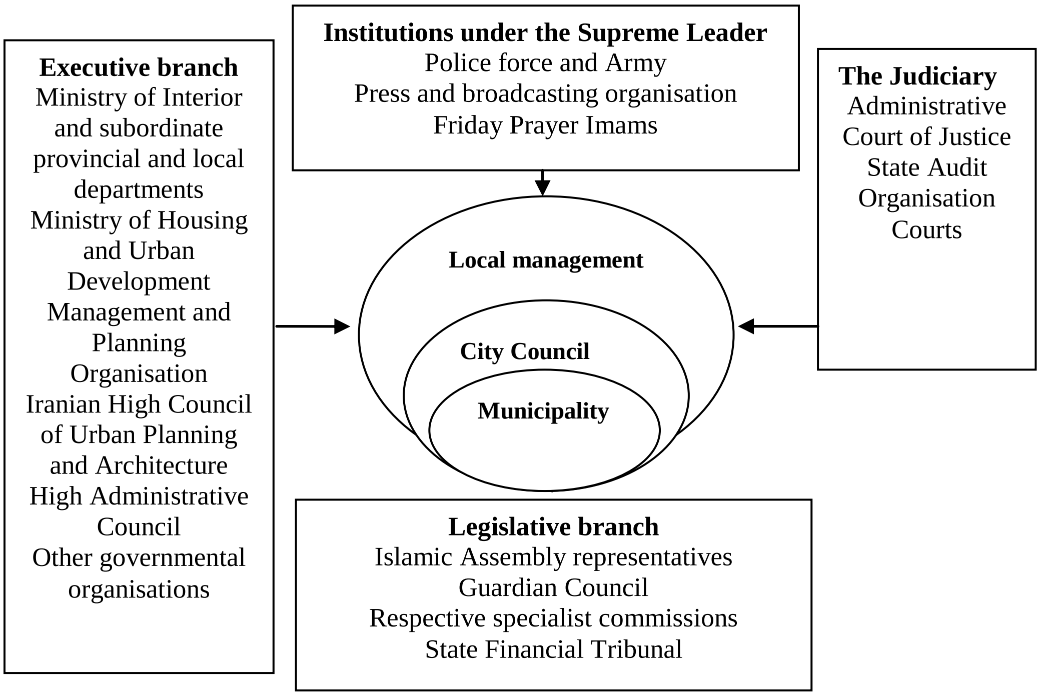


Figure 6.12: The relationship between government at local and central level (Akhoundi, 2006:11)

Recently the position of disaster management and research has been strengthened by the municipality, leading to the preparation of initial studies in this regard at local and district level. In an attempt to collect relevant data and create a collective action plan, Tehran municipality has accepted the responsibility of a series of studies at city and district level under the management section of its bureaucracy. But the context and approach to this series of studies, as will be discussed later, is limited to post-disaster general rescue operations and training. Hence, the research will analyse this weak approach in the development plans of Tehran.

6.5 Details of Spatial Structure

In order to define details of spatial structure, first its meaning and the criteria in which spatial structure development occurs should be understood. Spatial planning is not a strict rule. It is an adaptable and multi-dimensional framework with a tendency towards social interest according to the time and the place. Therefore, it can vary from area to area and time to time, contain similarities or contradictions. Based on this assumption, spatial planning offers a picture of the general space structure, affected by existing elements of the city at a specific time. The network model of spatial structure is mainly about direct connections at the city scale. Patterns of a single centre, or diagonal and centralised, can be considered functional and suitable for small cities. However, the functionality, stability and consistency of spatial structure in a big city such as Tehran require structural evolution towards decentralisation: perhaps multi-centred, multi-faceted, and a strong network (TCC, 2006; Madanipour, 1998).

Tehran’s backbone is a network of roads with built-up areas in between. These roads act as axes, dividing up the city, and are the main transport routes. In a city structure based on its road network, the role of certain elements alongside city centres is significant in spatial coherence. These elements include the transport network (especially the metro and its stations), ring roads, city entrances, gateways and other elements that specify district areas.

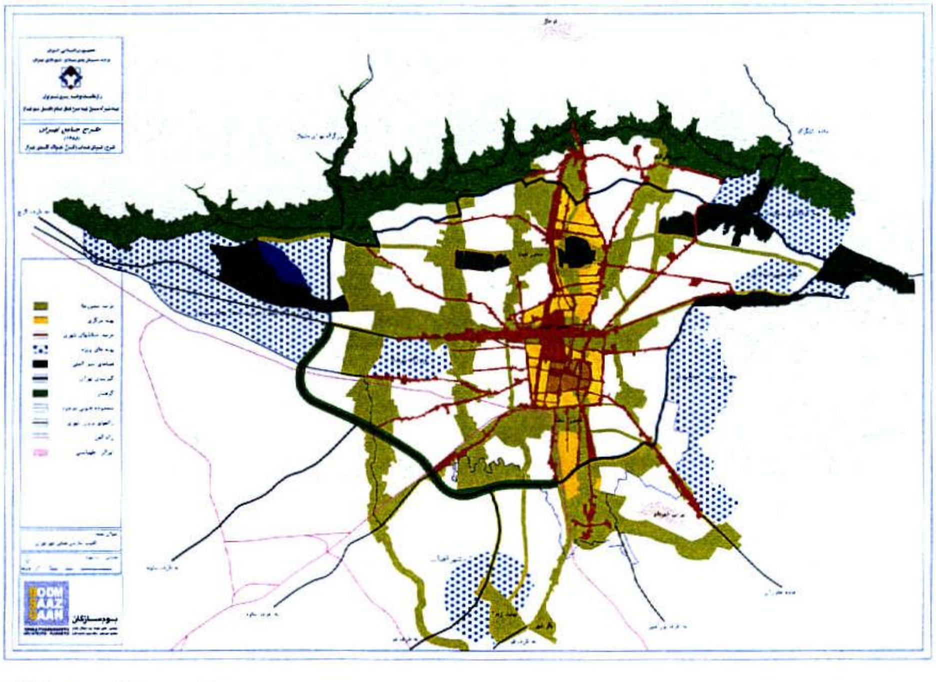


Figure 6.13: Road networking zxes of Tehran (TCC, 2006:17)

6.6 City Axes

Urban axes (main roads) have a vital role in forming a coherent network organisation in Tehran City. They are used for local and regional and even national purposes and also have an impact on the quality of services that a city can provide. These axes that give network structural to the city include (TCC, 2006):

- Natural axes, such as the river valley which has shaped five northern–southern axes, including Kan, Farahzad, Darakeh, Darband-Ray, Darabad-Bibi Sharbanou (Figure 6.14).
- Axes which are used as main roads and transportation along the east-west direction, including the Hemmat motorway, Engelab and Shush-Bessat (Figure 6.15).
- Secondary roads, as the connective axes are formed within the areas around historic cores and other areas.

The role of these secondary axes is as vital as others because of the volume of traffic that passes through them daily. These five axes, in line with the natural axis of

Kohsaran in the north and the Azadegan motorway in the south, have created the structure of the city. These axes, whether they are natural features (rivers) or roads, can be used for reorganisation and planning purposes. They can be considered as dividing lines for urban planning and emergency purposes. In the north–south direction, the rivers distinguish five areas, starting from the Alborz mountains and continuing in the form of axes with routes to the middle of the city (Figure 6.14).

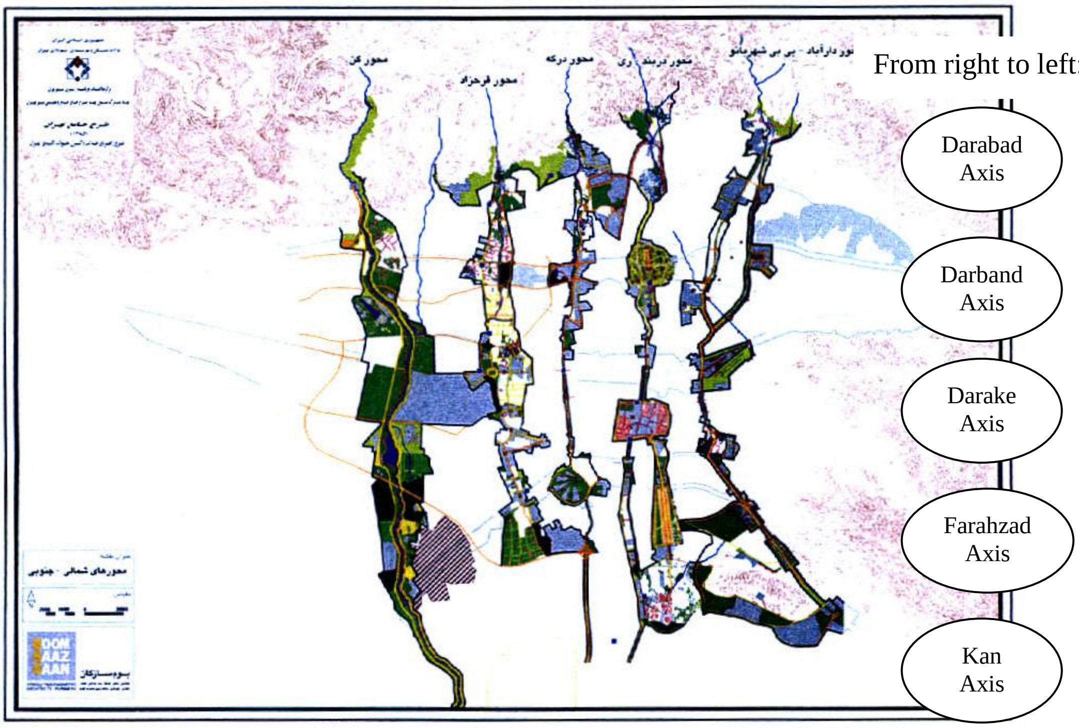


Figure 6.14: Northern–southern axes (MHUD, 2006:38)

Although all these axes facilitate the functionality, movement and contingency of urban life, each has its own characteristics. In the next section, each axis will be studied separately in terms of their natural characteristics and the areas that they connect or cross. The first one is the westernmost axis, named Kan.

Kan Axis: The Kan axis is the furthest west of the northern-southern axes in the network of the spatial structure of Tehran city. It starts from Solghan village in the Alborz highlands and meets the Azadegan motorway in the south. From there it continues southwards and passes Chahardange at the junction with the Saveh road, arriving at Shatere village. Its continuation from north to south is defined by the direction of the Kan River. The powerful presence of this waterway through the city has made a strong connection between land and water. The characteristics of the area and functionality of the surrounding areas of this axis have provided significant attractions for recreation and tourism. In other words, it brings liveliness and rejuvenation to this part of the city. The 2006 Master Plan suggests the construction of two roads along the river bank to facilitate vehicle and pedestrian movement around it. It has also been recommended that improvement of the quality of the urban environment is achievable via the creation of spatial connectivity between natural features and by maintaining control over any construction and using the quayside as green space, which in turn can improve the quality of this axis environment.

Farahzaad axis: This axis, named after the Farahzaad river, starts from the Alborz mountains and in the south, it arrives at the Azadegan motorway (Jahad Square) which crosses the Tehran–Qum motorway. It continues to the south and passes Imam Khomeini’s tomb. The distinct characteristic of this axis is the presence of the Farahzaad valley between Ashrafi Isfahani motorway and Yadegar Imam motorway. The urban area formed in between could be reorganised and improved through the Farahzaad valley plan, which would eventually give sustainable characteristics to the surrounding area. The spatial combination of the Farahzaad valley area and its natural and urban coherence within the two motorways are some of the potentials to organise the Farahzaad axis as one of the public spaces of Tehran City, by creating a linear park along the valley. Meanwhile, the southern half of this axis performs successfully as a suitable area, as the home of a variety of economic and social activities, offices and public areas. This axis has traditionally been host to a large number of people during the hot summer season, due to the coolness of the river banks and its parks and restaurants.

Darakeh axis: The Darakeh axis is bounded in the north by the Darakeh valley in the Alborz highlands and in the south by the city’s vegetable market; it borders the Azadegan motorway.

The distinct characteristic of this axis is that it is rich in providing general services to the city and beyond. In addition, the astonishing picturesque landscape of this axis (the Chamran motorway) has created a valuable environment. When it reaches the

Ghalemorghi fields, there is potentially a good site for creation of a new city centre. Many universities and colleges are located along this axis and these attract a large number of younger people to the region. Tehran's international exhibition centre and Iran's broadcasting studio are also other major buildings along this line. Therefore, it can be physically and socially improved as a cultural zone. The pattern of traffic movement in the direction of Darakeh axis is based on high speed and motorways. This information will be used later in the research to help the theory of fast and effective management of disaster.

Darband–Ray Axis: The Darband–Ray axis connects the three historical fields of Shemiran, Tehran and Ray and is the most important axis of Tehran. This axis specifically connects the historical area of Tehran with Tajrish and Ray. As most historic elements and government buildings are along this axis, making the connection between the variety of physical factors and the spatial quality of the area is recommended. This in turn will promote the quality of services, especially economically, that the area provides to the public. Each centre has witnessed urban development and growth during the last century and formed today's Tehran. The axis explains the story of the life, growth, development and finally the triple historical connection of Tehran, Ray and Shemiranat (TCC, 2006).

Darabad–BibiShahrBanoo Axis: The fifth north–south axis of Tehran City is the Darabad–BibiShahrBanoo axis, defined in the North by the Darabad valley and in the south by BibiShahrBanoo mountain. This axis is considered as the eastern limit of the central section of Tehran city, in conjunction with Darakeh axis as the western limit of this section. By this is meant that along the Darakeh axis, large-scale industries are located, around one of the first motorways of the city. However, despite the importance and priority of the Darabad–BibiShahrBanoo axis the motorway along it was one of the last motorways to be built, and in fact is still under construction. It lacks harmony and organisation in its urban elements and the surrounding area. It has functioned as the centre for the eastern area of the city, and should be improved to play the role of a centre for the north-east and south-east, on the basis of present abilities in surrounding areas. From a natural landscape point of view, the Darabad river valley and the BibiShahrBanoo fields are two areas providing the opportunity for tourism and leisure. Two historical sites, Golestan Tehran and DoshanTappe airport are two important and significant fields in the east of Old Tehran. The pattern of traffic movement along the Darabad–BibiShahrBanoo axis, connected from north to south, is similar to that of the Darakeh axis. Other secondary routes give priority to pedestrians and are closer to the centre of commercial activities.

Eastern–western axes: **t**he above descriptions set the general picture of main transport network and roads (Figure 6.14). These have explained their relative importance and concentration of services and urban centres around them, and possible improvement in respect to spatial, physical and transportation factors. Three important east–west axes, Hemmat, Engelab and Shush-Bessat, carry Tehran's traffic from east to west daily. They are some of the busiest routes connecting urban area and other routes. Although creating the possibility of movement and ease of transportation in their major role in Tehran's road network, each of them has a special spatial structure with respect to their position and independently allows a proportion of vehicles' movement throughout the city. The first of these is Hemmat in the north of the city.

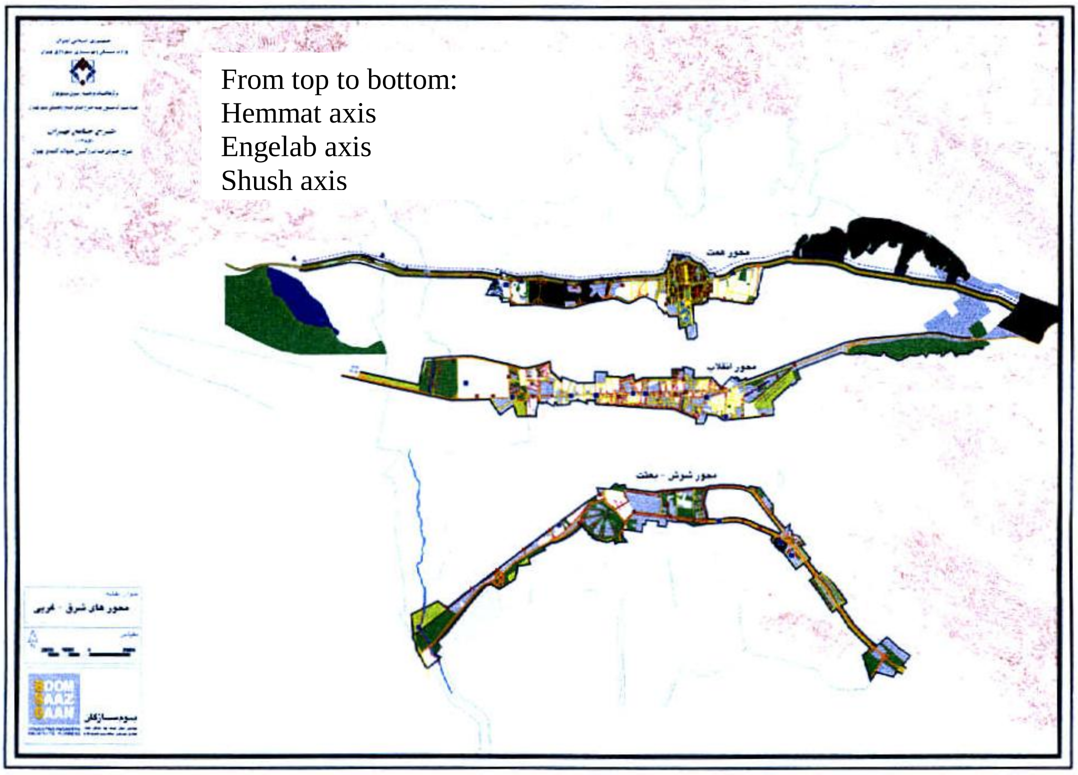


Figure 6.15: Eastern–western axes (TCC, 2006:44)

Hemmat axis: The Hemmat motorway is the longest road within the city, it extends from the furthest part of the Lavizan area to the far western boundary of the city (the boundary of the 22nd district) (TCC, 2006). It crosses all five north-south axis explained in previous pages. It is defined by Ghazal Park (outside the city limits, bordering the 4th district) in the east and Chitgar Park (in the middle of the 22nd district) in the west. In between, it passes and connects some of the biggest inner-city parks and woodlands. These include: Lavizan Park, the Shamsabad hills, Pardisaan Park, and Chitgar Park. In the meantime, in terms of traffic, it allows a high percentage of journeys to and from other roads and motorways. The distinct characteristic of the green axis of Hemmat is the physical continuity and movement within it. In terms of the general view of roads and cityscape, it is very green and different in comparison to the north–south axes. In respect to its general structure according to the natural topography, it sometimes comes close to the urban built environment and sometimes runs parallel to its edge. In some places it is built over bridges or lower than the surrounding land.

Engelab axis: the Engelab axis is the most important east–west axis of the city of Tehran, with a long historical background. It separates the northern and southern parts of the city. At the present time, the Engelab axis connects Karaj and Damavand to Tehran and directly enables numerous direct and more complex journeys that do not necessarily connect with the central parts of the city. After new developments to the road network of Tehran, and the building of the Azadegan ring road as a perimeter at the edge of the city (excluding the areas of Shahr Ray and BibiShahrBanoo), some adjustments and redefinitions of the Engelab axis have occurred. Culturally and politically, the Engelab axis played an important role within modern Tehran’s history. The first university of Iran (Tehran University), the first internationally-known Iranian monument (Azadi roundabout), the first international airport and many other buildings were built along this axis. Its spatial structure includes a wide area: for instance, Keshavarz Boulevard in the north and Jomhouri Street in the south. It is one of the seven major centres of Tehran City, as a cultural centre, and in the form of new economic activities.

The strategic location and valuable historic background of this axis, in line with the concentration of specific cultural and economic activities alongside it, and with its role as a boundary between modern Tehran in the north and old Tehran in the south, could be the basis of any future development and renovation plan. The structure and hierarchical category of movement along Engelab axis is a combination of fast and slow traffic. But it requires fundamental traffic management regulations to be able to cope with other axes such as Kan, Farahzaad, Darakeh, Darband–Ray and Darabad–BibiShahrBanoo, as well as the Azadegan motorway, especially in the event of an emergency.

Shush–Bessat Axis: the Shush–Bessat axis is one of the three east–west arteries of Tehran city, and is the result of the continuation and connection of Khavaran Road, the Bessat motorway, Shush Avenue and Saveh Road. At the present time this axis enables journeys outside the city towards Saveh, and goods and passenger movement between the city and suburban areas. It facilitates connections between the central section of Tehran and the southern areas. With respect to the connectivity of the urban area, the public services and the residential area along Khavaran Road and Saveh Road represents the limits of this axis. The area between the Bessat and Shush motorways from the south and north, Shahrzad Avenue (the third road of Shahr-e-Ray) and Ghalemorghi from the east and west is a vast area accommodating various activities such as industry, transportation and warehousing, and needs intervention to become more useful. Distinctively, the Shush–Bessat axis has close connections with major business centres in Tehran (the bazaar) and also works closely with industrial areas within the urban environment. Its service covers a wider area than that within the city boundary. To some extent, this is as a result of being next to the national railway station and the southern coach terminal as the most important elements of transportation, with connections to Imam Khomeini Airport and three major railway lines which pass through Tehran (Khorasan, Geom and Saveh).

6.7 Identifying the Structural Parameters of Tehran City

With regard to the natural environment, historic background and activity system, the most important elements comprising the present areas of Tehran are:

- *Natural elements:* highlands of Alborz in the north and east, outlying villages, subterranean canals and streams and green fields and desert in the south.
- *Historical elements:* historical areas of Shahr-e-Ray and Abdol Azim harram, Old Tehran, Shemiranat and the contemporary residential areas.
- *Operational elements:* Central section (the area includes motorways), areas of suburban activity including industry and the major roads of the city.
- *Movement elements:* major north–south and east–west motorways, road and railway links and ring roads.
- *Urban area elements:* dense residential areas in the south and high-rise buildings in the north.

Tehran's master and development plans have had partial success with these elements some projects have been successful and some have failed. Accordingly, the idea of organising Tehran's areas has not been limited to introducing frameworks and theoretical sectoral intervention. However, in practice, setting roles and collaboration for management of urban development remains premature.

The spatial structure of contemporary Tehran can be considered a compactly centralised, single body urban context surrounded by scattered settlements. The process of historical urban development was concentrated around the central area, expanding in all directions. The three urban centres of Tehran, Ray and Shemiran (with the overwhelming development of Tehran) gradually connected activities. In recent decades, the ever-increasing centralised process of decision-making and government management has resulted in an aggravated single-centre functionality of Tehran City. Although the city expands in different geographical directions, despite the strictly centralised system, the axes of various service centres are diverted from the original centre (the bazaar). These roads act as open ground from the heart of the city towards an open and outgoing system. Unbalanced development and distribution of functions and services has been caused mainly by the lack of preparation and not having a related plan ahead of time (Madanipour, 1998).

Functionality, sustainability and coherence of spatial structure of the area in metropolitan cities require evolution in physical development patterns (TCC, 1995). In terms of the development pattern, it is the structural evolution from a centrally concentrated core shape to a network pattern. In this pattern, the aim is not to create a hierarchy in the level of each centre's functionality, but to distribute activities on a wider scale, wider unique identity and functionality, bringing cohesion to the physical, social and economic utilitarianism of each centre (TCC, 1995). Applying networking and a multi-centre pattern in physical development brings a number of advantages to the city, as follows (MHUD, 2006):

- Distributes providing services functionality all over the city;
- Creates numerous operational and structural cores;
- Encourages the use of improved and different transportation modes and roads.

Based on the variety of opportunities that implementing a multi-centre pattern can bring to the city, in the latest Tehran Master Plan (2006) the consultant suggested that the pattern should be the main framework to implement the above for the future development of the city (MHUD, 2006). The multi-functionality of the capital city and the necessity of organising horizontal and vertical development of the urban area necessitate using the modern multilevel and structural of roads network. In order to increase practicality of this pattern, the following objectives were considered to be important (MHUD, 2006):

1) Consistency and balance in the spatial structure of the area of Tehran, benefiting from distinct natural elements and suburban potentials;
2) Decentralising from the centre and distributing the centrality and density across the city;
3) Becoming multi-centred and multi-sectioned;
4) Limiting physical development with the borders of Tehran City;
5) Continuation in functionality and balance in the physical development of the city;

6) Taking advantage of the potentials of the city;
7) Strengthening the transport network according to the city's capacity and spatial development.

(MHUD, 2006:14)

On the one hand, this has prevented the concentration of services and population in one area, but at the same time the city has developed in every direction and requires expending urban infrastructure.

6.8 The 1968 Master Plan of Tehran

The first extensive plan of Tehran was put together by researchers in 1966. At the time, the population was 2.7 million and the area of the city was 180 km^2; however, the plan predicted that these values would rise to a population of 5.5 million and an area of 650 km^2 by 1971 (TCC, 2006). The plan stated that the development of the city would be in a westward direction, and that the city should be split into ten districts, each district serving a maximum of 500,000 people and with its own council (*ibid*). At the heart of each district, there was to be an activity centre, separated by green open spaces, and including commercial, industrial and administrative activities (*ibid*). Motorways and standard connections were also to be introduced in order to augment the city's transport network.

The plan aimed to establish smaller suburban areas; although Eslam Shahr and Gharchak were not included, Karaj was, and had a population of 40,000 at the time. Another aim was to reduce the population density from 150 people to 90 people per hectare, and to allow the service area for each person to be 55 m^2. The primary objective of the plan was to relieve the city's problems, but without any zoning regulations to control land use or density (UNDP, 2005). All development within Tehran abided by the master plan between 1968 and 1979, the time at which the Islamic Revolution occurred. The (city-wide) Tehran municipality based their plans of each district on the master plan, and all amendments of building density and land use were carried out within the master plan's framework.

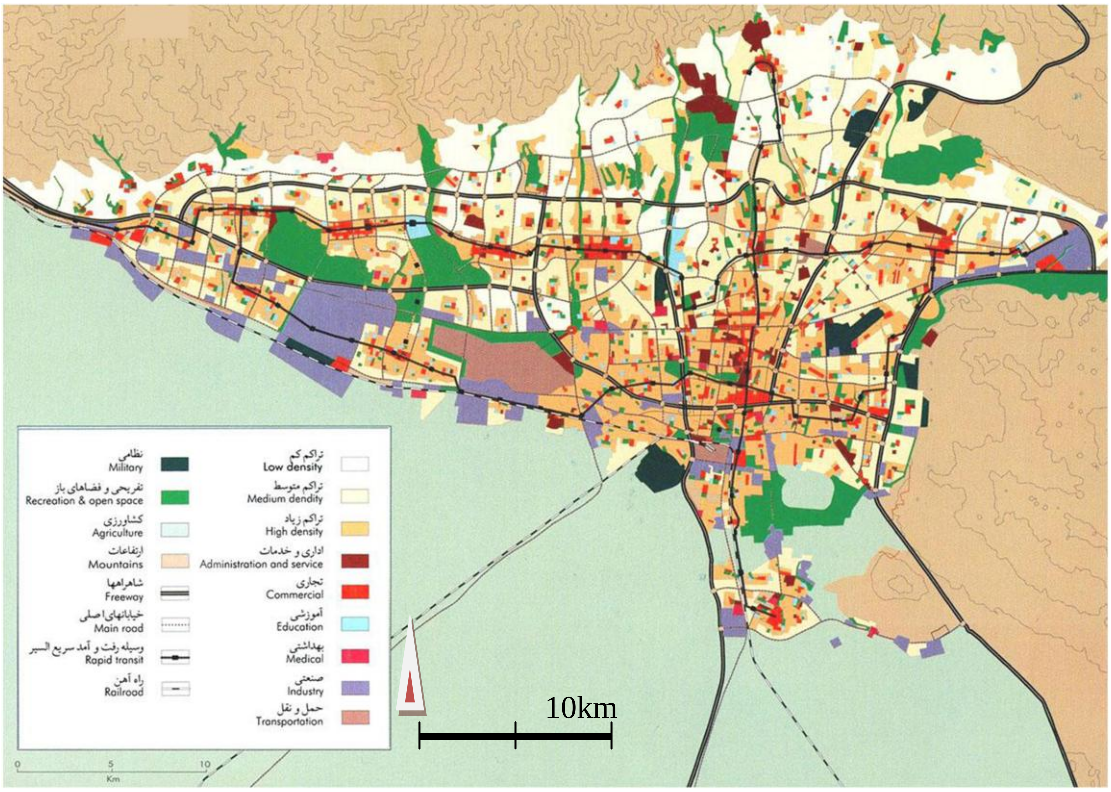


Figure 6.16: Tehran's Master Plan in 1968 (Haghani, 2010:214)

6.9 Comprehensive Plan of Tehran (1991)

The circumstances of the late 1970s were not able to continue, as the downfall of the political-economic elite meant that the government had to concentrate on war issues. The former master plan was discarded following the Revolution, and mass migration to the city of Tehran occurred due to the Islamic government making free land and cheap rent available for low-income people (Haghani, 2010). The matters of land ownership, and its supply, allocation and preparation for housing in urban areas, were looked into by the newly set up Urban Land Organisation (ULO), as stated in the Urban Land Act of 1982 (Ghanbariparsa and Madanipour, 1988). The government was not able to provide the resources and developments within the urban area to meet the housing demand of the growing urban population of Iran, as the growth rate was 5.4% annually (MPO, 2005:26). This change in the demographic pressure of the country meant more housing was needed. For this reason, the government undertook the supply-driven housing strategy, which comprised urban land redistribution and supplying social housing, which was less than 50 m^2 in area. Tehran has examples of these houses, which were a quick-fix answer to the housing problem. They became accommodation for small-sized families, but did not stop the trends of migration and city expansion. In fact, this initiative only added another chapter to housing speculation.

To prevent people moving to Tehran, some government plans such as cheap rent, subsidies and tax incentives were reduced within the First Five-Year Development Plan (1989–1995). However, these prevention tools failed and the population dramatically increased. This required the master plan of 1991 to be approved by MHUD during the mid-1990's (UNDP, 2005) as there were many other factors that increased the speed of Tehran's population increase. These consisted of job opportunities, social facilities and economic attractions.

Table 6.4: Urban and rural populations and their annual growth rate (MHUD, 1995; UNDP, 1994)

Year	National population (,000)	Annual growth rate (%)	Urban population (,000)	Annual growth rate (%)	Urban population (as % of total)	Rural population (,000)	Annual growth rate (%)
1966	25,789	3.1	9,794	5.1	38	15,995	2.1
1976	33,709	2.7	15,855	4.9	47	17,854	1.1
1986	49,445	3.9	26,844	5.4	54.3	22,600	2.4
1992	61,600				58		

ATEK Consulting Engineering (1991) became the private consultancy tasked with preparing the first post-revolution master plan (UNDP, 2005). Wide-ranging regulations were taken out and new regulations were put into the new plan: for instance, "two storeys on the ground floor car park or on the basement" was accepted (this increased to three storeys in some cities in 1984) (Haghani, 2010). Whilst looking into these changes, the central government authorities also considered designating another city as national capital, so that the ever-increasing pressure on Tehran would ease (*ibid*). Eventually the government reached the conclusion that moving the capital was unrealistic as the city was still expanding, private investors were still drawn to Tehran, and the city was evolving into one of the largest economic zones in the country. Plans were therefore made to rebuild Tehran as quickly as possible, and were undertaken straight away.

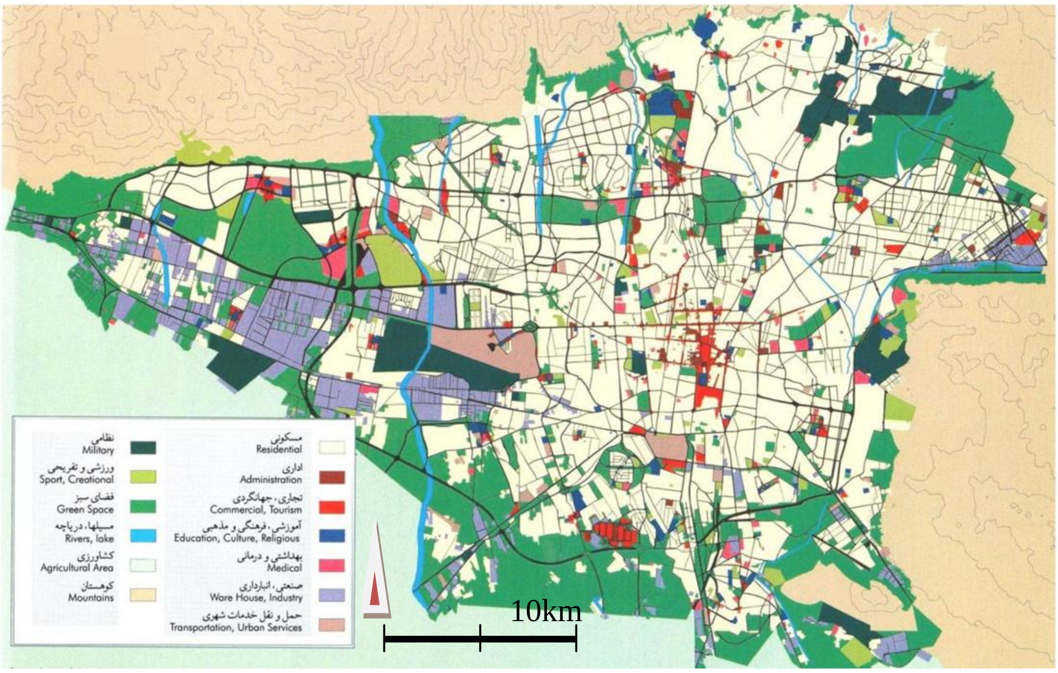


Figure 6.17: Tehran's Master Plan of 1991 (Haghani, 2010:214)

In the new master plan (1991), the previous ten districts were reduced to five (north, south, east, west, and central), but the road networks and the area Tehran occupied were similar to before (TCC, 2006). The population increased from 5.5 million to 7.65 million, and the facilities offered per head reduced from 55 m^2 to 32 m^2 (*ibid*). This plan also examined the impact of the newly-constructed surrounding towns such as Karaj, Eslam Shahr and Gharchak (*ibid*). The construction of a further five towns was advised in order to cope with the larger population; however, the existing surrounding residential areas were not taken into account and this idea was not successful in relieving Tehran's housing problems (Madanipour, 1998). The plan did not mention disaster management or mitigation at all.

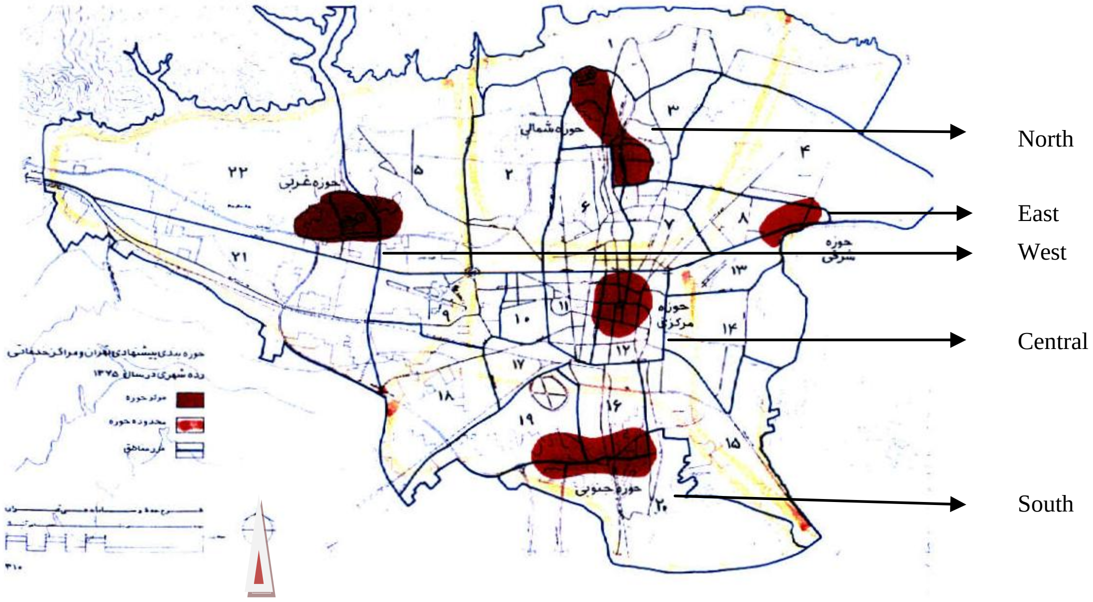


Figure 6.18: Districts and areas in the first Master Plan after the Revolution, 1991 (TCC, 2006:160)

The use of the plan was generally discredited, as the central government had withdrawn financial support from the municipalities in 1981, which meant that achieving the costly plans without government help became impossible. New towns could not absorb the predicted increased population, and central government did not support Tehran’s municipality in stopping illegal housing activities either. A self-sufficiency initiative was introduced, so a tax system on properties, corresponding to their function, was administered by Tehran’s municipality (Tajbakhsh, 2003). After the war, the municipality was able to raise enough money for the construction of new motorways, the improvement of the city’s sanitation, the extension of green spaces and parks, and the availability of general public services, by making agreements with property owners, and also by density bonusing.[28]

[28] Density bonusing is a controversial but extremely popular method of raising the municipality’s finances, by selling the building density (for example, permitting a property owner an initial two-storey building at 100% density, then increasing it to a four-storey building with 100% plus *x* amount of density and charging an amount for each m² of extra permission) or changing the use of the property (for instance from a residential to an office or commercial use which will give extra value to the premises and the permission can be bought from municipality on *x*% of the added value.

6.10 The Master Plan for the Surrounding Areas of Tehran (2002)

Local authorities began to look into Tehran’s surrounding cities and areas, due to both an increase in the number of problems within Tehran, and social restlessness within the surrounding areas. The expansion of the cities and settlements around Tehran was partly the cause of the population of Tehran province increasing from 700,000 to 3.5 million between 1966 and 1996 (TCC, 2002). The surrounding areas were highly dependent on Tehran in relation to basic civic needs and housing, as they did not have adequate facilities of their own (Goharipour and Karimi, 2011). A lot of the residents here were vulnerable people, with low incomes and living in illegally-constructed houses. Providing enough houses and services for such a large population was immensely difficult. In 1996 MHUD therefore began to put together a plan, “The Plan for the Management and Development of the City of Tehran and its Suburban Areas”, which would allow the residents to deal with the various problems, particularly within the newly-developed residential areas. Within the same year the cabinet accredited the plan and the engineering consultancy Boom Sazgan was asked to carry it out. The High Commission of Architecture and Urban Design (HCAUD) accredited the study in 2002, followed by the cabinet of MHUD.

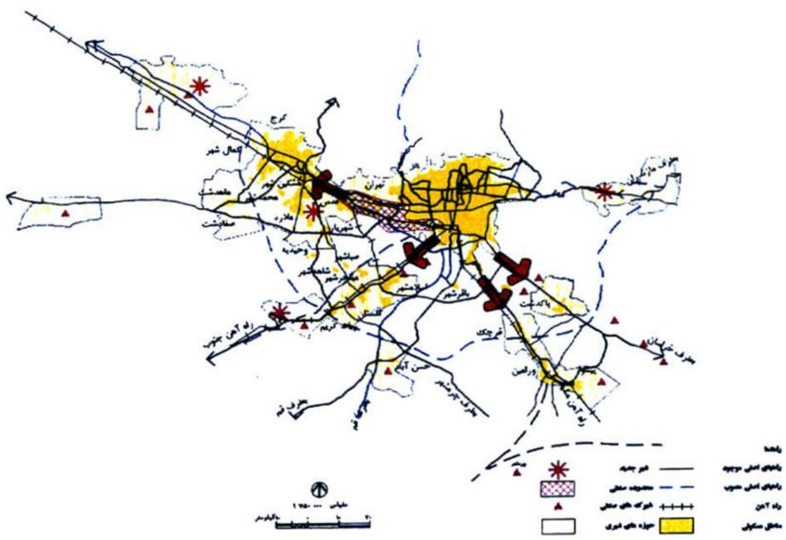


Figure 6.19: Pattern of development of Tehran Province (MHUD, 2002; TCC, 2006:10)

The objective of the plan was to keep the habitation and settlement of the growing population in control, both within Tehran and the surrounding settlements. One way of doing this was by dispersing the population and services of the city into the surrounding areas, which would result in those areas acquiring improved social, economic and urban services, as well as becoming far less dependent on Tehran. This was accomplished by creating a management centre for Greater Tehran, rearranging illegal settlements, and amending both the physical and social conditions of the suburban areas. The plan explained that Tehran would continue to be the capital city and required to play an important role in both the region and the world (TCC, 2002). This plan also stated that the urban population would not rise beyond 7.65 million. However, many of the proposals within the plan did not take place, despite gaining authorisation from the cabinet. Creating the Greater Tehran Management Centre, for instance, was a complicated but useful idea that never took place due to the lack of institutional capacity of various different authorities, their different regulations and priorities and the lack of a collaborative action plan. Also, there was not a clear and robust recommendation for disaster mitigation within the plan, which could easily be discredited if an emergency were to happen.

6.11 The Aims of the Master Plan of Tehran (2006)

Tehran and the surrounding areas have not always been managed in direct compliance with the master plans. This is apparent when the objectives of previous plans are compared with the reality of the urban structure. This has been partly blamed on the plans' approach when addressing the problems and therefore suggesting solutions for them; and partly it is the result of the municipality's governance mechanism. In the latest Tehran Master Plan, as discussed in the following sections, there has not been much improvement in these aspects. Part of the city's financial needs for urban development and the restoration and provision of daily urban services, as well as other activities, comes from building density bonusing techniques. The property developer does not always have consent to build over the plan's stated limit within the method of selling density, so this could simply mean that he changes the function of the land or building to something that will ultimately be more profitable; for instance, switching from a residential to a commercial function. It is thought among critics such as

Farhoodi et al. (2009) or Roshan et al. (2010) that these events are detrimental to the building industry and reduce the use of land.

The municipality accredited new regulations within the plan to try to amend housing circumstances, one of which was to reduce the number of storeys allowed on a plot of land. Regulation 269 of the 2002 Master Plan stated that only seven storeys were acceptable in a residential area; this was later changed, and Regulation 329 of the 2006 Master Plan stated that only five storeys were allowed. The plan also called for more involvement of other local authorities, such as the Engineering Construction Organisation, to have their say in the process of writing the plans. The local authorities and organisations could then play a major part in acquiring a durable and integrated plan, in which the aims could be realistically reached, by putting forward their knowledge and facilities.

Looking at Figure 6.20, it can be seen that the national role (level 1) and the regional role (level 2) of Tehran were investigated together, before being applied to the local aspects of the city of Tehran (level 3). All of these factors were then put together in order to devise a master plan which was comprised of the aims, approaches, and frameworks at all three levels. This plan was then used to produce documents containing rules and regulations for city development which Tehran was to abide by. In the beginning, the main objective of this integrated plan was to restore the city and improve the inequality and disarray of the city’s physical developments, which would be accomplished by utilising the master plan documents for city development. However, ultimately, the main objective of the master plan was to construct a written document to both discover and present the problems within Tehran. This was required in order to carry out the structural changes to the city, which would result in improved utilisation of land, and to activate a practical plan for city management. In this plan, there was also a section relating to natural disasters, including earthquakes and floods (TCC, 2006). The plan used the JICA and TDMMC studies and analysis of 2004 to comment on general regional requirements. Nevertheless, serious regulations were not actually instituted to “incorporate hazards into the land use and planning process” (UNDP, 2005:11). The 2006 Master Plan also noted the necessity of analysing land use in order to give various areas certain functions; residential areas have other uses at present, which results in the functions of the city being in disarray.

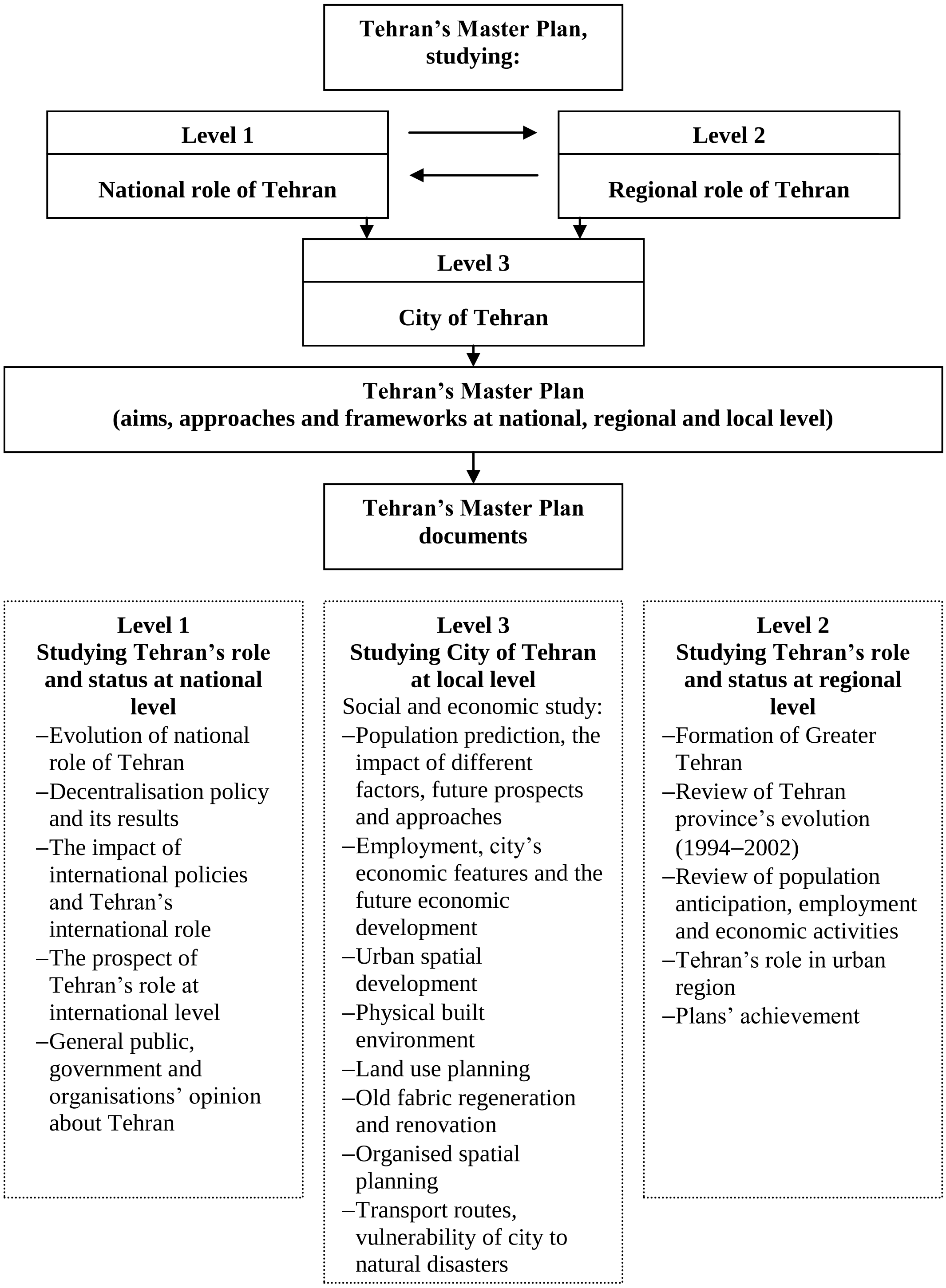


Figure 6.20: Guidelines for master plan's study: Tehran's Master Plan (TCC, 2006: 13)

6.12 Objectives and Expectations of 2006 Master Plan

The major problems of Tehran are the variable construction activities and the unapproved developments, especially in the northern and eastern areas. The disarray of land use has resulted in the impossibility of a secure and healthy living environment. Although the council has tried to retain green spaces and expanded the of public open space areas, the cityscape still needs work, as does the number of services accessible to the public within the city. The master plan’s priority set the targets for the city as follows:

1) *The city had to portray an Iranian and Islamic centre*. There is consensus amongst the planners and planning authorities on such a general concept. However, for the last three decades, and even within this specific plan, there is no transparent and simple example of such identity and how it could work with modernisation, exotic materials and general public interest.

2) *The city had to become knowledge-orientated, worldly, and an international centre*. The ambition of creating an internationally-recognised and economically competitive city has always been expressed in the plans which are inspired by the globalisation process. But the challenge for Tehran has remained about the clarity of aims, inclusiveness and comprehensiveness of the master plan and its competition with the central government Five-Year Development Plan and political agendas.

3) *It had to become an enterprising city and safe for investment*. This claim by the plan is worthy but not clear in its approach. The plan did not study this deeply and did not provide reliable suggestions and ideas in terms of macro- or micro-economy activities, location of industries and policies that could facilitate local, national or even international investments. The plan became more contradictory, as it recommended out-migration of industries without recommending adequate infrastructure and road access to them.

4) *By enhancing the quality and quantity of green spaces it had to enhance the environment.* Pointing out green spaces as a significant item in improving the quality of the urban environment was repeated many times in the plan. Setting them aside as a priority is precisely an advantage to urban life, but there is no mention of the multi-functionality of these spaces, especially with regard to disaster management. It also lacks spatial coherence within the densely-populated areas of the southern districts.

5) *The city needed to improve aesthetic and attractive public places*. This included roads and open spaces. This implies that "aesthetic" was not clearly described, which made for an open-ended and literally useless agenda. There were suggestions about the involvement of the private sector and other government institutions, though without seeking their cooperation.

6) *The extent of safety and the withstanding of disaster had to improve.* This is a turning point in this plan in comparison with previous plans, in terms of the recognition of disaster-related policies. However, this was an extremely under-developed strategy with no academic or realistic approach. This was, indeed, only the first step towards an internationally-recognised policy, which requires background knowledge and adequate management technique. Highlights of the plan's recommendations are explained later.

7) *The plan aimed at Tehran becoming a sustainable city comprising sufficient facilities and infrastructure for economic and social activities, recreation and living.* How could this happen? It was not clear from the context of the plan how the municipality could achieve such goals. The role of other government organisations was not clarified. The use of sustainability ideology did become part of the plan's literature, without clearly identifying the challenges of Tehran's management mechanism or preparing background inter-organisational coordination and strategic development policy. This significant ideology, and how it could meet the requirements of a practical initiative, was not fully developed in the plan's recommendation.

8) *The ambition was to have a comfortable city that offered augmented and suitable plans to ensure public well-being.* The well-being consisted of various factors and defining points which were not clearly identified and described in the plan. The consistency and accessibility of public services, such as metro stations, parks and schools, were amongst such items. But there are other factors, such as social and economic conditions, that can influence the community’s well-being, but were not included in the plan. This, alongside other short-sighted approaches used in the plan, discredited it as an integrated policy.

9) *The plan hoped to minimise inequality, as well as providing thought-out and controlled public welfare.* The general claim of the plan was hidden within the aims. In order to eradicate inequality, for instance, the plan suggested the improvement of the elevation of some of the privately-owned buildings. This might be an effective tool to reduce the environmental inequality amongst neighbourhoods, but it barely touched on wider discussion in society and the differences between poor neighbourhoods and affluent areas. Using this kind of insight into planning had just recently emerged into Iranian planning system, but without a suitable background.

10) *The city had to improve as a metropolis with a central role in political, social, cultural, and economic issues in the country, as well as having national and international roles.* To become so, the plan suggested fast-flowing traffic, improvement of urban infrastructure and reduction of air and sound pollution. These elements, alongside strict controls on building activities across the city, were identified as the touchstone of being a world-class city. The area of the plan’s context again was prepared by the same actors, planning consultants, the municipality, HUDO and the provincial governor’s office. The diversity of discussion was weak as the decisions.

For the strategic development framework, the plan advised an integrated approach amongst key city governance actors. Therefore, elements’ vulnerability within the government structure and with other stakeholders would improve. In doing so, the most substantial task was suggested as working out what problems were causing these vulnerabilities; they were identified by the plan to be utilising the knowledge of the municipality and other organisations. This knowledge was suggested to be around the current issues shown below:

- *Utilising local, physical, social, economic and human resources, and potentials, to strengthen Tehran's status on a regional, national and international level.* This could initially strengthen the local economy and improve the quality of production.
- *Abiding by the plan's regulations, especially on the city boundaries, in urban management, and laying out the boundary lines of the city so that further development would be avoided.* In this way, the majority of building activities and urban development would be observed by the municipality and irregularities would lessen.
- *Maintaining a population of 8.3 million (TMCSC, 2010) within Tehran and preventing the construction of illegal settlements in old and new suburban areas.* Providing adequate services to the city's population, as well as controlling its development, is crucial. But the question remains around the approach taken to achieve such goals.
- *Promoting and helping bring about economic activities, and amending present business activities, as additional development is essential*. Tehran is in need of 3.25 million new jobs, according to studies.
- *Preventing damage to natural features of the environment by urbanisation.*
- *Alleviating the impact on urban life at a time of natural disaster.* It is not clear who and how would carry this out and with what plan.
- *Improving the transport network and bringing disciplinary regulations and management for transportation into effect* by introducing basic public transport, managing the supply and demand of private transport, introducing road standards and creating infrastructure.
- *Introducing realistic yet flexible regulations for land use in order to make people aware of urban spatial built environment standards and the physical quality of urban fabric.* This is an ideal approach to planning, which requires collaboration amongst key local and central authorities.

- *Having complete control over the amount of land set aside for residential use*, population density, the correct use of city land considered for public spaces, improving the quality and potential of current public buildings and facilities in order to offer a range of functions and opportunities for various social activities.
- *Refurbish old fabric and historic buildings*. This can reduce the vulnerability of historic fabric, in terms of losing economic and spatial elements.
- *Ameliorate the quality of environmental conditions and urban life.*
- *Protect the natural, historical and cultural heritage.*
- *Enrich social life by implementing plans in certain locations* to increase the number of community centres.

The plan discussed the issues around the management of public services; however, it did not cover a realistic way of putting the objectives into action. The plan stated that the requirements of residential areas should not put the spatial characteristics of the neighbourhood in jeopardy. Although there was no account demonstrating how it was calculated, the 2006 Master Plan stated that the maximum population of the city should be about 8.6 million, based on the availability of public spaces and services. The plan also worked on finding a solution for the illegal and scattered settlements surrounding the city by imposing a green belt around the city, in order to control further development. However the plan did slightly contradict itself, as it also sought to ameliorate the environmental and social conditions of these areas, which would inevitably lead to more migrants moving there. The amendments consisted of strengthening structures, making buildings safer, and establishing resident support activities, which would therefore improve housing and living standards (MHUD, 2006:75). One of the plan's objectives was to maintain land for green spaces and social activities by prohibiting the construction of buildings on these sites; changing the use of a current green space was prohibited, unless it was for a public service.

To try to minimise social exclusion and inequality, the plan proposed that the southern and central areas of Tehran should have their community centres and other leisure activities improved and augmented, and suitable public spaces and services made available. The plan also explained, although not in great detail, how important public participation was in the refurbishment and regeneration of old areas. It then went on to state how local elected councillors and community representatives had a major role in local management and in solving local issues.

6.13 The Master Plan's Policy to Make Tehran Safe against Natural Disasters

The master plan, in a naive and underdeveloped approach, addressed the necessity of improving Tehran's physical features to withstand major disaster. The following are its main outlines. As this shows, there is no in-depth understanding of the vulnerable aspects of the city and how they can be improved.

6.13.1 Earthquake

It is an indispensable obligation that steps are taken to recognise the possibility of a natural disaster, especially an earthquake. This affected the context of the plan, which recommended the following:

- Areas positioned on the first-level fault lines in the north and south of Tehran, as well as areas which are geotechnically unstable, should be used only for green spaces, not for construction.
- The population density in the high-density areas of Tehran should be reduced.
- Construction should not take place on steep slopes.
- Earthquake-resistant building structures should be built.
- Certain public buildings and land should be equipped so that they are able to provide emergency service during a disaster; the international standards advise that these buildings should be designed and constructed as earthquake-resistant. During a crisis these designated areas could be used as temporary shelters.
- The ways in which to convert the open and equipped spaces into shelters and rescue stations should be thought about so people can be helped if an earthquake does occur.
- Dangerous industries should be relocated to the outskirts of the city to minimise the number of casualties.

- Safety measures should be undertaken in public buildings and infrastructure.
- Preparatory measures of how to manage and act in an emergency situation should be put together prior to the emergency.

The plan's aims were vague and not clearly connected. The purpose of this research is to guide the city on how to use the urban development plan during the occurrence of an earthquake.

6.13.2 Flood

The 2006 Master Plan also gave information on another emergency situation: flooding. The following is a list of measures that should be undertaken during development for safety purposes, according to the plan:

- Safety devices and canals should be planned and distributed in the north of the city in order to control the flow of water from the highlands.
- Areas which are at high risk of flooding should be located, and drainage constructed which will efficiently collect the flood water.
- Regulations should be put in place for all buildings, no matter what the function, to take anti-flood precautionary measures into account.
- Water drainage systems and ways of collecting surface water should be improved in order to maximise the flow of water into canals.
- Land should be studied for flood risk and small shallow ponds built which would easily absorb water, to maximise rainwater absorption.
- Open green spaces should be reorganised between residential areas in order to help absorb flood water.
- Building safety against flood should be improved, particularly within vulnerable areas.
- The number of buildings built on the river bank should be reduced, and rules and regulations should be introduced for buildings so that damage due to floods is avoided.

- Prevention and management plans should be effective, and firemen should be properly trained, in order for the city to be fully prepared to deal with the needs of an emergency.

All of the above plans are imperative; however, the guidance is unclear, the name of the responsible authority has not been given nor how disaster management mechanisms would work in real situations, and there have not been enough academic studies.

6.14 Development Plan of District 17

This unapproved plan (2011) has again used the same framework as previous plans to propose changes in the area. Its aims are to:

- Improve the quality of urban environment for a better and sustainable development;
- Be regulated in terms of urban management and future changes at national and local level;
- Reduce environmental pollution;
- Reduce the extent of damage to buildings and reduce population numbers;
- Renovate and regenerate the old, dense urban fabric of the area;
- Strike a balance between different services and public requirements;
- Give direction to the spatial distribution of the population;
- Move causes of pollution out of the area;
- Relocate the existing businesses to non-residential areas;
- Improve the quality and quantity of green space of the area according to its population;
- Improve the road traffic and other networking features.

Despite the failure of past plans in terms of integration and rapid growth of the areas, this plan is again quite similar to the others. It starts with the chronological study of the area, describing how in the past it was subject to initial master plan decisions. The plan believes that this district was mainly influenced by somewhat external factors which reduced the quality of the district's built environment. Low land prices and unavailability of services have attracted noisy industries into the area. In terms of residential building quality, its natural environment, alongside residents' economic condition has also affected the quality of local housing. The proximity of the area to the centre of Tehran, the national railway and other major services has made it a focal point. In the past there was also emphasis on renovation of the area. Similarly, it was due to illegal land subdivision and building activities that, despite its location inside the city boundaries, the area was occupied mainly by low-income people and its housing is of poor quality.

Table 6.5: Details of the properties in D17 (MHUD, 2011:20)

USE	PLOTS (no.)	LAND (m²)	AVERAGE PLOT SIZE (m²)	DENSITY
Residential	32627	2,893,442	88	65
Commercial	954	1,069,019	1,120	42
Mixed use	6,571	926,071	140	69
Shopping centres	5	5970	1,194	98
Religious	202	61,668	305	65
Educational	72	156,224	305	65
Cultural	12	34,449	2,870	29
Medical	11	14,287	1,298	44
Sport	4	21,541	5,385	90
Urban infrastructure	152	28,056	184	31
Urban facilities	4	293	73	100
Governmental	13	13,373	1,028	39
Warehouses	5	4756	951	22
Green space	47	78,568	1671	0
Military	2	26,110	13,055	22
Derelict land	1,555	282,212	181	0
Agricultural	5	18,985	3,797	0
Unfinished buildings	131	67,162	512	0
Field	58	43,818	755	1
Buildings	429	439,223	1,000	30
Total	**42,859**	**6,175,237**	**144**	

The urban characteristics of the area are/were influenced by the Tehran Bazaar in the north, the railway running through the area, unplanned inner-city developments and many more factors. This has led to the main commercial and industrial activities being located on the edge of the district and around the main roads. The absence of a spatial centre of activities and shopping centre is notable. Table 6.5 shows the number of land plots for certain specific usages. The area is extremely run-down, densely populated, disproportionate, unbalanced and of mixed use. According to the 2011 development plan data, 67.7% of land plots are less than 100 m^2 in area, which would make any changes to the spatial fabric of the area difficult.

The plan has recommended a series of partial interventions and improvements to the quality of residential buildings, road widths and organisation of commercial and industrial activities. However, as expected, firstly all the figures and data come from official figures, conducted by government organisations and other sectors. Secondly, local residents' involvement within the planning process is lacking. Thirdly, except in a few sentences, there is no reference to or use of JICA or other disaster planning studies. Therefore, these have not had any impact on the recommendations of the plan. Fourthly, land-use planning, which is purely a physical development element, dominates the context of the plan. This in turn has an impact on the practicality of decisions, the plan's integration with other sections of society and with various organisations. There will be more discussion in this regard in the concluding part of the thesis.

6.15 Conclusion

As has been described in this chapter, the topographic location of Tehran on the fault lines of Damavand, the Mosha Fault, the Tehran Fault and the Ray (Rey) Fault, which extends to the Alp-Himalaya orogenic zone, is the main element increasing the danger of an earthquake. Considering the potential earthquake hazard in Tehran due to existing active faults requires development of disaster management infrastructure and space. At the same time, Tehran has experienced the highest urbanisation process of any city in Iran in the recent years. The city has five main north–south and three east–west transportation axes, which are the busiest traffic movement routes. As they are looked at in detail, it is evident that they are in need of extensive improvement to meet their present needs for the high volume of traffic. If they are going to be considered as possible emergency transportation routes in the aftermath of an earthquake, major reconstruction is required for their accessibility and serviceability and the surrounding open spaces. The next chapter will portray the spatial structure of the city for future research development.

Chapter One……………………………… **Introduction**

Chapter Two…………………………… **Conceptual Framework**

Chapter Three……… **Evaluation of Damage and Risk due to Earthquakes**

Chapter Four………………… **Open Space and Diversity of Services**

Chapter Five………………………… **Research Methodology**

Chapter Six….. **Identifying the Spatial and Geographical Structure of Tehran**

Chapter Seven. **Use of Urban Risk Assessment Tool for Main Planning Resources**

Chapter Eight… **Evaluation of Risk in the Study Area**

Chapter Nine…. **Open Space Design Criteria for Refuge Areas**

Chapter Ten…………………… **Conclusions and Recommendations**

7.1 Introduction

The previous chapter illustrated the general spatial characteristics of Tehran in terms of its regional transport arteries. It also explained the historical development process of the city, charting the irregularities that exist within the planning management system. This chapter will use the VCA assessment tool to critically analyse the present legal documents referred to by planning authorities, which in Tehran (refer to Chapter 6, section 6.7) consist of the HUDO office, the planning consultancy, etc., the council, and, above all, the municipality, to guide, control and regulate any urban activities conducted by citizens or officials in Tehran. The tool has the capability to be used for primary and secondary sources, with different detailed focuses. It also has elements of a physical assessment tool as well as assessing social issues. This will be exclusively looked at in the next chapter, where possible physical earthquake damage will be analysed for Tehran as a whole and for District 17 in particular.

7.2 Vulnerability and Capacity Assessment (VCA): A Tool for Guided Structural Analysis

This framework is a practical and chronological guide which intends to conduct a step-by-step process in order to reach a plan. The plan aims to:

- Provide essential information for “becoming the entry point to an emergency need assessment following disaster”;
- Create a community to identify living environment risks and hazards;
- Identify local capacities to manage the disaster’s aftermath;
- Create cooperation and agreement amongst local authorities;
- Encourage conducting “prevention, preparedness and risk reduction” plan (Benson et al., 2007:2).

In doing so, the assessment would be in three rather broad categories:

- Utilising a designated method to identify the risks that people face at a city and local level;
- Working out the extent of vulnerability to those risks at both levels;
- Identifying the city and local capacity to cope with the risk and react to it accordingly (*ibid*: 3).

Following the assessment, the research analyses the information on the given context of Tehran and the District 17 community's vulnerability to hazards. The main concern is the spatial structural analysis, which addresses the location, accessibility and capacity of existing and new open spaces within the case study area. This analysis will lead to the reduction of the risk of potential disaster, whilst also reducing vulnerability and increasing capacity in a genuinely participatory manner.

The following table (Table 7.1) summarises the framework for Chapters 8 and 9; it includes the conceptualising of general approaches to detailing local vulnerability and capacity. The two main categories of physical and social vulnerability are what this chapter and the next chapter will discuss. There will be some overlap within their context as it is hard to completely separate them, especially within the risk assessment arena. However, each section aims to discuss and highlight certain subjects under the main category. This set of chapters is also in accordance with the initial research concept (Chapter 2) under integrated disaster risk management, learning from earthquake damage to buildings and infrastructure, and open space as a facilitator and service area. The data obtained from various sources (interviews, questionnaires and secondary materials – published and unpublished) (Chapter 5, section 5.5) are the main contextual formation of the next few chapters.

Table 7.1 Vulnerability and capacity assessment criteria (Benson et. al. 2007:7)

Sector	Vulnerability	Subject	Context	Capacity	Chapters
Social	Occupants of unsafe areas			Social capital	7, 8
	Mobility, human vulnerability			Coping mechanism	8, 9
	Perception of spatial structure			Governance	7, 9
	Education			Leadership	7, 8
	Management and hardship			Non-governmental organisations	7, 8
	Disaster planning			Disaster plans	7
	Population details	Census	Census zone maps Population data of 1996 census		7, 8, 9
	Historical background and awareness	Earthquakes	Earthquake activities Earthquake scenarios List of historical earthquakes and damage records	Diversity	7
	Economic activities and industry			Economic capital	7
Physical	Buildings at risk	Building	Building data of 1996 census	Physical capital	7, 8
	Geography and geology of neighbourhood	Topography	Topographical characteristic	Resilience building and structures	7
	Wind directions	Geology	Geological map Fault map		7
	Land specification	Land use	Land use map		7, 8, 9
	Unsafe infrastructure	Hazardous facilities	Hazardous facilities data		7, 8, 9
	Inadequate facilities				7, 8, 9
	Building density				8, 9
	Roads and access, public transport	Transportation	Traffic zoning map Road network data		7, 8
	Public resources, parks, hospitals, open spaces, schools, police, fire stations	Urban facilities	Fire station data Health and medical centre facilities Police facilities Governmental public facilities Parks and open spaces		7, 8

This chapter covers the city's situation in terms of its historical urban planning experience and general vulnerability and capacity under:

- The location and geography of the city;
- Population and demographic information;
- Access and networks to and within the area;
- Economic activities location and structure;
- The area's resources.

This is followed by a more locally-oriented approach and identification of the Khazaneh neighbourhood in District 17. The sequence of provision of the data and their analysis may not be clearly marked; however, it is valuable information for further discussion.

7.3 Urban Development Plans of Tehran: A Multi-aspect Approach

Due to the introduction of transportation technologies, Tehran was able to decentralise and urbanise in the 20th century, with homes and factories being constructed on the periphery of the city. The master plan of 1967 was devised in order to keep this process in control; however, it resulted in a number of problems, one of which was the fact that the government had no choice but to set up new districts outside Tehran's existing boundaries (Madanipour, 2006). As the problem with irregular settlements had not been solved the municipality of Tehran abandoned the use of the plan in 1991 (*ibid*). Following this, "A-Tech", an Iranian town planning organisation, began conducting a new plan for the transitional period (1986–2006); however, it was not until 1993 that the municipality and the Urban Planning High Council were able to approve the plan (*ibid*). Utilising the scales of the urban region, sub-region, district, area and neighbourhood, the plan concentrated on growth management and linear spatial strategy. It encouraged conservation, decentralisation, polycentric development, the development of five satellite new towns and greater residential densities in the city (*ibid*). Dividing Tehran into 22 districts, within five sub-regions, was also offered for consideration (*ibid*) (Figure 6.4).

This plan not only looked at land use, but also aimed to solve several of Tehran's problems, some of which were the presence of environmental pollution and the absence of effective public transport and disaster preparedness, which was caused by the increase in the rate of urban growth. The District 17 development plan, as part of area development policies, has also been a useful piece of work in this research as it has provided invaluable information about the area and its development prospects.[29] So far all plans constructed for urban development within Tehran have been unsuccessful due to lack of finance, non-existence of cooperation, and not addressing the problems within the city.

Another useful source entitled *The Report and Study on Seismic Microzoning of the Greater Tehran Area* (JICA, 2000) is a document estimating and analysing the seismic vulnerability of the city, and which determines some recommendations for mitigation of damage and loss. This report was the first dedicated study targeting the risks to and vulnerability of the city, by using various analytical techniques and programmes such as GIS. It consisted of relevant and specific data, analysed in area maps, to illustrate the possible damage and estimate the destruction of an earthquake in the region. There are two main points about this document in terms of its use. First, although the data used in JICA's study was obtained from a range of local and national resources, there was hardly any reference to the master, or comprehensive, plan of Tehran. This means that it is an important document within the field of urban planning which was alienated and disconnected from other available resources. Second, there were a few practical recommendations to make new, strong connections with the Tehran development plans. This, again, undermined the validity and practicality of the recommendations, and all the efforts put into preparing this study. This chapter will consider and analyse them using the VCA tool.

7.4 The Problem

In the past few decades, the growth of Tehran has been completely different to the growth of all other large cities in the world, due to the impact of economic pressure

[29] In the previous chapter, the summary of both named plans was discussed.

and the weakness of specific comprehensive policies. The attempts of the municipality to provide urban services, improve the city infrastructure, exercise control over building construction activities and establish various agencies coexisting under the municipality's umbrella have not been able to conduct the city through its fast growth. Unregulated building activities, such as density bonusing (as discussed before) encumber the city management. In the interviews conducted in this research, many interviewees, including HUDO, a private consultancy, and IIEES believed that density bonusing is the main cause of Tehran's municipality issues. "The financial constraints of Tehran municipality has turned density bonusing into a hammer in the hands of municipality to destroy the city's safety" (HUDO officer). This was supported by the recommendation made by Boom Sazegan consultancy: "Density bonusing should be prohibited altogether and the municipality has to seek using other ways to solve its funding problems" (Boom Sazegan consultancy). The result would be different if density bonusing had never been created. One interviewee even arguably believes in putting a stop to this longstanding tradition.

The past failed plans have led to Tehran being unable to fulfil its role as a safe, fit-for-purpose city on national and international levels, and unable to reclaim its status as a capital city. The objective of Tehran's development plans is now to provide housing, businesses and offices for its existing population.

At a regional level, social and environmental problems within Tehran have been caused by the lack of consideration to the issues of population settlement, and to providing developmental civic activities in counties and populated areas around Tehran. High air pollution, traffic exhaust gases, serious vulnerability to probable earthquakes, absence of public spaces and civic facilities, a decrease in the security of residential areas, disparity and inefficiency of industrial areas, social and cultural abnormalities, along with an asymmetrical cityscape, lack of adequate disaster mitigation plans and management and several other issues have resulted in the need for extreme urban management and planning to improve Tehran's urban environment and living conditions. For instance, "the city is virtually surrounded by faults and has suffered large earthquake disasters in a cycle of approximately 150 years" (UNDP, 2005:13). It is predicted that it is quite possible to have a major disaster in the near future with a death toll of 120,000 to 380,000 if either the Greater Tehran Fault or the Ray Fault cause an earthquake scenario of MW=7.2 and 6.7 (*ibid*:13). The damage would range from 85% complete building damage in the south of the city to 55% extensive building damage and 20% complete building damage in the north (Rad, 2006:2). There are also many unsafe buildings, inadequate infrastructure and densely-populated areas in the city, which make it highly vulnerable. A comprehensive review and a study on the management process of city development are needed to manage these issues and obtain answers to solve these problems. Including all of these aspects within the city's development plan is crucial in assisting the achievement of safe, sustainable and comprehensive development.

Picture 7.1: Shemiran in 1957 (left), and in 2005 (right) (Haghani, 2010:219)

The need for such readjustment was emphasised by most of the interviewees at a government and community level. "Effective response to a disastrous situation requires changes in the pattern of road usage" (fire brigade officer) whilst "safety of roads and bridges are in doubt" (university lecturer). Nevertheless, the approaches to achieve a safe city are diverse, influenced by social, political, and administrative factors; the decision-makers' knowledge and public trust manifest the shortcomings of the existing system.

7.5 VCA Physical and Social Criteria in the Case of Tehran

With the VCA tool in mind, the following sections will analyse the geography, population, land specification and urban planning aspects of Tehran, the case study area (District 17) and the selected neighbourhood (Khazaneh). In this way, a general picture of the case will be presented which will consequently be used for risk assessment in Chapter 8. It is difficult to separate many general planning and city management elements which complicate the area; however, this is a preferred option in studying and evaluating the capacity and vulnerability of certain urban contexts.

7.6 Background to the General Vulnerability of Tehran

In 2005 Tehran had a population of 7.23 million and an area of around 780 km^2, and is positioned at the centre of a larger region (Rashidi, 2009) which has increased to 8.3 million in 2010 (TMCSC, 2010). Countryside and populated areas encircling Tehran are located around 30–40 km away, and as a whole have a population of 4.5 million (*ibid*). The majority of the building activities within the illegal settlements around Tehran are densely populated and are deficient in social and economic diversity, basic suitable infrastructure and most importantly disaster-resistant infrastructures. Due to the lack of facilities and services, these areas are extremely dependent on Tehran. Figure 7.1 shows the position of Tehran with its 22 districts next to its natural surrounding features.

The mountain in the north acts as a shield, but high demand for accommodating the 20% growth of population has pushed a new trend of building activities outwards in all four directions, especially east and south (Rad, 2006:20). The pictures (Picture 7.2) indicate how man-made built environments embrace and evade the natural environment in and around the city without any fear of obstacles. Figure 7.2 also demonstrates the dangerous location of the city in the heart of some active faults that have subjected the area to earthquakes several times before.

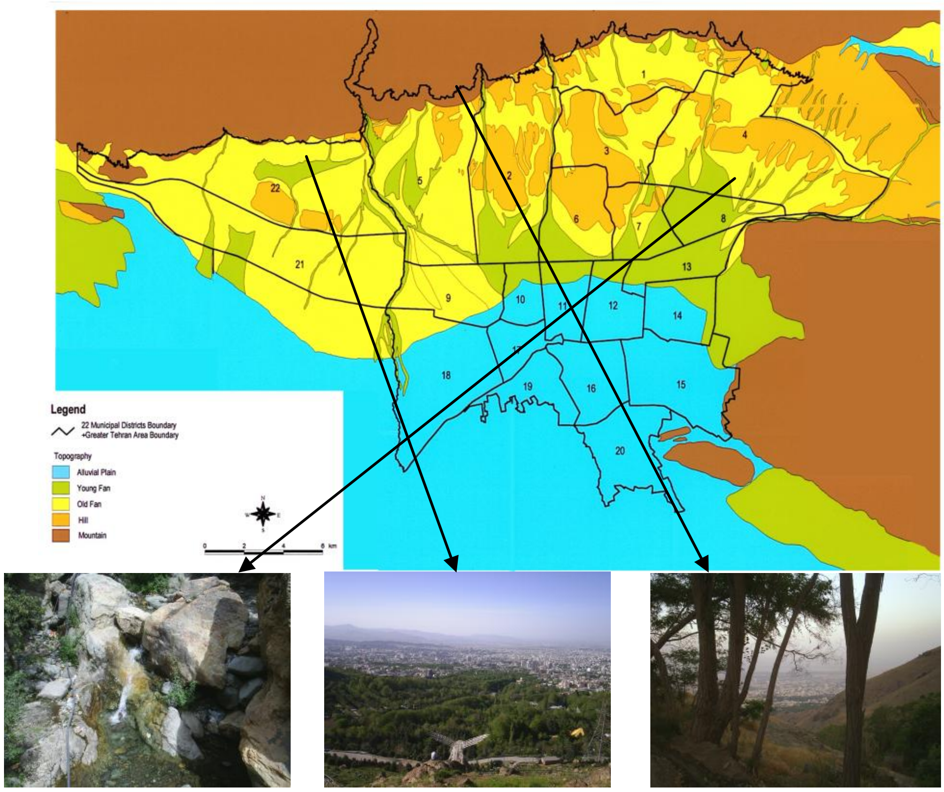


Figure 7.1 (above): Topography of Tehran and its 22 districts (JICA, 2000:18)
Picture 7.2(below): Tehran's natural environment

The specification of the geology of the city can be rigorously dangerous for building construction, which has been mentioned by Tehran's 2006 Master Plan, Tavakoli and Ghafory-ashtiany (1999), Hosseini and Jafari (2007), Motamed and Hosseini (2006) and Jafari and Hosseini (2005), besides some of the interviewees and the Seismic Centre of Iran. "The building industry is not advanced enough in Tehran to encounter all the necessary measurements to resist the earthquake." (Interviewee G). Also, "the quality of Tehran's urban environment is in the hands of property speculators and market, not in the control of government" (Interviewee J), which increases the physical vulnerability factor and risk of damage to the people. Amongst the southern districts of Tehran, not far from the Ray Fault, D17 (District 17) is at the heart of social and economic activities. D17 falls under the *Bs* category of geological formation, which is highly vulnerable to earthquakes. The D17 topographic condition has given three main specifications to the area (TCC, 2011:35):

- An 800 m difference between the height of the Alborz mountains on the very northern edge of the city and D17 allows water to run into the area, which makes the ground water level high.

- This condition has dramatically increased the possibility of local flood and other environmental disasters.

- The firmness of the ground soil is low, which makes the area vulnerable to earthquakes.

Its unique location not far from Mehrabad airport and Tehran’s main railways makes it a convenient place for living and easy commuting. However, there is no major waterway in the area, which disadvantages the natural environment. Figure 7.2 shows the steady downward slope from north to south, helping the flow of rainwater through the canals in the district towards the southern areas. Figure 7.3 also shows how the D17 geological specification influenced the physical development pattern of the area, which is mainly horizontal and compact.

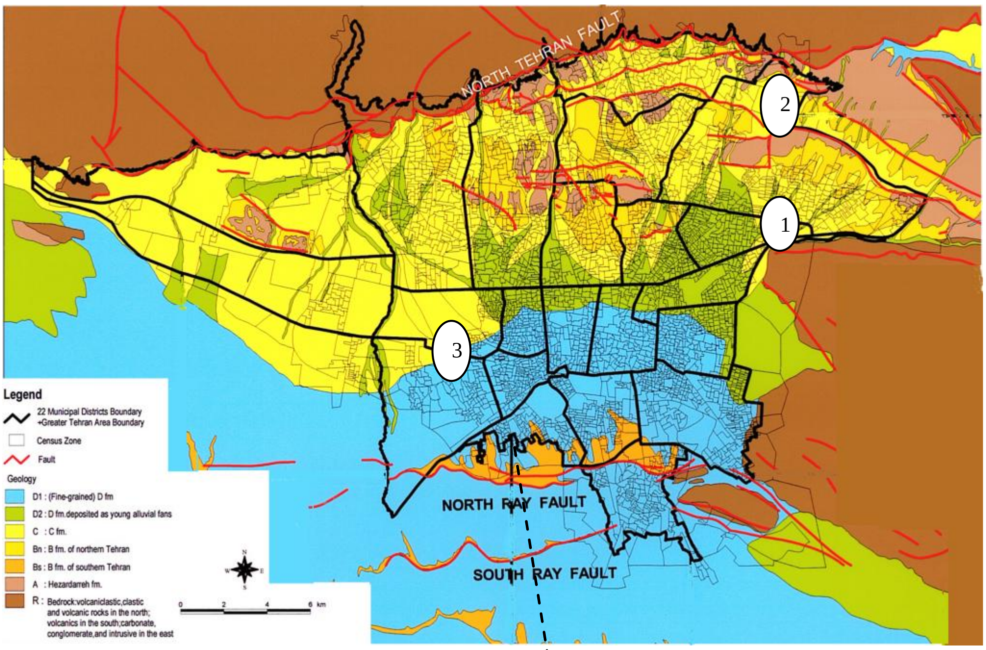


Figure 7.2: Geology of Tehran and its surrounding faults (JICA, 2000:22)

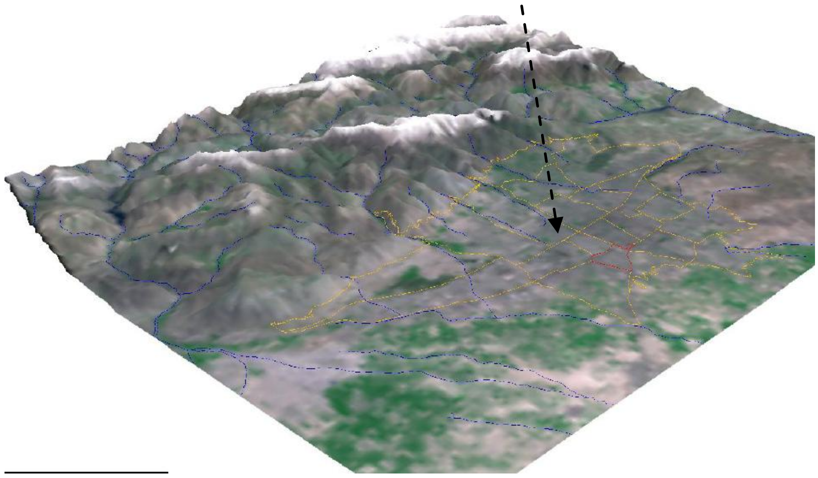


Figure 7.3: District 17 topography (Hosseini and Jafari, 2007)

Picture 7.3: 1) natural and manmade built environment, 2) natural hills around the city, 3) D17 topography

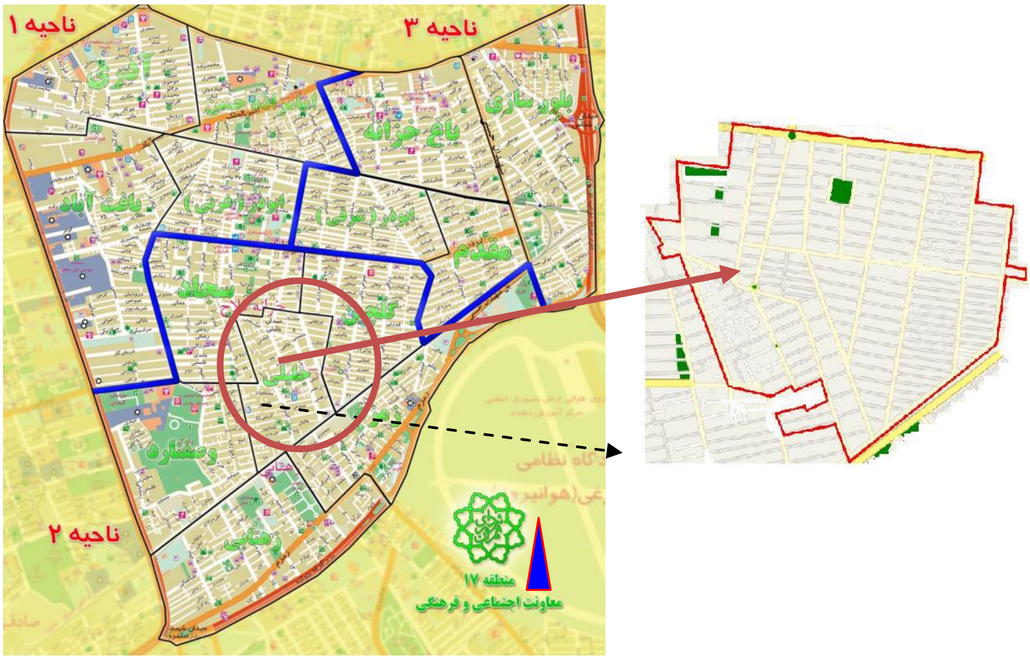


Figure 7.4: Khazaneh Neighbourhood

Picture 7.4: Khazaneh neighbourhood:

Jalili Square **Phoroozi Road** **Heidari Road**

In terms of building activities, the 2006 Master Plan has discouraged new building construction activities around the faults and those areas with geological issues. The regulations, however, were unfortunately based on non-compulsory recommendations without justifying the reasons, or specifying the hazardous areas, implementation tools or the collaboration of responsible organisations. Also, the plan has not proposed any financial solution to stop further development in those areas, and do not even publicise the possible future vulnerability of building activities to the local community or other relevant organisations. Hence, there is no prospect of cooperation between the government and local community in mitigating the vulnerability of buildings, supply lines and infrastructure, or in increasing the capacity of health centres, open spaces and public awareness. In the form of recommendation, the 2006 Master Plan advocated using public buildings and their open spaces for rescue and emergency service purposes. However, what it was lacking was a practical guide on their primary location, the services they might need to include, their area of coverage, and many more important issues. In a basic system of marking vulnerable areas, the plan simply pointed to the location of alluvials without further discussion. As the city has a high potential for a major dangerous seismic shake, simply locating such an issue will not help mitigate vulnerability. The master plan still plays an important role in directing urban activities within the city boundaries; therefore, its recommendations should be based on more specific and scientific reasons, and should incorporate other agencies and local communities. Similarly, the 2011 D17 development plan only briefly mentions the old fabric condition and how it can be vulnerable to natural disasters. There are also some general recommendations about the improvement of green spaces and road network standards. These have been highlighted throughout the plan. However, when it comes to the practicality of recommendations, it follows the same old-fashioned land-use planning method without precise clarification of who and how is involved.

The JICA (2000) study was based on a more scientific approach.[30] It used its own research group data, gathered locally, as well as key organisations' resources. It also examined the geological condition of the soil using mechanical testing machines. The method used in analysing the data and measuring physical vulnerability was also according to one of the five qualitative methods in building vulnerability methods (refer to Chapters 3 and 4). It utilised present geological knowledge, and used this data to estimate the possible seismic damage. It anticipated this to identify the vulnerability of various districts, but there was no obvious connection between this set of studies, the master plan or any past or present urban development plans. It became more apparent during the course of fieldwork and interviews that, despite an extensive financial investment in preparing and conducting researches and studies in various fields:

1) There is no specialist dedicated committee or board at the municipality, MRH[31] or the disaster mitigation and management team who can actually make

[30] See CEST (1998), Ghassemi (1999), Rezaeian (1998), Feghhi (1999).
[31] Recently the Ministry of Housing and Urban Development merged with the Ministry of Roads and it became the Ministry of Roads and Housing (MRH).

decisions, influence other members or act on disaster management and planning at a city level.

2) There are scattered studies in the field of planning for hazard preparedness by different organisations.

3) The key governmental actors have few connections and do not cooperate with each other.

4) The role of local residents, NGOs, international aid agencies and community representatives is totally ignored.

5) Each organisation works independently, with little interest in classifying and organising the scientific data analysis system.

6) Each interested organisation is extremely reliant on theoretical, non-practical recommendations, and passes the actions on decisions to the other parties.

7.7 Wind Direction: A Natural Physical Feature

Although studying the direction and speed of the winds in the city might not seem to be relevant to urban disaster management, studies of other countries show how wind can trigger the effects of fire after an earthquake. Even the JICA (2000) study did not consider the impact of wind as an item affecting vulnerability. But it was mentioned, surprisingly, in the interview with Interviewee F. He emphasised “the role of wind in the studies carried out by Japanese researchers to measure the potential damage to the buildings after big earthquakes of the past” (Interviewee F).

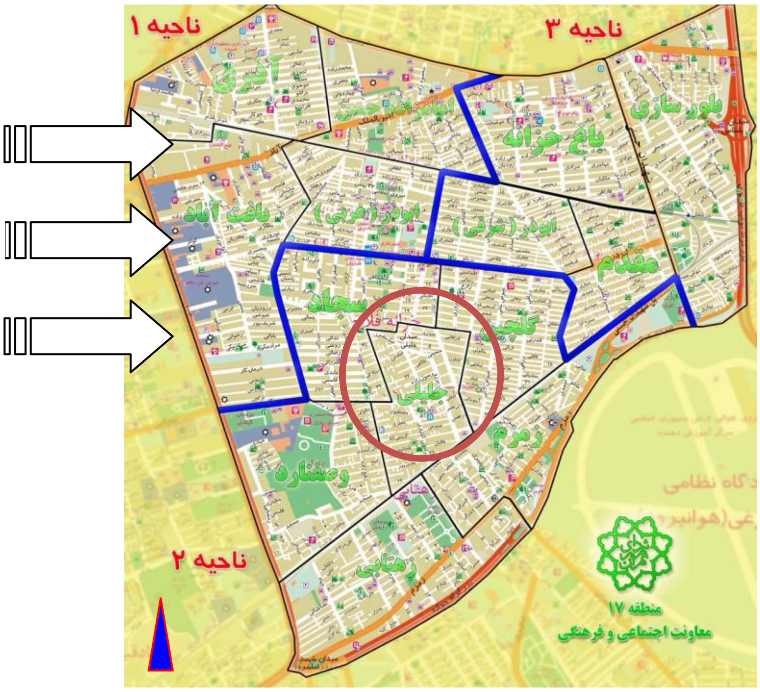
Table 7.2: Wind direction and frequency data for the years 1995 to 2005 (Keyhani et al., 2010:197)

Wind direction (clockwise in degrees)	Frequency (%)										
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	1.85	1.87	2.16	2.15	2.19	2.87	2.16	2.67	2.5	3.18	3.08
22.5	0.96	2.12	2.26	2.23	1.71	2.29	1.71	1.98	1.92	2.56	2.22
45	0.68	0.75	0.68	0.72	0.51	0.75	0.44	0.51	0.38	0.44	0.99
67.5	1.4	1.04	1.5	1.68	1.35	1.6	1.33	1.64	1.57	1.3	1.23
90	1.44	1.84	1.3	1.78	1.33	1.36	1.03	1.64	0.86	1.95	1.61
112.5	2.43	2.18	3.66	3.59	3.1	3.51	3.73	3.77	2.84	2.8	2.53
135	1.74	1.33	1.78	1.95	1.33	1.55	1.09	2.23	1.64	1.23	1.64
157.5	4.76	4.68	6.33	5.52	5.65	5.22	5.75	5.17	5.61	5.63	5.62
180	13.43	15.37	15.86	14.07	14.62	15.03	16.08	16.37	17.05	15.13	14.4
202.5	4.08	5.09	5.58	5.37	5.82	4.58	5.24	6.75	6.34	5.81	6.72
225	1.33	1.78	2.09	1.76	1.23	1.01	1.88	1.54	1.47	1.91	1.93
247.5	2.23	2.95	3.33	3.66	3.12	3.59	3.18	2.47	2.86	3.79	3.25
270	4.76	6.04	5.68	6.52	7.08	5.94	5.29	5.58	5.66	4.98	5.78
292.5	3.45	2.96	3.49	4.07	4.38	4.71	3.59	4.09	4.82	5.24	4.32
315	2.77	2.29	2.7	1.78	2.4	2.59	2.05	2.36	2.46	2.39	1.71
337.5	3.46	3.33	3.93	4.14	3.87	4.12	3.87	4.79	4.14	5.05	6.09

As Figure 7.7 shows, Tehran benefits from a natural breeze which helps to moderate the city’s climate. The comparison of polar diagrams for the years given indicates that the wind direction and frequency is very stable in Tehran, with a westerly wind the most probable. However, the concentration of the majority of industries in the west and the high probability of fire after an earthquake, coupled with the dominant west to east wind direction, puts the city in a vulnerable position (Parsipour, 2010). This is an important consideration in locating safe areas in a neighbourhood, in relocating the use of surrounding buildings, and also to design and construct fire-resistant buildings around an open space refuge.

With D17 being part of Greater Tehran, the area has a similar wind strength and direction; however, the concentration of many industrial zones in the south and west makes this area and its surrounding districts some of the most polluted areas of the city. This is coupled with vehicle traffic and narrow roads which injects an extensive amount of CO_2 into the local air. The wind direction in D17 (Figure 7.5) could possibly be a hazardous factor in spreading fire from the west to the area. Within the Khazaneh neighbourhood, again, the same condition applies in terms of wind speed and direction. This has affected the direction of building elevation to avoid possible westerly rain and using natural sunlight, especially during the cold season.

Wind direction mainly from the west



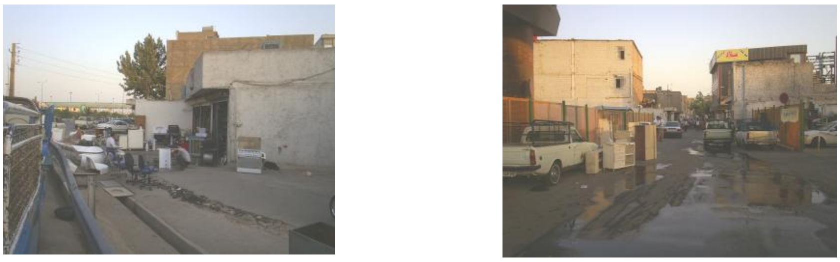
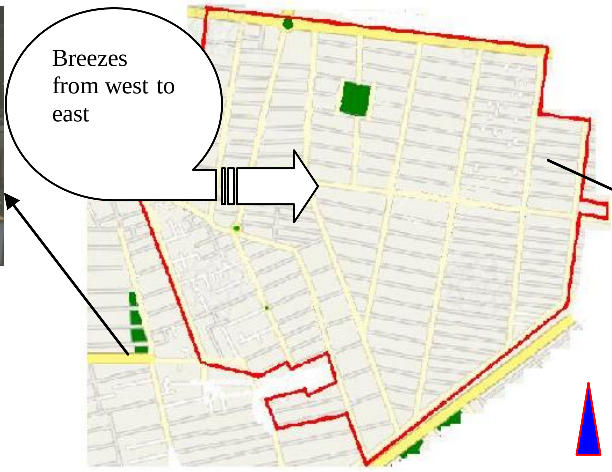


Figure 7.5 (above): Wind direction in District 17

Picture 7.5 (below): Industrial activities around District 17

Picture 7.6: The streets cause pollution



Picture 7.7: The housing direction in the case study area

Figure 7.6: Wind direction in Khazaneh Neighbourhood

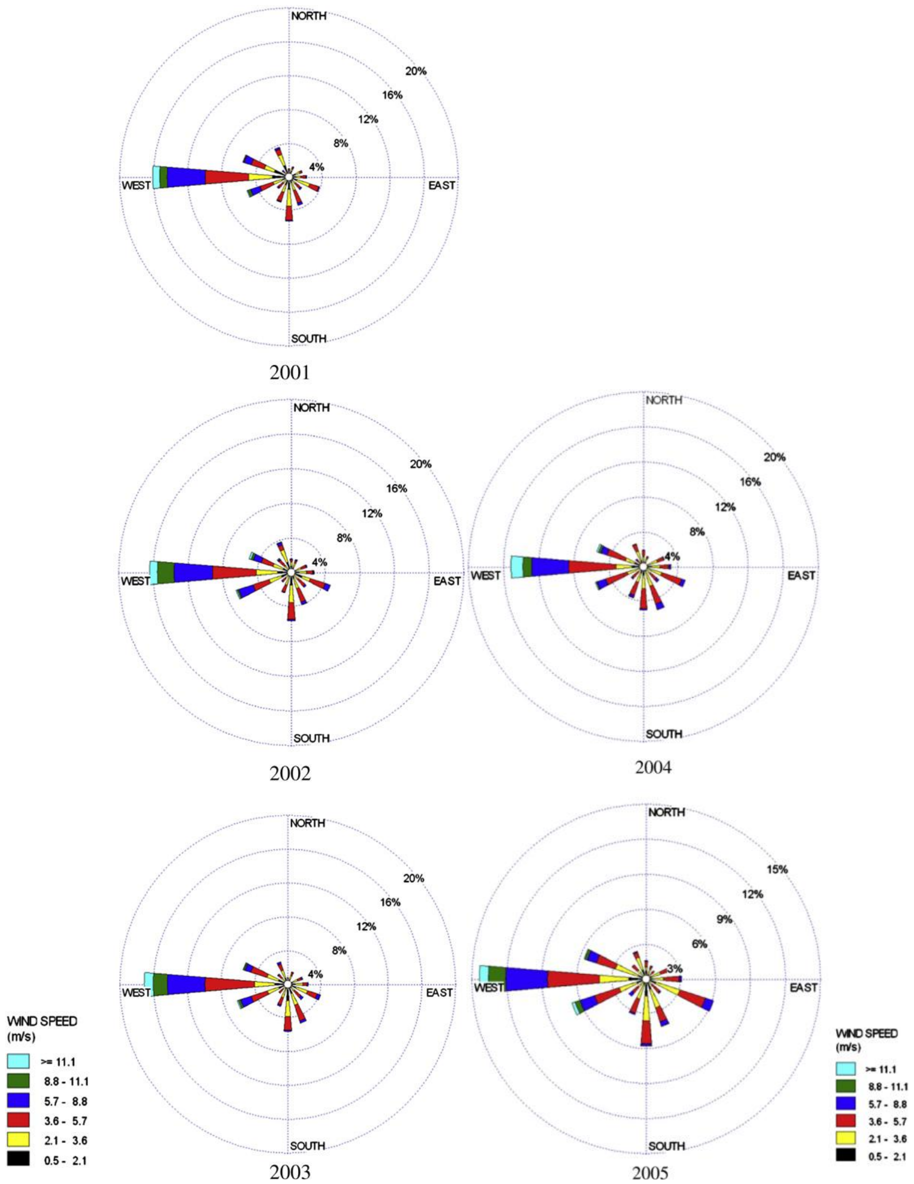


Figure 7.7: Polar diagram, wind direction for the years 2001–2005 (Keyhani et al., 2010:198)

7.8 Chronology of Past Earthquakes: Social Indications of Vulnerability Assessment

Tehran’s geological ground specification has created a high potential for a destructive earthquake. Its past seismic activities (Table 7.3) are an indication of severity and period to reoccurrence, which is more vulnerable than ever. Studies done by Ashtiany et al. (1992), Moinfar et al. (1994) and Berberian and Yeast (2001) all warn that Tehran is awaiting an earthquake of magnitude 7 or more. Many of the past earthquakes are recorded as being damaging and devastating according to historians

Amberaseys and Melville (1982). The earthquake in the year 985 is described as the most disastrous one, which affected a large part of the northern and central areas of the country (*ibid*).

Table 7.3: Historical earthquake data in the Tehran area (JICA, 2000; Rad, 2006)

Year	Month	Day	Mw	Latitude (degree)	Longitude (degree)
743			7.1	35.30 (Garmsar)	52.20
855			7.0	35.60 (Ray)	51.50
856	12	22	7.9	36.20	54.30
864	1		5.4	35.70	51.00
958	2	23	7.7	36.00 (Mosha)	51.10
1119	12	10	6.4	35.70	49.90
1177	5		7.1	35.70 (Tehran)	50.70
1301			6.6	36.10	53.20
1485	8	15	7.1	36.70	50.50
1608	4	20	7.6	36.40	50.50
1665			6.4	35.70 (Mosha)	52.10
1687			6.4	36.30	52.60
1809			6.4	36.30	52.50
1815			6.5	36.20	51.10
1825			6.6	36.10	52.60
1830	3	27	7.0	35.80 (Mosha)	51.70
1868	8	1	6.3	34.90	52.50
1930	10	2	5.4	35.78	52.02
1957	7	2	6.7	36.20	52.60

Year	Month	Day	Mw	Latitude (degree)	Longitude (degree)
1962	9	1	7.1	35.54	49.39
1983	3	26	5.3	36.12	52.10
1990	6	20	7.4	39.96	49.39
1994	11	21	4.5	35.90	51.88

It was followed by the earthquakes of the years 1177 and 1830 which destroyed existing large cities such as Qazvin, Ray, Damavand and Shemiranat (Rad, 2006). The Manjil (1990) and Bam (2003) earthquakes were recorded as the worst and most devastating of all in modern times (*ibid*). Their epicentres were far from Tehran; however, the extent and severity of damage to buildings and population could possibly be quite similar to what would occur in a Tehran earthquake scenario. It is not clear when and where the next earthquake will occur; however, it is the government's and people's responsibility to ensure it will have the least possible impact on the city's physical and social structure. The history of D17's establishment goes back to the 1920s, when the city of Tehran was expanding in every direction. Therefore, as part of a larger context, it has not suffered individually from earthquake damage. It was outside the old Tehran boundary till the 1950s, and urbanised by modern-style architecture after that. For the occupants of this area there is not much more impact than what Tehran has experienced from past low-magnitude earthquakes. This was also revealed in the interviews conducted by myself during the fieldwork:

> As far as I remember, there has not been a big earthquake in Tehran. The government makes this claim to push the construction standard up.
>
> (31-year-old local resident)

> We have enough resources in the area to cover people for an emergency situation, but we have not had a real experience yet.
>
> (Interviewee B)

7.9 Population at Risk: A Social Vulnerability Index

After explaining the location of the case study area, the most influential factor in identifying and assessing the vulnerability of the area is its population structure and social capital. This is, indeed, the first cause of concern in hazardous situations and locations. Tehran is the most densely-populated area of Iran (Rashidi, 2009). The population distribution by census zone is shown in Table 7.4.

Table 7.4: District census zones, SCI, 1996

District	*No. of census zones*	*No. of census zones*		*Highest population density (person/hectare)*		*Area (hectares)*	*Population*	**Population density (per hectare)**
		Density exceeds 600 p/ha	Density exceeds 800 p/ha	Density (p/ha)	Zone no			
1	163	0	0	391	01075	3,462	245,502	71
2	238	0	0	313	02149	4,968	456,414	92
3	155	0	0	349	03108	2,945	259,019	88
4	297	5	0	710	04133	7,260	663,166	91
5	215	1	0	673	05033	5,915	427,955	72
6	123	0	0	324	06088	2,149	220,331	108
7	151	0	0	554	07081	1,541	300,212	195
8	150	5	0	712	08014	1,327	332,005	250
9	80	10	0	761	09047	1,960	173,482	89
10	125	2	0	632	10083	806	282,308	349
11	110	0	0	446	11089	1,189	225,840	190
12	108	0	0	422	12060	1,359	189,625	140
13	113	0	0	508	13034	1,391	245,142	176
14	168	1	0	621	14119	1,459	392,524	269
15	252	33	4	878	15060	2,852	622,517	219
16	129	6	0	744	16077	1,649	296,410	181
17	109	30	0	783	17082	829	32,239	465
18	121	14	1	826	18097	3,794	293,598	77
19	88	8	0	680	19041	1,152	227,389	197
20	167	0	0	588	20093	2,033	354,449	174
21	85	4	0	778	21048	5,206	188,890	36
22	26	0	0	164	22010	6,154	56,020	9
Total	3,173	119	5			61,404	6,742,165	110

Table 7.5 summarises the annual growth rate of the population from 1956–91.

Table 7.5: Annual growth rate of population 1956–91 (Khatam, 1993:106)

Years	Tehran Metropolitan region	Tehran City
1956-66	5.78	6.68
1966-76	4.37	4.27
1976-86	4.27	2.82
1986-91	3.2	1.31

Table 7.6: The change in the main age group 1966–91 (Taleghani, 1992:8-10)

Year	Main age group (%)		
	0–14	15–64	65+
1966	41	56	3
1976	36.8	59.9	3.3
1986	37.4	59.2	3.4
1991	36.3	59.9	3.8

As a destination for work and new life, the male population in Tehran has been higher than the female: 51.5% of the population in 1991 were male (Taleghani, 1992:24). Some areas like the historic and central parts have a more equal balance in population gender, whilst new suburban settlements consist of mainly men (USPCT, 1994:33–34). Interestingly, Tehran accommodates more older and younger people in comparison to other parts of the country: half of the population were younger than 23.3 years in 1991 (Taleghani, 1992). Figure 7.9 demonstrates that, in general, outer districts have a younger population than the north or central areas. In District 19, for instance, more than half of the population are very young, under the age of 16.7 years (USPCT, 1994:83).

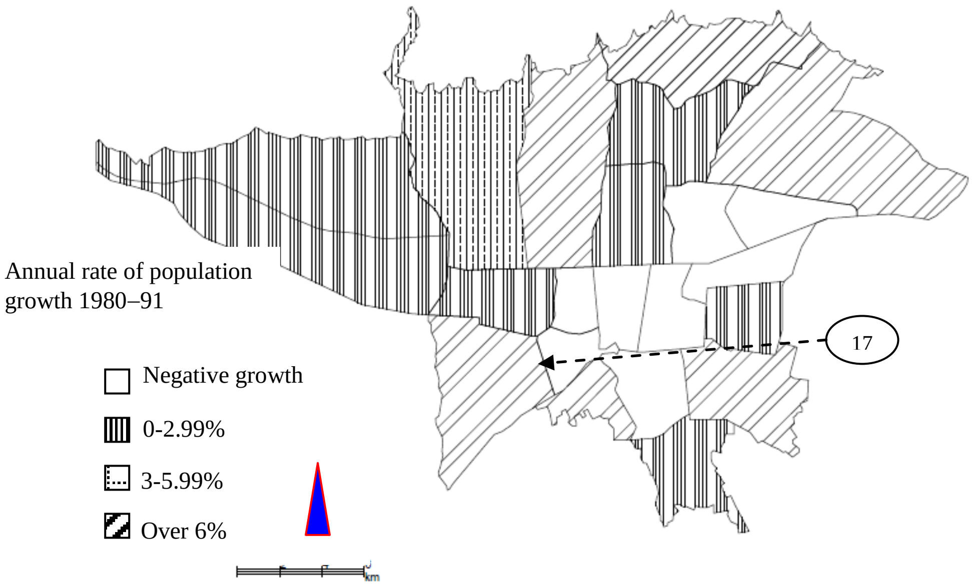


Figure 7.8: Annual rate of population growth, 1980–91 (Madanipour, 1998:85; SCI, 2004)

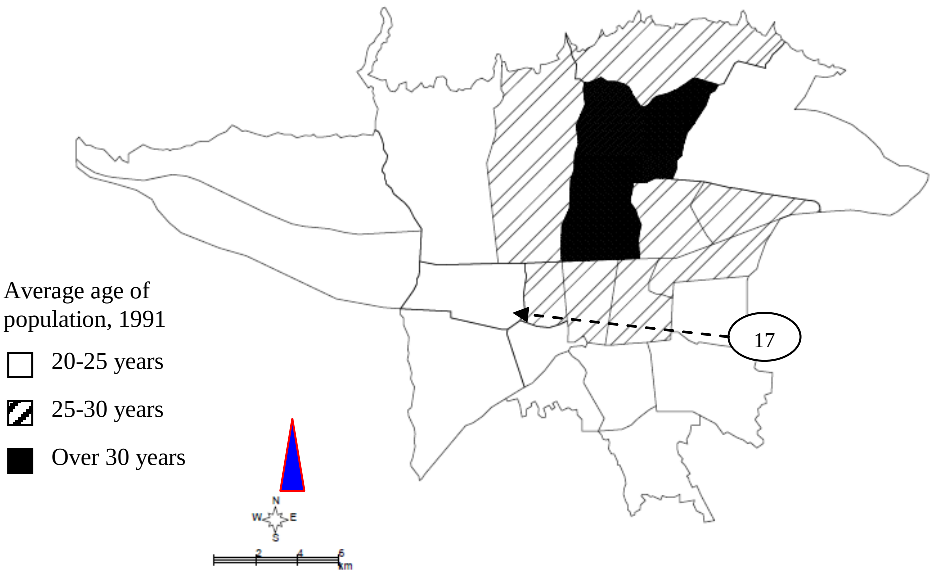


Figure 7.9: Average age of population, 1991 (Madanipour, 1998:87; SCI, 2004)

In terms of household size, again, as expected, the southern and newly-developed areas have, on average, larger family sizes. Figure 7.10 confirms the distribution of household size based on the 22 districts.

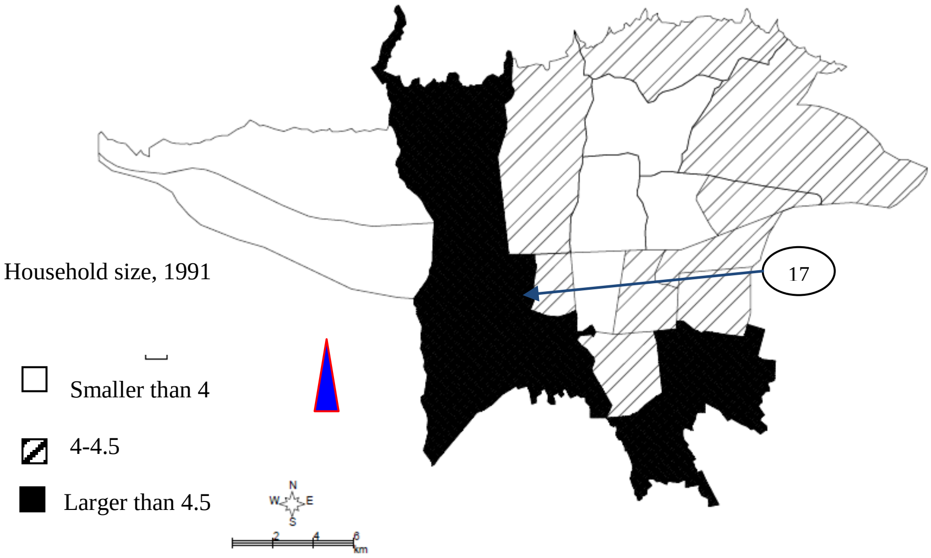


Figure 7.10: Household size, 1991 (Madanipour, 1998:92; SCI, 2004)

Household sizes are, for instance, 3.6 for District 3, with more affluent residents, and 5.2 for District 19, with a lower income and higher unemployment rate (USPCT, 1994:28).

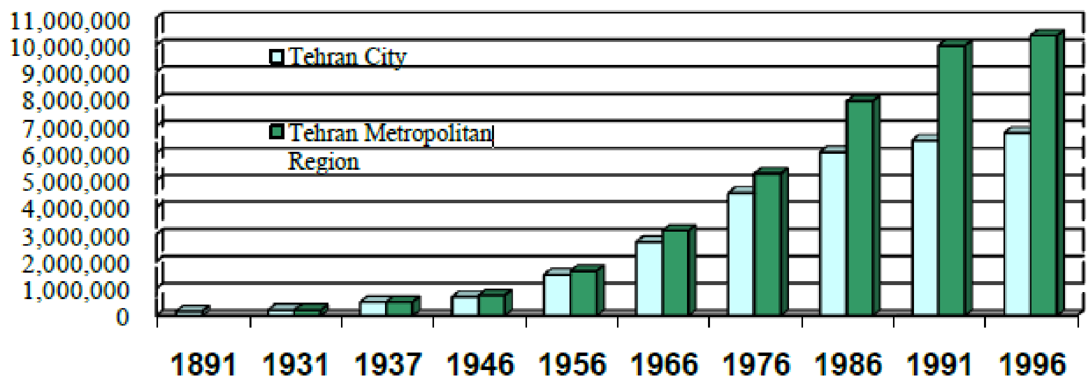


Figure 7.11: Demographic growth in Tehran city and its metropolitan region (Haghani, 2010:117)

This pattern is not established using any specific developmental framework, and population concentration has been higher in some districts. Urban development confusion results from rapidly growing urban areas, and development does not follow the distribution pattern of infrastructure or existing facilities. Figure 7.11 also shows the annual rate of population growth in Tehran between 1891 and 1996. In some central districts, due to the concentration of offices and commercial activities, as well as the high price of land and buildings, the population has decreased. This statement was supported by the public when they were asked to explain the length of their residency in Khazaneh neighbourhood. “My family bought the property here 25 years ago. The price of the above house is cheaper in here and the people who live here are more friendly.” (M.W.23). In an interesting statement a local resident even claimed that “the cost of living in this area is less than the north, as the fruit shops are cheaper, taxis charge less and building a house costs less” (M.R.56). The pattern of population growth and distribution in D17, according to its latest development plan (2011), has been negative since 1980 in terms of the total number of people and population density. Tables 7.7 to 7.9 indicate the changes within the area’s population in terms of growth.

Table 7.7: D17 population, 1980-2002 (SCI, 1980–2002; TCC, 2011:52, TMCSC, 2010

Year	1980	1986	1996	2002	2010
Population	353,428	336,052	287,367	255,337	27,2265

Table 7.8: D17 population growth rate, 1980–2002 (SCI, 1980-2002; TCC, 2011: 52)

Years	1980–86	1986–96	1996–2002	1980–2002
Growth rate	-0.84	-1.55	-1.95	-1.47

Table 7.9: Detailed information about D17 and its sub-areas (TCC, 2011)

District	**Area (he)**	**Population (head)**	**Population density (p/he)**	**Building**					
				Residential	Commercial	Industrial	Green space	Military	Derelict land
District 17	822.09	256,022	309						
Area 1	252.6	64,300	252	69%	12%	10.5%	3%	-	0.5%
Area 2	221.3	105,023	334	71%	15.5%	4%	5%	1%	3.5%
Area 3	247.1	86,502	369	70%	14%	5%	1.5%	1%	1.5%

In comparison to the central and northern areas, the southern areas of Tehran generally tend to have a younger and poorer population who have lower standards of living, greater population densities and more vulnerability. The parts of Tehran with the richest cultural heritage are the central districts, which accommodate several historic buildings. Due to the number of public buildings and commercial activities (e.g. the Tehran Bazaar), the population of these districts dramatically increases during the day. The northern districts are known for newer structures, higher income groups and higher literacy rates.

The most populated district within Tehran is District 4, with a population of 663,000, whereas the least populated district is District 22, with a population of only 56,000 (TCC, 2006). The average population density of Tehran is 110 persons per hectare, however one of the highest population density values in the city is within District 17, where it rises to 347 persons per hectare (*ibid*). These population density values are determined by census zone, derived from the 1996 population census data (Table 7.4).

Picture 7.8: Young people in Gholestan Park

Picture 7.9: Shahi Ghasemi Road in Khazaneh neighbourhood

In D17, the pattern of population growth, family size and even building density is influenced by various issues. The general trend of population growth in this area does not necessarily follow natural growth patterns, due to the impact of economic activities, the proximity to the bazaar and administrative centres, the spatial characteristics of the area, and the availability of urban services, which all influence the population pattern. D17 is not a high growth area, but it is densely populated. The area profile is young and with large families. Some of the reasons for the mixed messages sent by this district's population change in the interviewees' minds. Some of the local people's opinions expressed in the questionnaires are:

- Outward migration of people from the area due to change of their social condition: "When my four children graduated from university, they did not like to come back here and live in this neighbourhood." (61-year-old primary school teacher).
- Lack of economic and employment opportunities in the area: "Most of the high class shops are in Tajrish and Shariati [northern districts] not in Shahid Moghadm [a local street]. It is hard to keep your business running in here where people are poor." (35-year-old local businessman).
- Large families in the under-25-years age group (i.e. below the average age of marriage): "Most young people have no desire to stay here. They do not like to raise their children in this area. They go somewhere which is less polluted and has better housing." (Interviewee C).

Table 7.10: Demographic details of the interviewees

Family size (%)			Age group (%)					Gender (%)		Number of schools			Education (%)		
1–2	3–5	5+	0–5	6–18	19–27	28–60	60+	F	M	Primary	Middle	High school	Reading and writing	Diploma	Higher education
17	30	53	8	10	39	38	5	49.2	50.8	9	5	2	25	59	15

A local resident in the Khazaneh neighbourhood points out how she has witnessed her neighbours' children growing and moving out of the area in the last 35 years, which does not make the area one of the most ideal places in Tehran to live: "My three children used to go to school with a group of kids in my neighbourhood. None of them has remained here. They either left Tehran for good or moved to other areas." (F.R.55). The results of general information about the Khazaneh neighbourhood, derived from the questionnaire, are presented in Table 7.10.

This neighbourhood, therefore, has a young age profile. The number of schools in the area is a good indication of its needs for primary education. From a cultural point of view, most of the local occupants are from the working-class category with an interest in having more children. The majority of females have a low educational attainment level and are not interested in higher education, especially those who married early: "My two cousins and I got married before the age of 19. I managed to get my diploma, but they did not." (21-year-old woman). This obviously affects the average family income and therefore, their housing quality: "In this small street, only three women work. They are educated and can find a job." (44-year-old woman). It also influences the general public's awareness about the natural disaster preparedness and rescue procedures. In Chapter 8, when the risk in the study area is evaluated, there will be more detailed discussion in this regard.

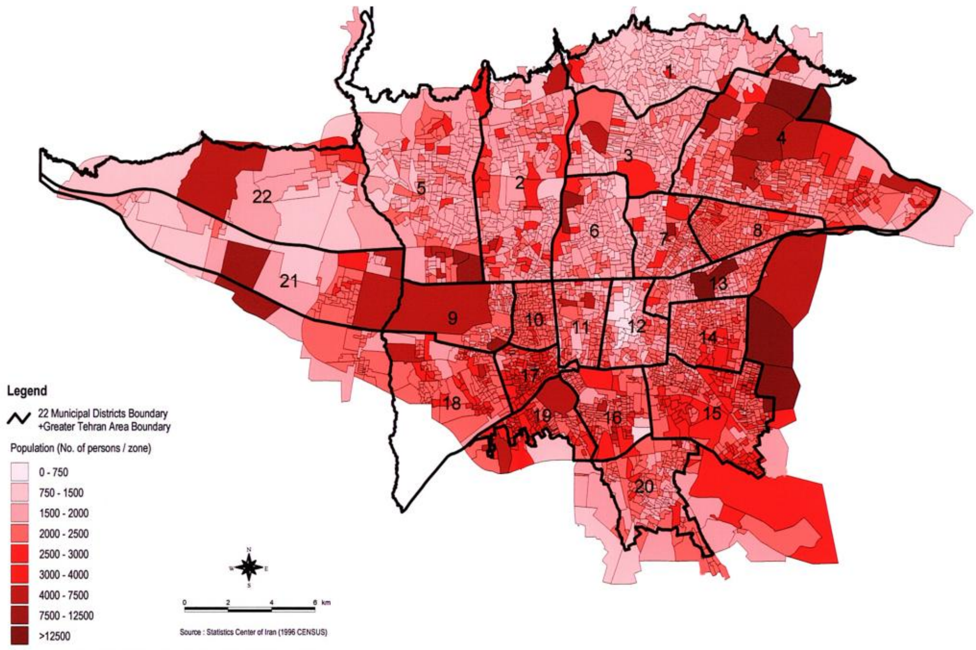


Figure 7.12: Population density, Centre of Earthquake and Environment Studies of Tehran (CEST) (JICA, 2000)

Taking all of this into account, the southern and central districts appear to be the most vulnerable, especially to an earthquake. The JICA (2000) study about earthquake disaster management demonstrated that the southern districts are more at risk at the time of an acute disaster. Table 7.4 shows that Districts 9, 15, 17 and 18 have population densities of more than 600 persons per hectare, in over ten census zones, which is extraordinarily high, even for Tehran. In order to tackle the overcrowding problem, Tehran's Master Plan (2006:32) states:

- Tehran will have to cope with a population higher than its maximum capacity, in relation to public facilities and services, if the population growth continues as a result of selling building density.

- There will be an increase in the number of residential areas if the city management does not take steps to prevent uncontrolled growth. Also, problems will be caused by the inability to provide people with civic facilities and services, especially to those who are residing in old, underdeveloped and vulnerable locations.

- Social exclusion could take place if the northern and southern parts of the city continue to move towards each other in relation to the overall size of the city, which will be a major socio-economic problem.

- Population concentration and inward migration could reach the absolute limit if a balanced and thought-out movement of economic activities concentration is not undertaken.

The plan has identified the problems only from the planning consultancy point of view. In my opinion, the criticism remains over the main knowledge resources, the development of understanding the process of growth, the why and how of changes and the need to accommodate the population, the interference of national and local economic forces, etc. In the study carried out by the Tehran Disaster Mitigation and Management Centre (TDMMC, 2005),[32] interviews with local planning officers revealed that there was a high level of willingness amongst local residents in the southern parts of the city to participate and cooperate in risk mitigation and social capital enhancement. In terms of increasing public awareness, “we can teach and train students in school how to react in an emergency situation” (40-year-old high school teacher). For road quality enhancement, “if everyone parks the car in the garage, the local roads are useable for people to escape. The municipality should charge those who do not follow this.” (56-year-old local man). Also, in a radical suggestion, a resident

[32] Tehran Disaster Mitigation and Management Centre (TDMMC) carried out a research project after the JICA (2000) report, which was published in 2005. The study mainly focused on the training and public awareness aspect of disaster management. This became a guideline for some limited studies and recommendations published by district municipalities.

who suffered from amnesia caused by his experience of the Bam earthquake (2003) said:

> The owners of those buildings that do not meet the building safety standards and requirements and will not be earthquake-resistant, should be charged and made to improve the safety of their buildings. Because it is not only their life, but other occupants who live in that building.
>
> (29-year-old local man)

The context of the urban development plan and any other available publications does not exclusively explain how the support and assistance of the local community is gathered and put into use.

7.10 Land Use and Economic Activities: A Combined Socio-physical Feature

Tehran's administrative and service-oriented economy is consistently expanding the city. The city hosts more than half the country's industry, in the form of the manufacturing of cars, electronics and electrical equipment, weaponry, textiles, sugar, cement and chemical products (Rad, 2006:26). The service and utility sections of the city account for 66% of the economy; manufacturing is in second place at 31%; and agriculture is in third place, as it only accounts for 3% of the economy (*ibid*:26). The need for commuting and adequate public transport facilities has been a major problem for the city since the 1980s. Uneven distribution of economic activities in and around the city makes it hard to separate the residential buildings, government offices, universities and small businesses from one another within the context of city neighbourhoods. Tehran's role as the centre of administration and economic activities also makes it a road and railway hub for the whole country. It is the centre of cultural display, political formation and evolution, social networking and educational excellence. Together this creates a world of opportunity and attraction for people from all over the country. As Table 7.11 indicates, there are some areas with more residential uses and some with service priorities.

Table 7.11: The percentage of main land-use categories of Tehran (Rad, 2006: 28)

Use	*Area*	*Percentage*
Residential	177	**28.5**
Commercial and administrative	26	**4.2**
Industrial and units	27	**4.3**
Transportation and storage	30	**4.8**
Urban services	50	**8.1**
Green spaces	70	**11.3**
Farm land	35	**5.6**
Military	49	**7.9**
Roads and networks	114	**18.4**
Derelict land	43	**6.9**
Total	**621**	**100**

Unlike other big cities like London or Tokyo, Tehran has failed to make further headway in its technological and economic structure. Both the efficiency of services and the environmental quality of Tehran have been worsened by unparalleled expansion of industrial units and businesses (both legal and illegal) in residential areas. Positioning commercial buildings on main roads, and on vital axes, has a positive impact on the spatial environment of neighbourhoods, as the majority of business owners regularly improve the appearance of their place of commerce, especially in a competitive market, to attract more customers. But this causes obstructions within the transportation system. A great number of people have begun working in the public sector, within government offices and centralised government structures, due to the employment opportunities available (Bertaud, 2003). This has led to favourable circumstances arising in the private sector, as both large and small projects can be undertaken to cater for the government’s requirements, and goods can be created for the public sector: “Whilst land use across the city is mixed, residential use dominates in the northern and eastern quarters, industrial use in the west and south-west, and commercial and office use in the central quarters.” (Madanipour, 1998:122). Those areas that act as commercial and economic activity centres do not have adequate services and have varying population densities over the 24 hours of a day (as does Tehran’s bazaar). Their requirements are slightly different from the localities with residential usage. These public buildings’ resistance to earthquakes should be much higher than that of residential buildings, which, for example, only have a maximum of four people in occupancy.

In D17 the major use of land is for residential purposes (Table 7.12). The distribution of different uses within the area is influenced by many factors:

- Tehran's 1968 Master Plan, which placed D17 into the city's future 5- and 25-year legal boundary (TCC, 2011:12). This plan considered three main uses for the area: residential (north, north-east and some central parts), industrial (north-west and adjacent to the main western roads) and agricultural (the rest of the area). This decision, firstly, legalised the previously illegal settlements without decent infrastructure and road networks; and secondly, encouraged new and illegal developments outside the boundary.
- Two main railways in the north and south-west of the area, which prevent any kind of permanent occupancy of the land within their 60 m green belt boundaries. This might have been ignored by illegal settlements; however, these two main features have created tens of level crossings and causes disruption in the spatial structure of the area.
- The age of the buildings, their quality and the size of land plots also affect the quality of people's lives, the nature of industry that can fit in these plots, the market for new building activities, the encouragement of locating government offices in the area, etc. The high number of narrow roads and cul-de-sacs in the area also makes neighbourhood regeneration difficult, as it requires negotiation with a large number of residents and an extensive amount of compensation to improve accessibility of the area.
- The proximity of Ghalemorghi airport (Golestan Park) to the area did largely discourage and prevent multi-storey buildings in the past. It might have been replaced by a park just on the edge of the area; however, its sound pollution and other restrictions have always precluded the growth of the area in comparison with other districts.
- The topographic condition of the area might not be a major factor in shaping the spatial characteristic of the area; however, the high amount of water in the ground makes construction of building foundations difficult and unaffordable. Therefore, except for government buildings, the affordability for multi-storey buildings is limited.

The D17 municipality has proposed that the following land use for this area complies with the 2006 Master Plan’s general policy (Figure 7.13), as the plan (2011) states that the area requires improvement in its commercial, green space and service fields.

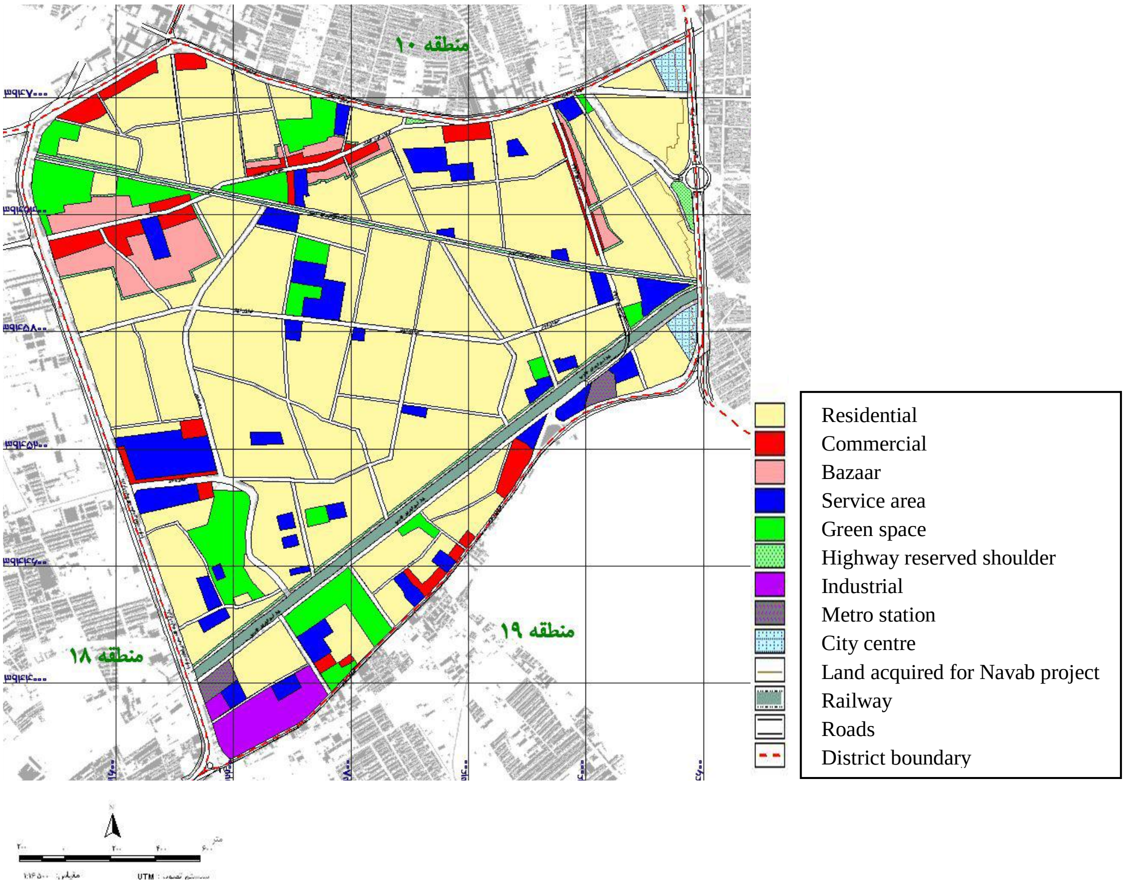


Figure 7.13: District 17 development plan (TCC, 2011:121)

Table 7.12: District 17 present and proposed land use (MHUD, 2011: 77, 79)

Use of land	Present Area (ha)	Present Area (%)	Suggested Area (ha)	Suggested Area (%)
Residential	278.72	60.27	570.78	71.86
Commercial	38.71	4.87	0.78	0.10
Urban services	38.9	4.9	23.43	2.95
Industrial	61.2	7.71	36.37	4.58
Green zone	25.92	3.26	26.93	3.39
Derelict land	42.49	5.35	5.64	0.71
Roads	86.99	10.95	90.34	11.37

Use of land	Present Area (ha)	Present Area (%)	Suggested Area (ha)	Suggested Area (%)
Railway boundary	21.37	2.69	40.03	5.04
Total	794.30	100	794.30	100

A quick comparison of the present land-use plan and the proposed plan (Figure 7.13) indicates simple changes in the use of land and buildings, especially around the edge of the area. Some roads are suggested to be merged and some to be widened. Table 7.12 also compares the present and proposed use of land, which is arguable in many aspects. But what this thesis is more interested in is the distribution and improvement of open spaces, road networks and building safety, which will be discussed in more detail in Chapters 8 and 9.

Also the tendency in the area for multi-storey development due to high house price inflation has compelled the municipality to put restrictions on the number of storeys in housing development and cap the permitted density. In this area, which is mainly residential, most economic activities are distributed along the verge of roads without any specific regulations or styles (Picture 7.10).

Picture 7.10: District 17: mixed use of streets, shops and residential buildings

Table 7.13 is a summary of services available to D17 between the years 2001 and 2003.

Table 7.13: Comparison between land use in 2001 and 2003 (TCC, 2011:45)

Use	*Area in 2001*	*Area in 2003*	*Changes*
Residential	345.36	310.59	-34.77
Commercial	57.92	89.67	+31.75
Educational	14.64	14.63	–0.01
Religious	4.9	5.5	+0.60
Cultural	2.43	2.6	+0.17
Medical	5.57	4.33	–1.24
Leisure	1.35	0.90	–0.45
Sport	4.56	8.82	+4.26
Administrative	5.48	3.98	–1.50
Green space	33.01	33.88	+0.79
Military	2.96	2.33	–0.63
Industry	40.01	36.51	–3.50
Urban infrastructure	2.8	3.7	+0.90
Warehouses	14.21	19.24	+5.03
Vacant land	22.33	23.72	+1.39
Derelict land	8.55	8.55	0
Agricultural	2.52	2.52	0
Roads and boundaries	225.70	222.91	–2.79
Total	794.30	794.30	0

The high proportion of young people has had an impact on the number of schools in this district. For example, in this area alone there are 78 schools, in which the majority work in two shifts of mornings and afternoons (TCC, 2011). In terms of open spaces, the review of the land-use plan highlights the lack of adequate green spaces and parks, which at the moment are concentrated in the southern and western part of the region. It has been noted, due to the results of the questionnaire, that the community is interested in more public facilities such as leisure centres, parks and designated shopping centres: "Our children have to go to the other areas to use the library, swimming pool or even the gym. In this area there are not enough suitable facilities." (M.R.35). "The small park next to my house is not safe and does not have any playing equipment. My kids get hurt and prefer to play in the street." (M.R.28). "The local shops only sell groceries. I usually do my shopping somewhere else." (M.R.49). The Khazaneh neighbourhood also captures the same sense in answering the questionnaire.

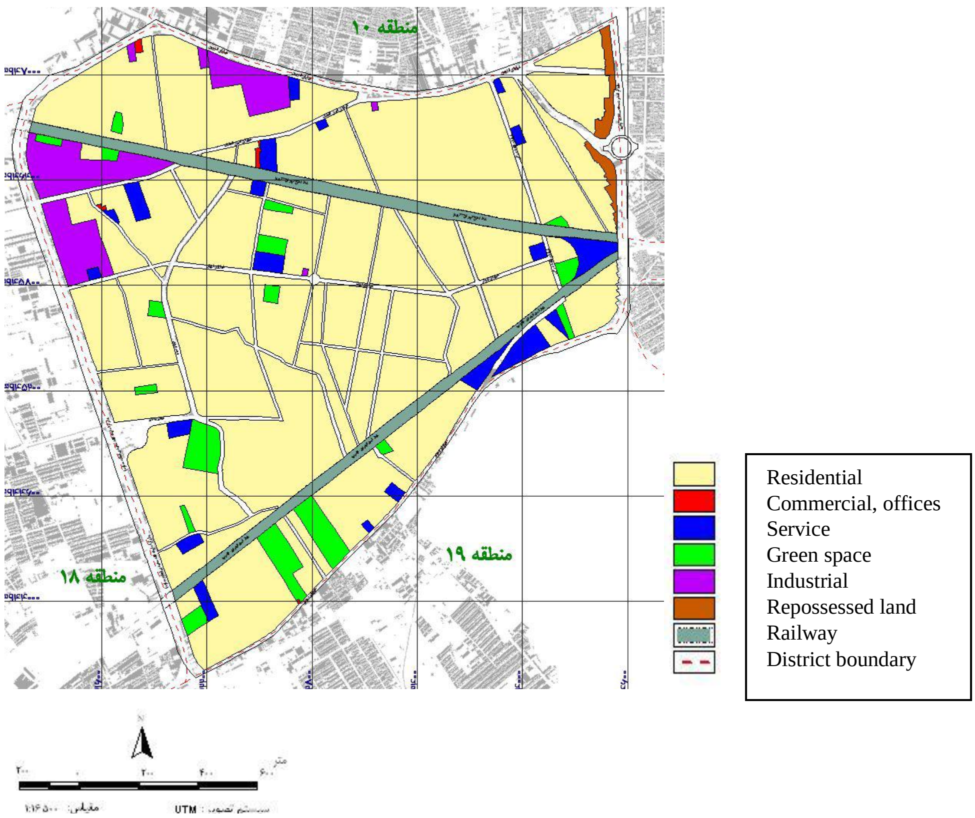


Figure 7.14: Land-use plan of Khazaneh neighbourhood (MHUD, 2011:121)

Picture 7.11 (from right to left): uneven distribution of public buildings, high population density, proximity of hazardous facilities

In one resident's opinion, "the park at the top of my street is not a park, it is a place for drug dealers to exchange goods. It is not even green." (M.R.62). Also, "I bought this flat six years ago. I only used the small library next to the municipality office once. They had fewer books than me." (M.W.45). Local concern is around the lack of employment opportunities and long-term economic activities in the area, which has brought an insecure environment to the neighbourhood and its lifestyle. In terms of spatial structure the area suffers from the:

- Concentration of services on one side;
- High density of population;
- Unbalanced distribution of public buildings;
- Proximity of hazardous industry.

Within the next section there will be further discussion about the number of major services in the region and road networks.

7.11 Urban Facilities: Part of a Wider Physical Vulnerability Assessment

There are many services that are classified under the title of public service, including educational buildings, hospitals, parks, fire or police stations. They are part of a city's everyday essentials and can play an important role in the event of an emergency. They can act as a temporary shelter or safe area, and increase the city's response capacity. Identifying their location and proximity to populated urban areas can help to promote them structurally for disaster preparedness planning. Their function can also be improved by including facilities such as medicine or water for the event of a disaster. The disaster mitigation plan is in fact to have adequate disaster-resistant public buildings to provide services to the people.

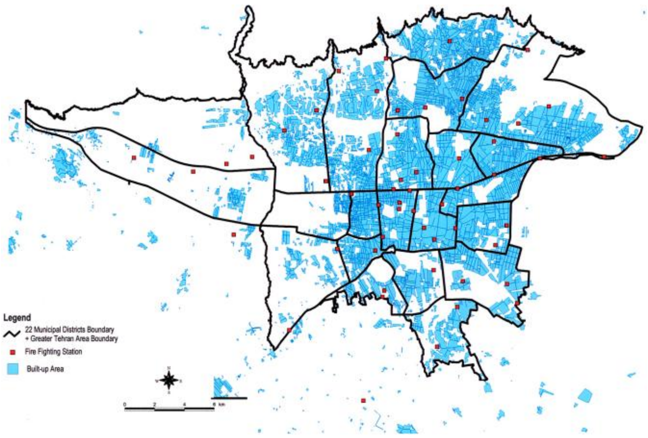
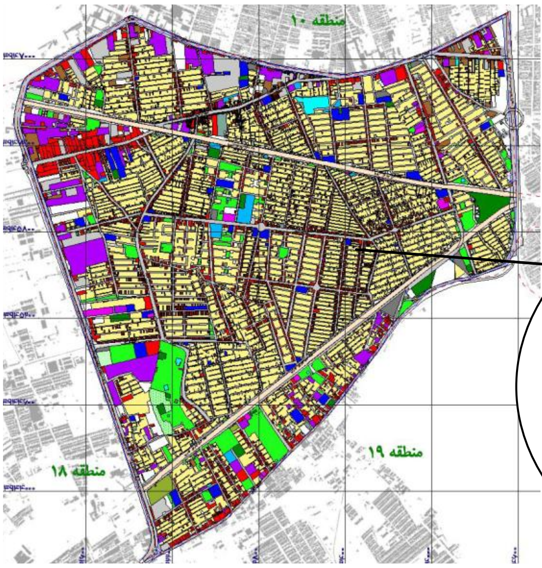


Figure 7.15: Distribution of fire stations within the city (JICA, 2000:72)

Picture 7.12 (above and right): The fire station in D17 and its surrounding roads



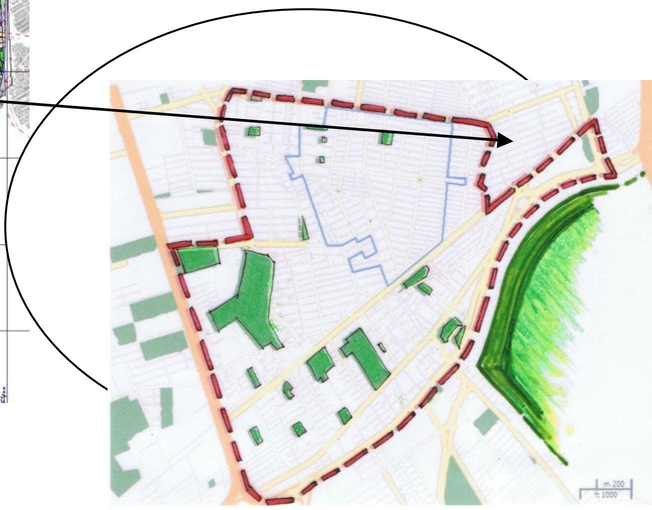


Figure 7.16: Khazaneh neighbourhood and the location of the area fire station

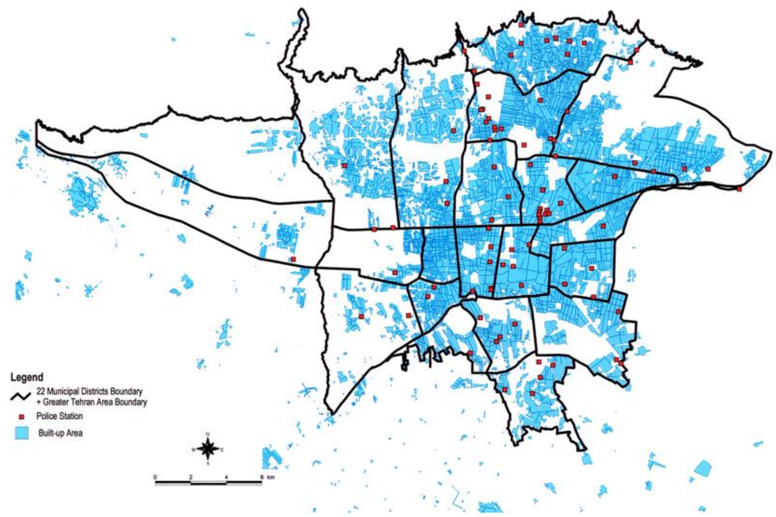


Figure 7.17 (above): Distribution of police stations in the city (JICA, 2000:73)

Picture 7.13 (below): Police station and the roads around it

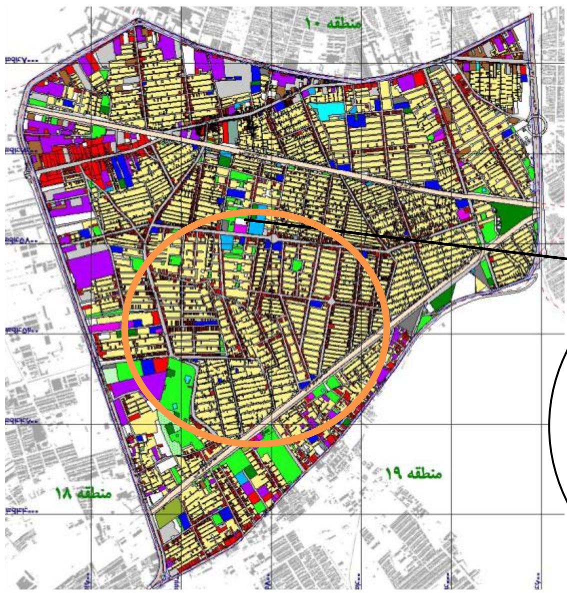
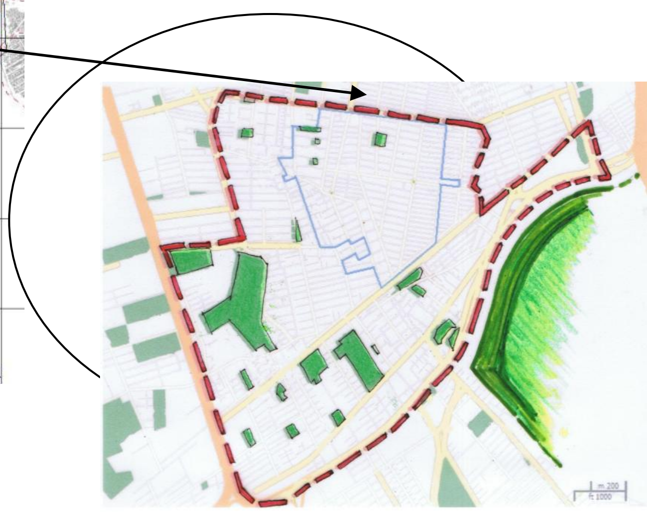


Figure 7.18: District 17 police station and its location in Khazaneh neighbourhood



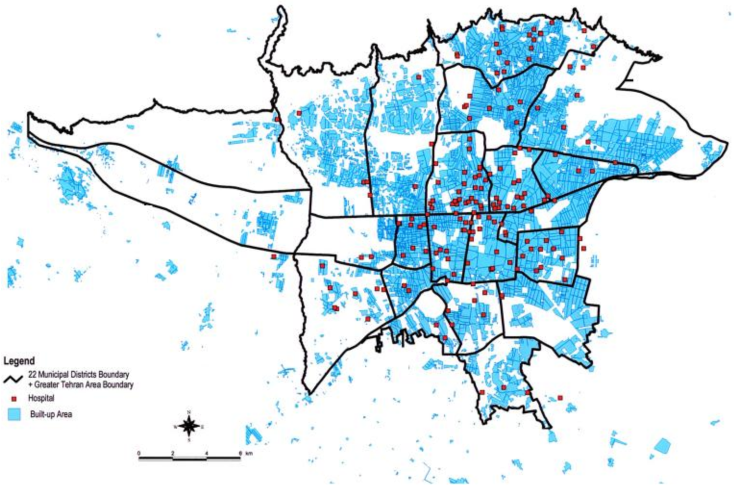
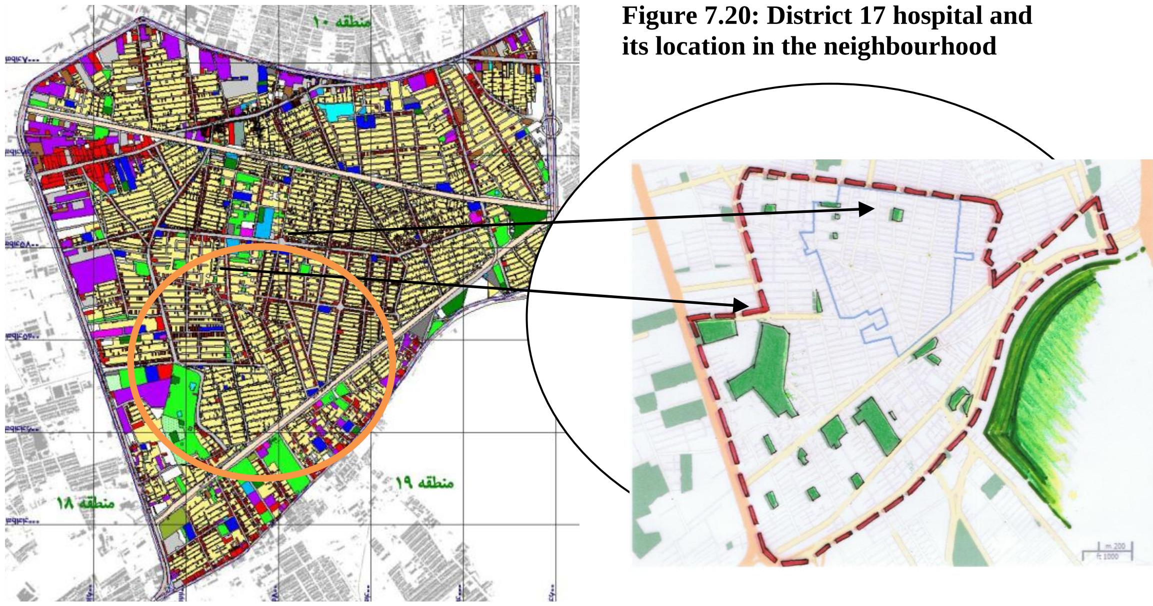


Figure 7.19: Distribution of hospitals in the city (JICA, 2000:75)

Picture 7.14: The dental hospital and the private clinic in the neighbourhood

Figure 7.20: District 17 hospital and its location in the neighbourhood



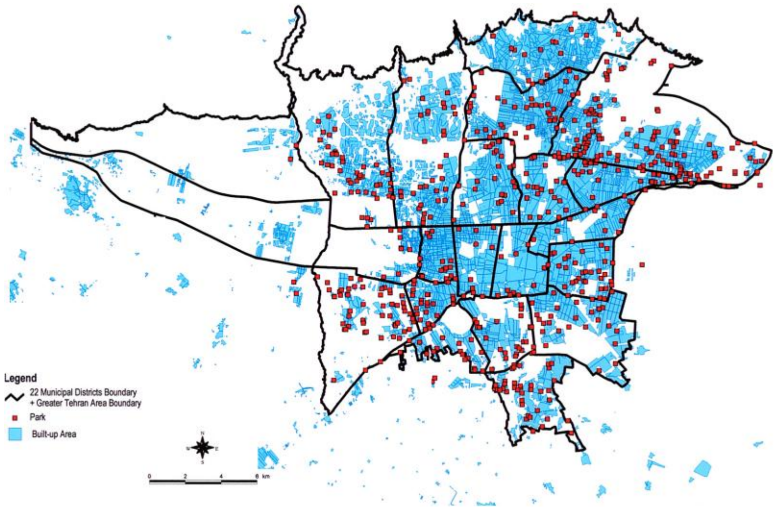


Figure 7.21: Distribution of parks within the city (JICA, 2000:76)

Picture 7.15: Parks in and around Khazaneh neighbourhood

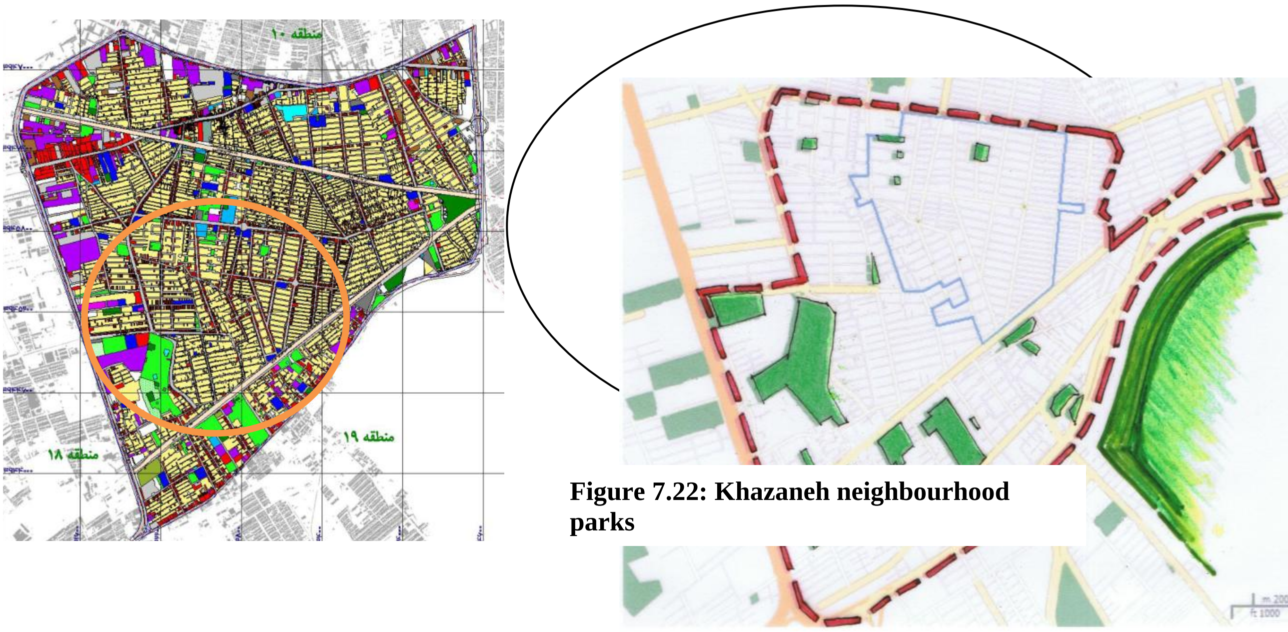


Figure 7.22: Khazaneh neighbourhood parks

As far as this research is concerned, their location and capacity is important for the planning authorities to equip them with some facilities and equipment needed for disaster. Figure 7.15 shows the distribution of fire stations around the city. Their small number, for instance, shows the deficiency of such an important service in the city. Even for some areas like Districts 7, 8 and 17, despite the high density of buildings and population, only one fire station is considered. The devastating 2003 Bam earthquake left the city with no functioning fire station, as almost all of them were destroyed (Hosseini and Jafari, 2007). These essential buildings should be examined in terms of their seismic resistance capacity to be able to survive earthquake tremors. The traffic and accessibility to and from these stations is also difficult. The quality of the structure of the fire station building in D17 is not of reinforced concrete (RC) and is weak, and it might suffer major damage if an earthquake struck. Its location in a corner of the district would make an emergency response difficult, even if were to survive the disaster. Especially towards the south, its surrounding roads are not wide enough to be used for emergency purposes. Therefore, for the Khazaneh neighbourhood, there is a high degree of insecurity and possible delayed rescue operations. The neighbourhood cannot be reached quickly from other existing fire stations in Districts 18 or 19.

This deficiency is again apparent in Figure 7.17, which shows the locations and distribution of police stations and the services that they can provide to the community. Although they are not the only military services which exist within the city, they are the most common and well-known organisations for this kind of services. Their equipment and facilities can play an important role in the quality of services they can provide in the event of an earthquake, for example. The location and importance of police stations in creating a sense of security and response to emergency calls is also important. D17 benefits from two police stations, one of which is steel-structured, and the other steel and brick, which might not have adequate seismic resistance, but could be used for communications and other services in the event of disaster. Their location is well known to local people, as the questionnaire results revealed. Therefore, improving the roads leading to them would be beneficial for accessibility purposes.

In Figure 7.19, the locations of hospitals are marked. It is evident that there is a high concentration of this type of facility in and around the central parts of the city, and a lack of it in Districts 2, 5 and 15. Although health centres can be used for emergency purposes, there is uncertainty about the quality of some of the converted or privately-built buildings in this category. Again, previous earthquake experiences in Bam (2003) show how the hospital buildings were damaged, and how the lives of many casualties were put in jeopardy by transferring them to the available medical centres many miles away (Hosseini and Jafari, 2007). Gathering data regarding the number of beds they have and the kinds of service they can offer was hard, however the next chapter will include more detailed information regarding the case study. D17 is lucky to have two hospitals in the centre of the area; however, their structural type is a matter of uncertainty, as one of them is RC, but built before 1991 and therefore more likely to suffer from extensive damage. Also the number of beds available is a maximum of 120, which is not enough for the local population. Fortunately, as Figure 7.21 indicates, one of the hospitals falls within the boundary of the Khazaneh neighbourhood which is an advantage for the local community. Also, the majority of respondents to the questionnaires were familiar with their location. “I think everybody knows where the clinic is. It is very handy to use this place rather than other clinics. They also charge less.” (M.R.33). However, the roads that create the network of connections within the surrounding area are narrow and might not be usable in the event of a disaster.

Schools (primary, middle and high schools) are the other public facilities in the city alongside other governmental offices. Their distribution in each district is quite good. They could act as temporary shelters if their building structure is of a good quality. Each individual building which has open space can also be used as a refuge area. The next two chapters will study and analyse their capacity for emergency uses. There are a number of other public buildings located in D17, such as government offices, which could be responsible for emergency uses for the area and its neighbourhoods. Some of them, like the municipality building, one high school and the fire station have open space attached to them, which could be used for rescue and temporary shelter areas; however, despite the emphasis against this in many building regulations and codes, some of them fall into the vulnerable building category and could collapse totally or partially. There are, in total, 78 schools and one government building in this district; however, five of them might be completely unusable as shelter (TCC, 2011:33). More than 60% of them are converted buildings and do not have enough space for emergency accommodation. Only a small number of them have the capacity to be equipped and improved for disaster preparedness purposes. The Khazaneh neighbourhood has, in total, 23 public buildings; however, only two of them are suitable for disaster-related services.

Parks and open spaces are the prime evacuation sites in each district. Their value, capacity, accessibility and exact location should be publicised, and some of them should have some emergency equipment such as water tanks, a first aid post or even a suitable landing site for a helicopter. As Figure 7.21 shows, there are plenty of them in each area. However, there are criteria other than quantity that should be considered for them to be able to be used for a refuge area or temporary shelter. The access to and from them, their surrounding buildings, their size and safety, and many other factors, are some of the elements affecting their use for disaster purposes. In D17 there are 29 large and small green spaces, mainly in the south and south-west of the area. Some of them, like Shagayegh Park which is only a play area (Picture 7.15), cannot be improved for additional functions, whilst Zamzam Park has the capacity to be improved and prepared to give emergency services to the local community. The Khazaneh neighbourhood is formed from four green spaces which are surrounded by residential and commercial buildings. The concentration of public uses and population around them has made them busy open spaces, especially during the day. At the moment they are only used for recreational purposes, but Chapter 9 will exclusively discuss their capacity to be used for disaster planning.

7.12 Roads and Networks

The road hierarchy and their widths play a crucial role in urban management and the balance of everyday life. Narrow roads less than 6 m in width are not practical for emergency services and can prevent access to other buildings on either side. The categorisation of roads in the 2006 Master Plan is simple (Table 7.14).

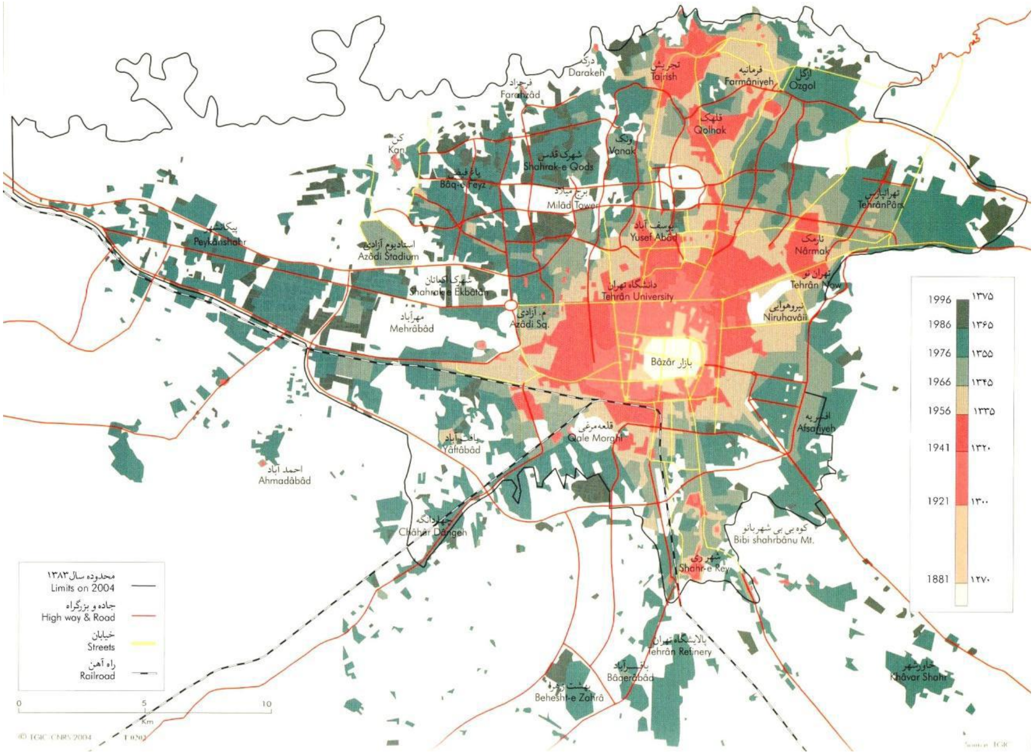


Figure 7.23: Tehran's growth up to 2004 and its new network system (Haghani, 2010:216)

They are in three categories: fast and interconnected roads; accessible roads; and mixed function roads (TCC, 2006). The role of the tram and metro is also important in the city's transportation system. The hierarchy and specification of the most common roads are summarised in Table 7.14 and were discussed extensively in Chapter 6.

Table 7.14: The specification of roads in the 2006 Master Plan (TCC, 2006:219)

Details	Motorway		Main Arteries		Local Accessibility	
	Highway	Highway	Level 1	Level 2	Junctions	Local
Accessible to the suburban area	No access	No access	Accessibility via low-speed zone	Direct access	Direct access	Direct access
Surrounding land use	Green space and service stations	Green space and service stations	Various usages	Various usages	Local usage	Residential and local services
Junction quality	Different levels	Different levels	Level	Level	Level	Level

Details	**Motorway**		**Main Arteries**		**Local Accessibility**	
	Highway	Highway	Level 1	Level 2	Junctions	Local
Distance between junctions	2000 m Min	1500 m	500–1000 m	300–500 m	250–400 m	100 m
Bus station availability	Forbidden	On the exit road	Allowed in the low-speed zone	Allowed	Allowed	Allowed
Pedestrian access to the other side	Forbidden	Forbidden	Footbridge or traffic light	Pelican or traffic light	Pelican or footbridge	Allowed
Pedestrian access to the road's area	Forbidden	Only for boarding and disembarking from buses	Based on the design and rules	Based on the design and rules	On the pedestrian area	On the pedestrian area
Separating movement directions	In the axis with 2 m width	Pivotal location with 2 m width	Pivotal location (blocking items)	Roads marking	Road marking	-
Capacity of lane per hour	1800 vehicles	1600 vehicles	1100 vehicles	1000 vehicles	-	-
Role of road	Fast connection of inter-areas	Connecting main city's centre of activities and facilitating fast connection between regions and areas	Connecting city's centres and connecting areas and neighbourhoods	Similar to previous column by lower speed	Connecting services and roads	Direct access to residential and service areas
Minimum width (m)	76	45	20	16	12	6
Minimum pedestrian width (m)	-	-	4	3	2	2

Around 60% of the 11.5 million daily journeys in the city are made by public transport, including unlicensed taxis (TCC, 1996:118–120). The problem with the majority of public transport, especially buses, is that they fail to deliver people to their final destination, use the same routes as cars, and do not meet the high amount of demand in the rush hour. Picture 7.16 shows how the city council tried to adjust narrow traditional streets for today's fast vehicle movement; however, this was not carried out in accordance with emergency and hazard mitigation requirements. The structures of buildings adjacent to the main roads are not considered to be hazard-proof. This will be considered in more detail when the building structures are studied and analysed later.

Picture 7.16: New buildings have to move back

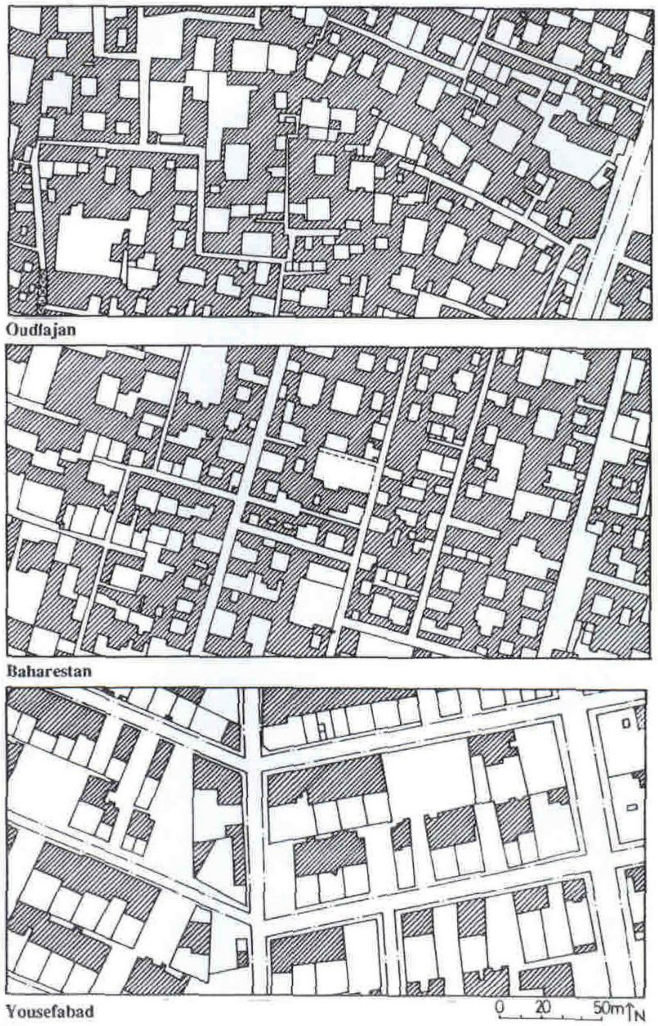


Figure 7.24: Evolution of the street layout from narrow to wide and straight network (Madanipour, 1998:121)

D17 does not contain any major motorway or high-speed road, due to its location and its main uses. Despite the warnings of the disaster plan of 2000 and the transportation problems of the area, the D17 development plan seems to be happy with the present situation. There are roads in and around Khazaneh neighbourhood which have been suggested for widening. However, there is no precise solution for roads of narrow (below 6 m) at the heart of the residential area. The majority of roads are classified as local, junctions, level 1 and level 2. The existence of the narrow 3–6 m roads in this district, especially in the Khazaneh neighbourhood, has many disadvantages for the area, which includes inadequate accessibility in the event of disaster. Figure 7.25 and Picture 7.17 also illustrate how on-street parking, multi-storey buildings along narrow roads, disorganised pedestrian zones that direct people to use the roads and the lack of speed management zones have made the streets of this neighbourhood unsafe and unfit for purpose.

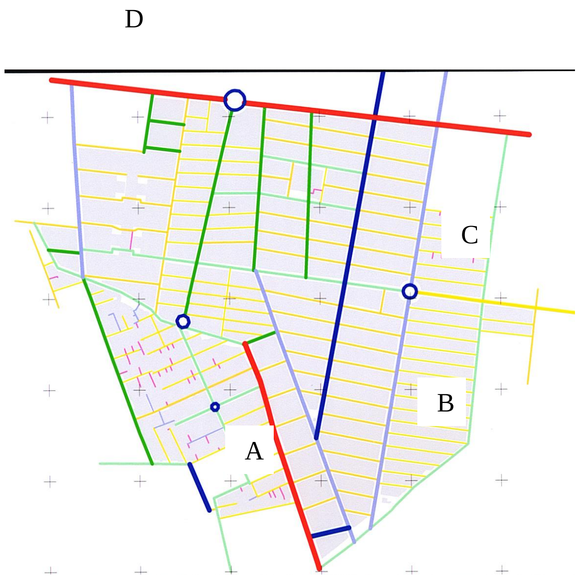


Figure 7.25: Road hierarchy in Khazaneh neighbourhood

Picture 7.17: from top to bottom, left to right: a) on-street parking, b) multi-storey buildings along narrow roads, c) disorganised pedestrians, d) lack of speed management zones

7.13 Urban Development and Growth Planning System Assessment

Urban management in Iran, like other areas of government, is characteristically strongly centralised. The city council and municipality under the supervision of the provincial governor deal with urban affairs. The extended population and complexity of managing Tehran required the municipality to have 22 district sub-divisions; each of the districts has a population similar to an average middle-sized Iranian city. Each district municipality manages finance and administration, welfare, urban services, research units, traffic and planning (Madanipour, 1998). The six main departments which deal with urban development are finance and administration, technical and development, city planning and architecture, planning and coordination, urban services and district affairs (TCC, 1996). The main features of the city management of Tehran in recent years are as follows:

- A programme of privatisation of some of the municipal services started [such as] … statistical information, cemeteries, the fire brigade, parks, transport and traffic control;
- A new wave of major urban development project has been implemented including roads and parks;
- The municipality has become more engaged in social and cultural issues [by setting up a new development] to deal with the establishment of cultural centres, public libraries, sport centres … ;
- The necessity of long-term planning for dealing with urban problems was stressed;
- In a short period of time the municipality has become financially independent;
- The mayor of Tehran has been given a more powerful presence in the parliamentary scene;
- The municipality … establishes new commercial units.

(Madanipour, 1998:72)

Besides the municipality, at both a city and district level, there are other provincial and national public organisations and ministries that have both individual and overlapping functions in the city, which has always caused confusion and disorder (Chapter 6, section 6.3). The ULO, the Religious Endorsement Organisation, HUDO and its units, the Plan and Budget Organisation and the Ministry of Economic Affairs are some that have direct intervention in urban decisions and management.

At a district level, D17, like the rest of the city, has its own district municipality which deals with plan endorsement, planning approval affairs, and services to the public, such as community centres, libraries, parks, general urban sanitation, etc. Its office is located in the heart of the area; however, it does not have much autonomy in the decision-making process, as the main municipality office and city councils are the principal decision-makers. The privatisation of some of the district municipality duties lessens the extent of self-determination of local government still further to that of an administrator and observer.

The local government division ends at this level, and there is no opportunity for residents of Khazaneh neighbourhood to influence the management of the area. Some initiatives, such as local representatives, or community social gatherings, give local people the chance to speak up for themselves to some degree; as the answers to the questionnaire revealed, however, it cannot be counted as an influential and reliable method. “We gather in the local mosque when there is a religious event and chat to each other about our neighbourhood. But we hardly see any councillor attending these gatherings.” (M.R.52). “We have never been asked by the municipality’s staff about our neighbourhood problems. The only staff I see is the bin man.” (M.R.29). There is no public consultation when preparing the area development plan. The situation concerning disaster mitigation or preparedness plans is worse, as they are almost a new and unheard subject for local people, as the questionnaire’s respondents claimed: “I never knew that disaster planning exists. What organisation holds the responsibility?” (F.R.29). “You cannot make a plan for an earthquake that has not happened. You may need ambulances and paramedics.” (W.R.19). Neighbourhood management is solely a governmental task, with very weak partnership, or none at all, with the community of the Khazaneh neighbourhood.

In terms of disaster management structure and relevant legislations, after the Manjil earthquake in June 1990 that left over 40,000 dead (UNDP, 2005:4), the government of Iran in general, and Tehran’s municipality and provincial governor specifically, carried out a number of studies concentrating on disaster preparedness activities. Their outcomes are the main regulatory frameworks and legislation for national disaster management:

- In 1991 the law founding of the National Committee for the Mitigation of Natural Disaster Effects (NCNDR) was passed through parliament.
- Approval of the study on seismic microzoning of the Greater Tehran Area took place in 2000.
- In 2003, the decision was taken by the Council of Ministers to approve the Rescue and Relief Comprehensive Plan.
- The Council of Ministers set up a specialised sub-committee in 2003.
- The Integrated National Disaster Management Plan (INDPM) was created in 2004.
- The Expediency Council decided to have basic policies for disaster mitigation and prevention in 2004.
- In 2004, the Council of Disaster Management was established and was chaired by the vice-president of Iran.
- The obligatory role of Standard 2800 for building construction was again emphasised in 2005.
- Incorporation of technical and safety measures and earthquake-resistant regulations became the responsibility of the municipality and executive organisations (UNDP, 2005:10).

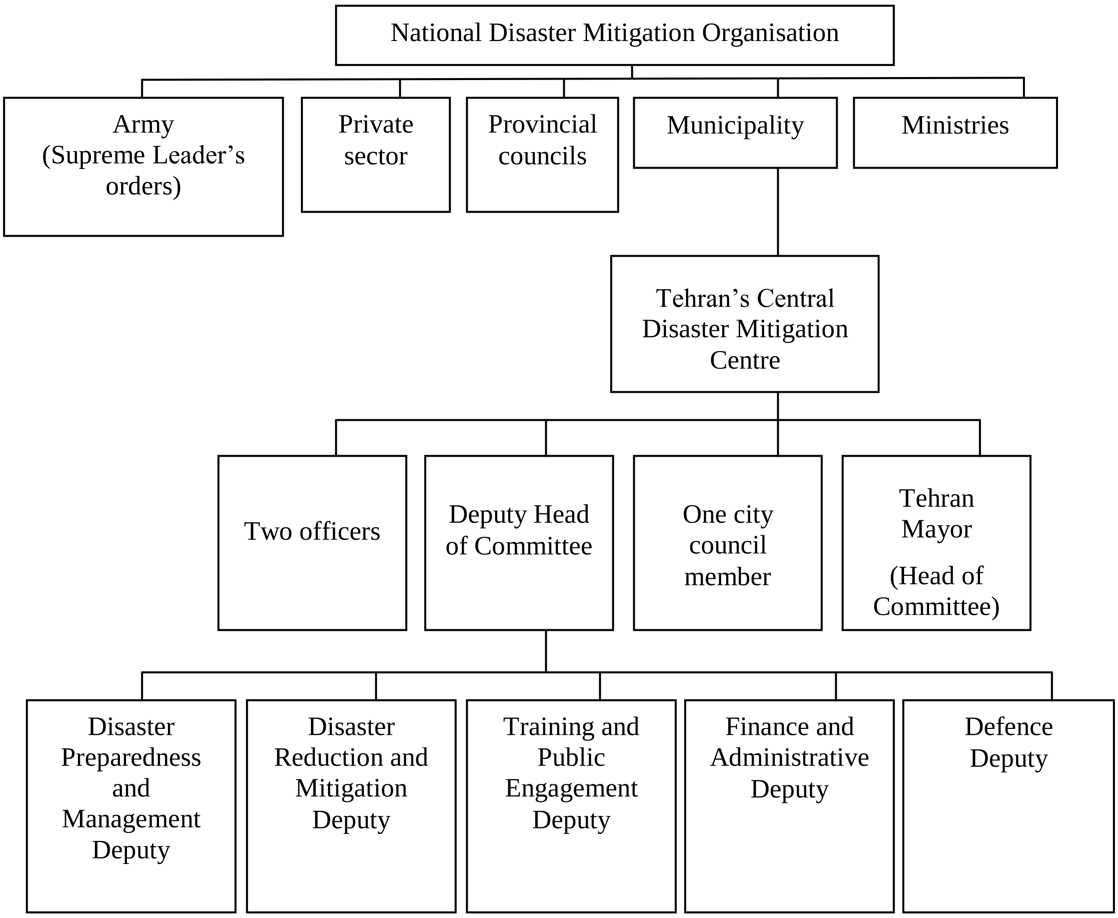


Figure 7.26: The Structure of National and Tehran Disaster Management Organisation (Tehran municipality website)

One duty of the Ministry of the Interior and its provincial offices is to manage disaster rescue and recovery services. The provincial governor is the head of the natural disaster organisation and makes decisions concerning the disaster management mechanism. Other local organisations, including the mayor of Tehran's office, play a part in this process.

In order to support the preparedness and mitigation policies and plans taken by this committee, two specialised bodies work closely together to provide the required studies and research and improve coordination amongst the different bodies for a response to an emergency. The first is the Bureau for Research and Coordination of Safety and Reconstruction Affairs (BRCRS) which has a rather broad mandate including "research formulation of preparedness and mitigation plans, … coordination of relief, reconstruction and rehabilitation" (UNDP, 2005:5). The second organisation is the National Disaster Task Force (NDTF) which concentrates more on emergency relief and operations. One of the active committees under HUDO is the “earthquake and landslide expert group” which is also a branch of NCNDR (*ibid*). There are also other provincial and national organisations supported by the ministries and universities, such as the International Institute of Earthquake Engineering and Seismology (IIEES) that incorporates the study and analysis of the disaster planning process (*ibid*).

Every year, the Budget and Planning Ministry sets 2.5% of the country’s budget for “advocacy and damage reduction” and “emergency management” (*ibid*:5). Tehran’s unique urban management system has a major impact on the hierarchy of disaster-related planning and practice. Tehran’s mayor is in charge of Greater Tehran’s disaster management, and its authorities are reasonable for observing and putting into practice the relevant regulatory obligations (Tavakoli and Ghafory, 1999). Since the merger of the Centre for Earthquake and Environmental Study of Tehran (CEST) and the Centre for Emergency Management Secretariat (CEMS) in 2003 into the TDMMC, the Tehran Master Plan for Emergency Management was produced in 2004 (UNDP, 2005). The plan is a laudable document without any obligatory and practical support (Rad, 2006). According to this plan, all 22 offices of the district mayors are responsible for disaster management in their areas. However, the two principal sources of regulatory laws for Tehran are:

- the Tehran comprehensive emergency management plan (TCEMP),
- the Tehran mayor’s decree of May 2003 (Bac-Bronowicz and Maita, 2010).

The former is an emergency response plan creating a network of connections amongst 24 organisations in the event of an emergency, whilst the latter mainly concerns TDMMC’s response and functions (*ibid*). It ranges from a coordination and supervisory authority function to direct formulation and preparation (*ibid*). It is a difficult task for the municipality to manage all the complexities and hardships of urban activities, and this has been responsible for compromising the city’s priorities. However, the establishment of some committees under the direct control of the municipality to concentrate on disaster-related management and planning has been a step forward in identifying the real vulnerabilities and giving them priority. There are still milestones to be reached to arrive at an integrated planning system, and it is difficult to create a network of relations between various organisations at local, city and national levels. The local community is the ultimate target of the TDMMC, which requires a series of collaborative actions and planning to enhance the earthquake resistance quality of locally-built environments as follows:

- Having tighter control on the residential building construction process;
- Increasing public awareness and training them for any disastrous event;
- Increasing collaboration amongst lead disaster management organisations before, during and after a disaster;
- Reducing the extent of damage and loss in every aspect of society;
- Managing the post-disaster recovery and reconstruction process.

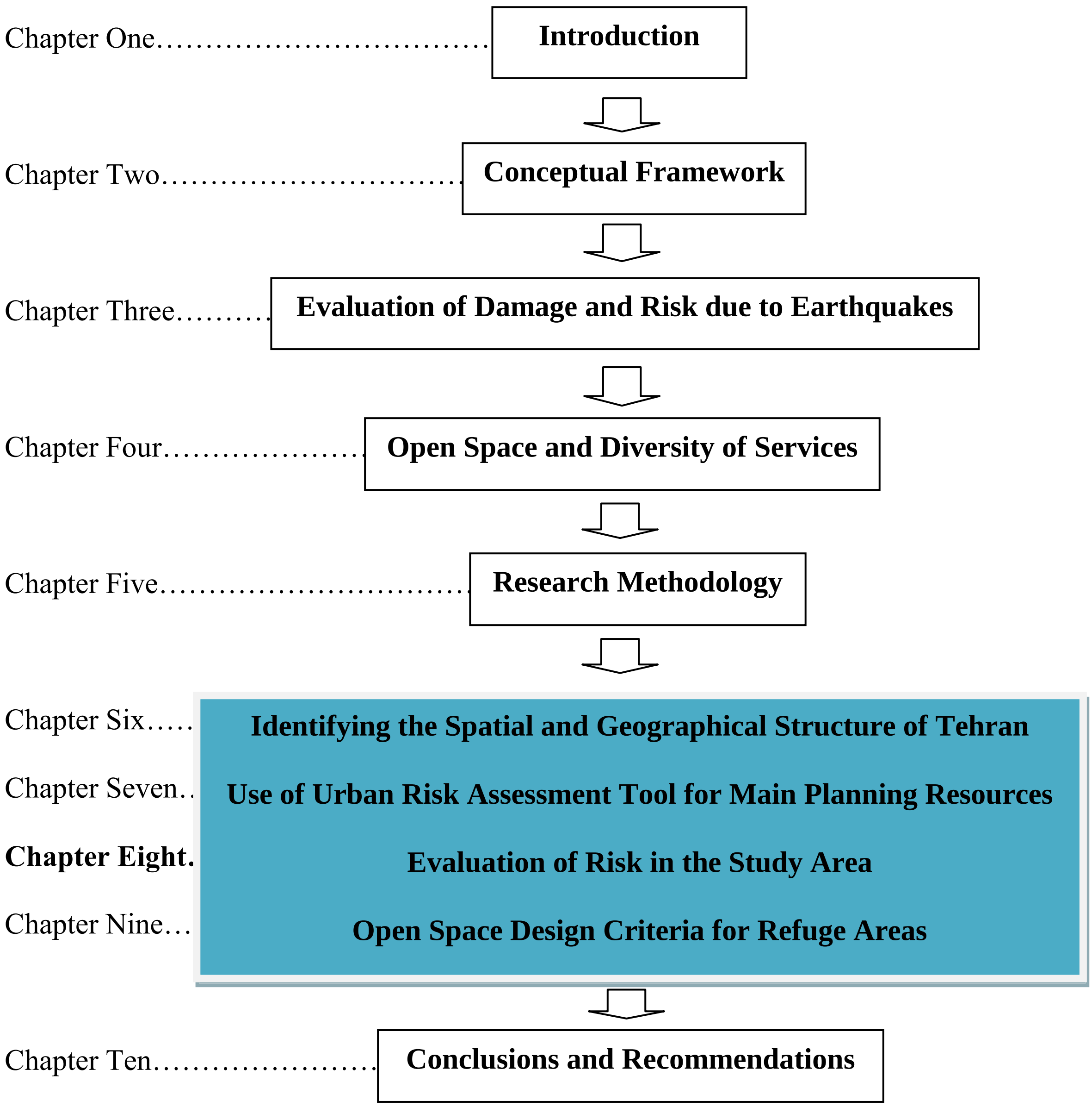
Despite the plan’s emphasis on seeking local partnership, and passing part of the disaster management and emergency rescue action to the district municipality, for the majority of participants in the research survey it is still the provincial governor’s responsibility, which has never been explained or clarified for local people:

> At the municipality, we work closely with local community and schools to train them how to react in an emergency situation. There are also volunteers from the Red Crescent organisation who attend schools and work with children.
>
> (Interviewee C).

> Our facilities are not adequate enough to cover the whole area. There are also traffic jams on the main roads that slow down our speed.
>
> (Interviewee D).

7.14 Conclusion

The chapter exclusively reviewed the capacity and vulnerability of Tehran in some aspects and District 17 in more detail. It contained invaluable discussion about the city of Tehran, District 17 and Khazaneh neighbourhood’s social demographic, the physical and spatial, infrastructure, master plans and networks. The context of the chapter mainly focused on the case study area's vulnerable points, capacity and structure (derived from direct observation, interviews, the literature and local documents). It showed how, despite the efforts of the municipality and other relevant organisations, the neighbourhoods are vulnerable to earthquakes. There may be many ways to analyse the data; however, this research has chosen the most suitable method according to the information available to the researcher. Through this, the second and third concepts of the research – learning from seismic damage to urban life and an integrated action plan – were met. As the chapter revealed, there are highly vulnerable features, such as road widths or the number of fire stations in the district, which are out of proportion to the district and have to be improved immediately. The discussion prepared the thesis for the next level: analysing and working on the design of a safe and serviceable open space. There will be more discussion of building damage in Chapter 9, which contains more detailed discussion and will highlight how the Ray earthquake scenario would affect the district and neighbourhood life.


Chapter One
Introduction
Chapter Two
Conceptual Framework
Chapter Three
Evaluation of Damage and Risk due to Earthquakes
Chapter Four
Open Space and Diversity of Services
Chapter Five
Research Methodology
Chapter Six
Identifying the Spatial and Geographical Structure of Tehran
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Use of Urban Risk Assessment Tool for Main Planning Resources
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Evaluation of Risk in the Study Area
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Open Space Design Criteria for Refuge Areas
Chapter Ten
Conclusions and Recommendations

8.1 Introduction

The risk equation is comprised of hazard, vulnerability and capacity. The previous chapter illustrated the main vulnerable elements and the quantity of the capacity of Tehran, aiming to assess them based on the probabilistic earthquake hazard described in Chapter 7. The chapter also evaluated the risk of building damage, population death and injury toll, as well as how essential the role of existing government and community's capacity is. This is part of the fulfilment process of the second conceptual framework of the research: "learn from earthquake damage on buildings, infrastructure and urban services". In order to do so, first, an earthquake scenario should be selected. This will help to estimate the extent of damage to the buildings (the first cause of human casualty), to the population, and to the social aspects of urban life. This will then determine the level of vulnerability within the physical and social context. The capacity of the government (at a local and regional level) as well as the community will then be evaluated. By examining the potentials and the capacity of the city and neighbourhood, it will become obvious what should be added to the present spatial structure to improve hazard resistance and reduce the associated risks. This is a complex multi-dimensional issue and therefore requires cooperation amongst key actors, integrated planning, and public awareness and training.

The focus of this section will only be on some aspects of social and physical vulnerability, which will be derived from available data and the results of interviews and questionnaires. The selection of subjects covered by this chapter has been inspired by the VCA criteria in Table 7.1.

8.2 Basic Idea for the Method Used for Damage Estimation

Chapters 6 and 7 focused on the geological characteristics of Tehran, its spatial structure, the location of many public services, buildings and population density etc. The structure of a building will be partially or totally destroyed by any force over its resistance. An earthquake can cause this overwhelming force which affects the foundations and structural and non-structural elements of buildings, caused by ground motion, landslide, liquefaction etc. Therefore, simply identifying the structural specifications, and calculating the resistance of the building, helps to determine its resistance against any external forces. The two sets of information needed for damage estimation in Tehran, as discussed and selected in Chapter 3, are earthquake motion and building structure, utilising a simple analytical model. The main structural materials features of buildings in Tehran are around brick and steel (semi-engineered), RC, steel and others (Figure 8.1). The majority of the residential buildings in the southern part of the city are made of brick and steel frame, with a construction of two to four storeys. Due to the residential nature of most of the buildings located in Tehran, this section concentrates on typical residential building characteristics and their vulnerability against an earthquake.

Traditionally, the study of building structures in Tehran shows that some base isolation techniques have been utilised to mitigate seismic impact on some types of the structures ever since 1960, when the engineering building codes were recommended by structural engineers (Yasuyuki et al., 2004). Using techniques such as the "construction of multi-layer stones, pouring sand between the ground and the load-bearing walls or installing pieces of wood (timber) between the load-bearing walls of some traditional structures" are examples of earthquake resistance construction in Iran (Nadarzadeh, 2009:40). The flowchart of residential building material is shown in Figure 8.1. Also, "the preparation of the database and the selection of the damage estimation method are both influenced by one another" (JICA, 2000:134).

Many methods and levels, in terms of the number of the buildings and the coverage area of study, are applicable when carrying out damage estimation. The United Nations RADIUS (Risk Assessment Tool for Diagnosis of Urban Areas Against Seismic Disasters) initiative was, for instance, one of the ideas launched by the secretariat of the IDNDR (1990–2000), aiming to reduce seismic disaster impact in urban areas (Villacis and Kaneko, 1996). In this study, a complete set of data from Tehran was unavailable due to various limitations[33] as, fortunately, Tehran has not been hit by any earthquake strikes. The method that is used in this study is a collection of various

[33] Organisations such as the Housing and Urban Development Organisation, the Statistical Centre of Iran or the Seismic Centre of Iran did not have a classified and long-term survey of the building structures in Tehran. Their data was either limited or did not match with each other.

methods used for other parts of Iran, such as Bam. Although each region has its own traditional construction method and materials, the majority of buildings located in urban areas are built in a similar way and fall into certain structural categories.

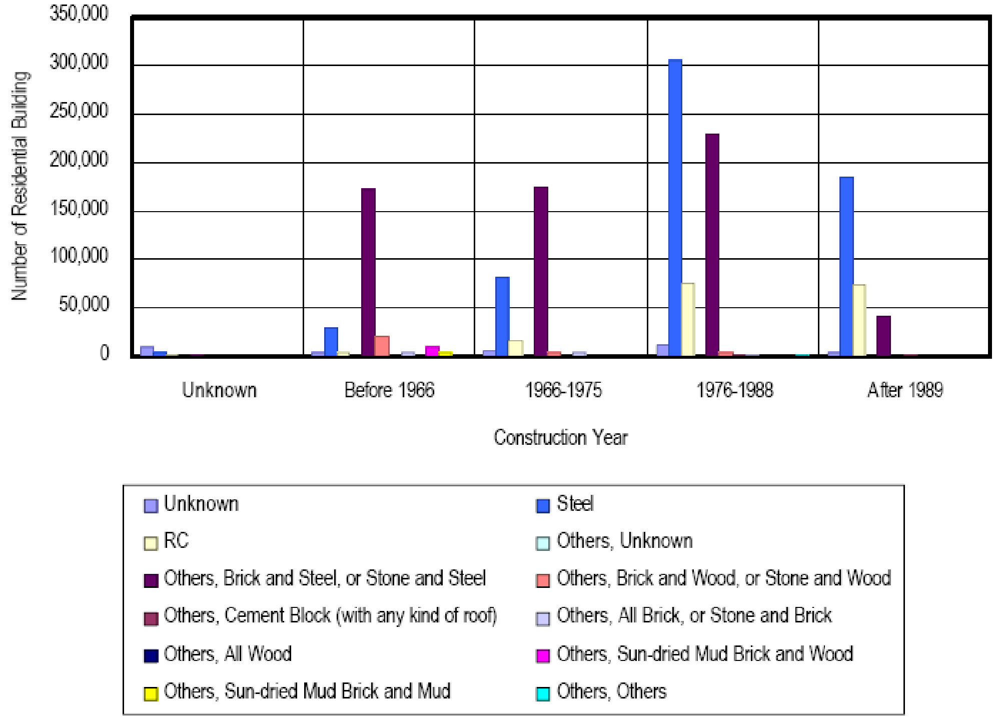


Figure 8.1: Number of residential buildings according to their year of build and structural material (JICA, 2000:135)

Thus it is important to select or produce an appropriate method for damage estimation, in which the available information is taken into consideration as much as possible. First a general background to the building seismic code of Iran will be presented.

8.3 Building Seismic Code of Iran

After the devastating 1963 Bouein-Zahra earthquake, the Iranian Ministry of Housing and Development commenced a study which was later published in 1967, called *The Building Safety Code During Earthquake* (Yasuyuki et al., 2005:95). According to this code, the structure of buildings higher than 11 m should be steel-framed or RC (*ibid*:95). There were also some regulations concerning masonry buildings' walls and foundations[34] which became the legal basis of all building activities. They were developed by the Iran National Standard Code no. 519, which concerned the loads applicable to the buildings, and which has appeared in the Iranian Planning and Budget Organisation's papers ever since (Berberian, 1999).

Today, the revised version of the National Standard Code no. 2800 of 1999, the *Iranian Code of Practice for Seismic Resistant Design of Buildings*, is the main guideline for building construction activities (BHRC, 1999). The code covers the minimum standards and requirements of the design and construction of steel, wood, RC and masonry buildings, to determine that they meet certain criteria and regulations for seismic building designs. The seismic base shear coefficient C is defined as follows:

$$C = \frac{ABI}{R}$$

Figure 8.2: Seismic base shear coefficient (JICA, 2000:102)

where A is the design base acceleration (ratio to gravity acceleration) which varies between 0.35, 0.25 and 0.20 according to the region, B is the building response factor, obtained from the design response spectrum as follows: $B=25(T_\circ/T)^{2/3} \leq 25$ (T is the building natural period (in seconds) and $T_\circ$ is a scalar quantity determined according to soil specification and which may be 0.4, 0.5, 0.7 or 1.0), I is the building importance factor (0.8, 1.0 or 1.2) and R is the building behaviour factor (4–11), which is a reduction factor related to the structural system and its ductility, as well as uncertainty of strength. The B/R ratio must in no case be less than 0.09 (Yasuyuki et al., 2005:96).

Signals at the bedrock regional reference structure *Sa* (1D) indicate a high risk of earthquake in Tehran. Furthermore, the structure of the majority of buildings in the southern part of the city fall into the classification of Chapter 3 of the code (the criteria for unreinforced masonry with tie-confining buildings) (Ghodrati et al., 2003). These

[34] The regulations are regarding the walls, their infill role in distributing forces between the walls and on the foundations.

buildings are mainly limited to two floors for residential use. Identifying typical structural systems in case study areas helps to estimate better the possible damage.

8.4 General Features of Building Structures in Tehran

The residential building database is based on the 1996 housing census data. It was carried out by the post office and includes the following information items for each building (JICA, 2000):

- Census zone number and block ID number;
- Construction year;
- Number of storeys;
- Structural type;
- Number of rooms;
- Number of inhabitants.

This is the basic information that describes the properties. The common structural system in Tehran, considering the load-bearing system, roughly falls into the following description:

1) Adobe: adobe bricks with mud or lime mortar in the form of cylindrical domes or a wood beam roof;
2) Simple masonry: brick or sometimes stone and concrete blocks with cement mortar and jack arch roof system;
3) Unreinforced masonry: brick walls with tie-confining and jack arch roof;
4) RC moment resisting frame with cast in place or precast slab and masonry infill walls;
5) Steel moment assisting or brace frame with jack arch or cast in place slab and masonry infill walls.

The common feature of the building structures is the brick jack arch (Figure 8.3, Sanada et al., 2005:97).

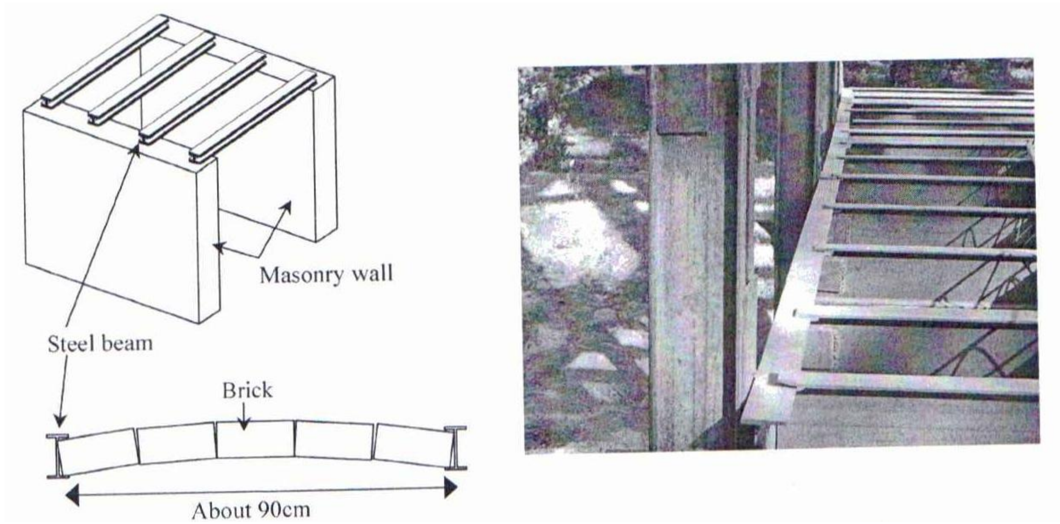


Figure 8.3: Commonly used jack arch slab in Tehran (left: wall supporting, right: girder supporting) (Sanada et al., 2005:97)

As the figure shows, the brick arches are supported by parallel I-shape steel beams or intervals of about 90 cm. These heavy slabs behave like a flexible diaphragm.

8.5 Buildings' Initial Vulnerability Data

As Table 8.1 shows, there are three main structural types of building in the city of Tehran, which are steel, reinforced concrete and masonry (and others). The majority of buildings structures are steel (41%) whilst RC (11%) is in second place (JICA, 2000: 146). The original data in this section was derived from the SCI (1996) report, and its accuracy is largely dependent on their resources. As Figures 8.4 to 8.7 (JICA, 2000:46, 48, 49, 50) show, the distribution and density of buildings in Tehran is uneven, and largely reliant on the property's use and the area's general function. In some districts such as 2, 4 and 15, there is a high volume density of building units, whereas some areas, like District 22, have a very low density. The distribution of the various building structures follows the growth pattern of the city in recent years, as does their seismic resistance quality. It is largely evident that Districts 1, 3, 4 and 22, the northern parts of the city, are less vulnerable to earthquakes, based on the research's earthquake scenario.

Table 8.1: Number of buildings in each district based on their structural specification

District	Type of Main Structure											Sum
	?	1	2	3	4	5	6	7	8	9	10	
1	1,398	17,610	7,202	10,950	1,074	213	689	23	216	196	63	39,634
2	2,115	32,960	17,101	11,253	166	202	612	12	21	27	172	64,641
3	1,112	20,548	5,576	8,712	251	76	295	8	97	91	35	36,801
4	3,215	40,498	6,515	30,936	369	276	655	41	45	37	55	82,642
5	1,645	29,250	11,763	9,875	269	260	152	8	76	11	43	53,352
6	756	14,278	2,577	10,233	286	34	180	54	14	33	8	28,453
7	1,576	18,710	1,907	20,914	1,070	124	376	12	122	48	33	44,892
8	1,700	18,985	1,352	28,309	188	28	721	13	8	25	10	51,339
9	503	4,747	557	14,500	171	12	121	1	2	60	6	20,680
10	1,186	8,117	218	28,682	986	18	708	6	296	70	42	40,329
11	1,051	9,975	492	15,338	3,137	31	472	53	1,249	330	136	32,264
12	958	8,493	436	9,648	4,698	59	493	205	2,710	850	141	28,691
13	1,133	11,781	580	20,459	1,148	23	196	12	104	84	8	35,528
14	1,716	19,946	839	29,726	1,822	82	158	111	639	284	25	55,348
15	2,714	27,203	1,945	38,546	2,286	114	292	99	508	308	1,240	75,255
16	1,408	8,852	424	23,399	1,495	144	462	70	967	208	9	37,438
17	1,229	7,490	148	23,401	385	14	336	4	95	98	12	33,212
18	1,306	11,496	269	22,247	132	12	164	1	20	26	3	35,676
19	759	9,273	292	16,086	107	16	134	5	20	30	8	26,730
20	1,381	16,480	2,082	21,139	713	307	440	24	377	273	62	43,278
21	741	8,798	1,831	10,366	55	479	29	1	18	28	21	22,367
22	132	4,312	1,500	740	11	7	32	2	0	1	1	6,738
City	29,734	349,802	65,606	405,459	20,819	2,531	7,717	765	7,604	3,118	2,133	895,288

Legend: ?: unknown; 1: steel; 2: RC; 3: others, steel & brick, steel & stone; 4: others, wood & brick or wood & stone; 5: others, cement block; 6: others, all brick or brick & stone; 7: others, all wood; 8: sun-dried mud brick & wood; 9: sun-dried mud brick & mud; 10: others (JICA, 2000:46)

However, the older areas of the city, such as District 17, are in need of serious seismic improvements as their population density and building quality make them the most vulnerable and hazardous areas to earthquakes, which can lead to an exceptionally high number of casualties. There are other criteria, such as the number of units and stores, having an impact on the extent of possible seismic damage, and are not illustrated in this chapter. However, they will be considered in estimating damage in the next chapter.

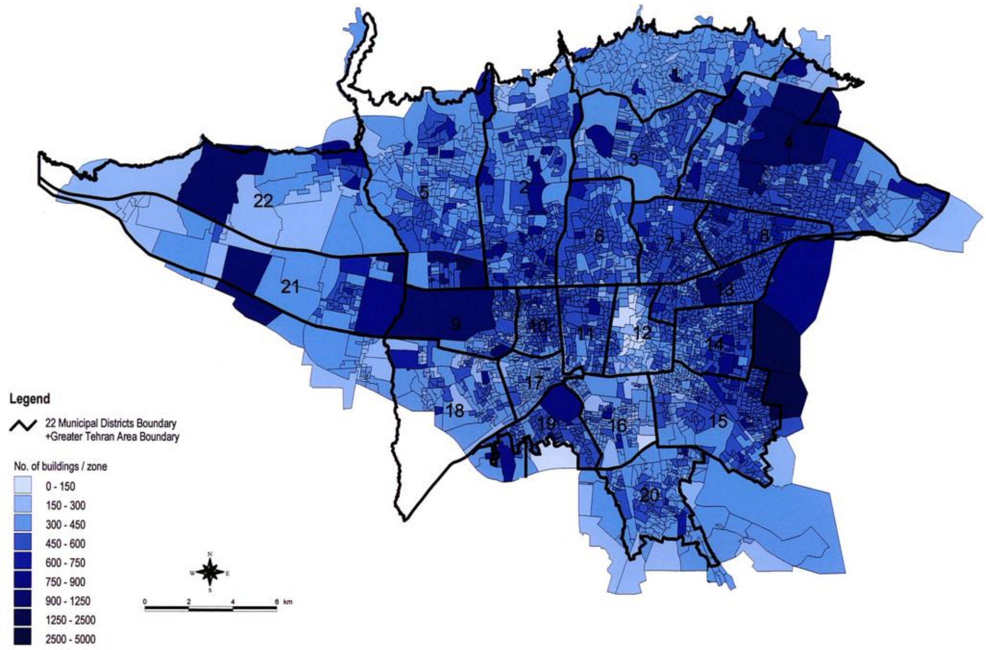


Figure 8.4: Building density per unit in Tehran (JICA, 2000:46)

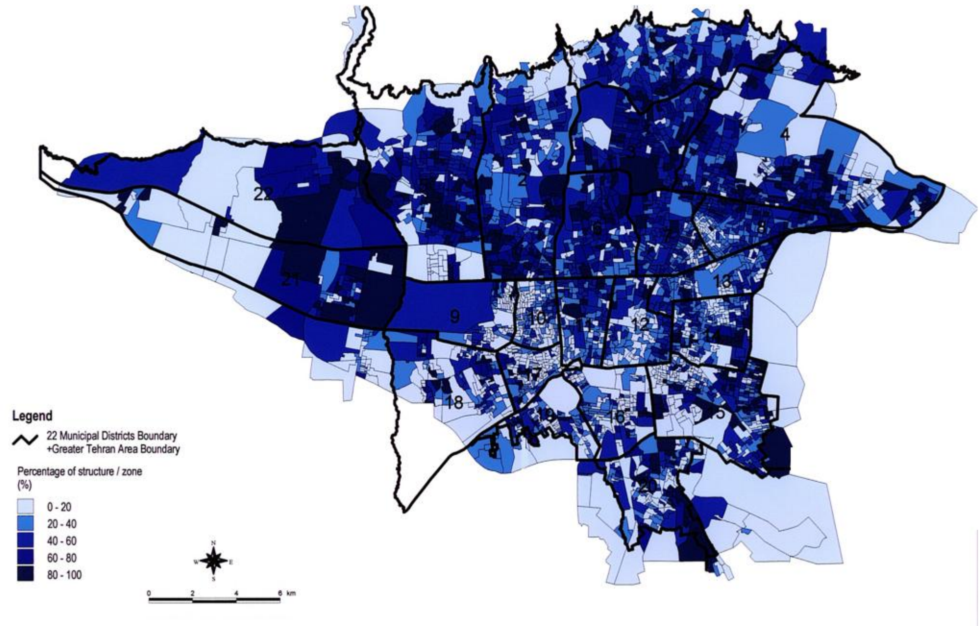


Figure 8.5: Distribution of steel structures within the city (JICA, 2000:48)

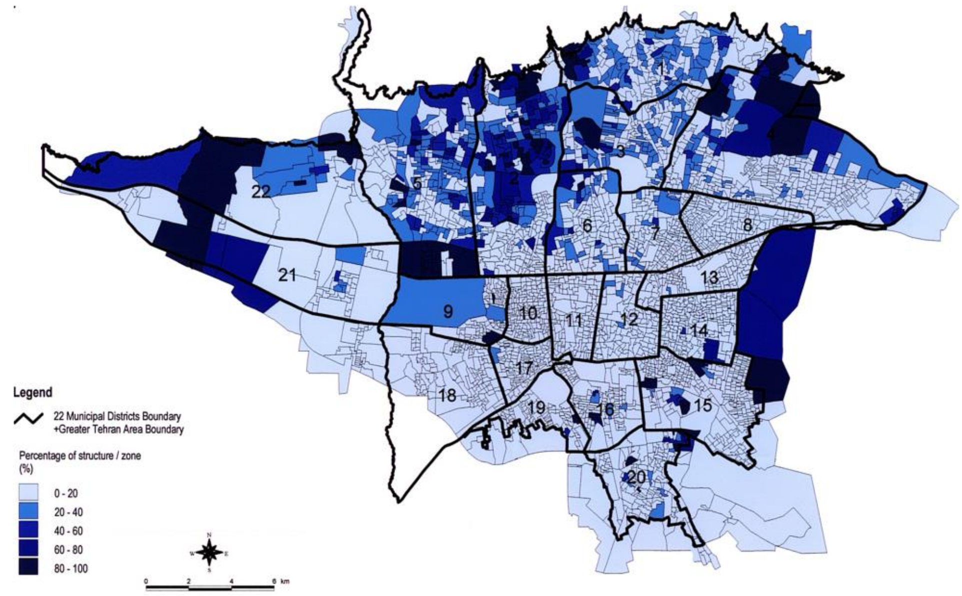


Figure 8.6: Distribution of RC structures within the city (JICA, 2000:49)

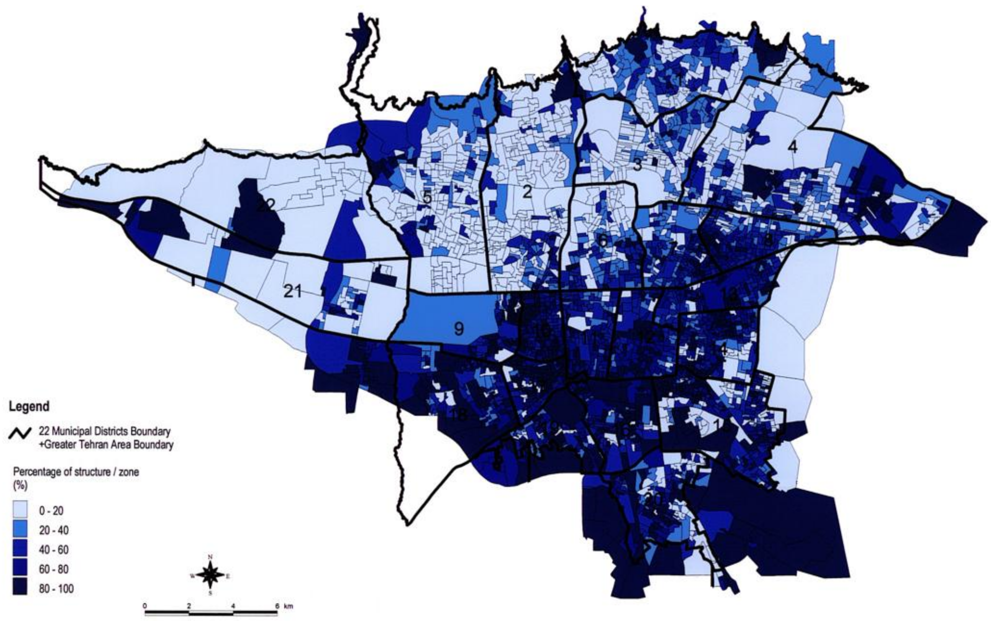


Figure 8.7: Distribution of other structures within the city (JICA, 2000:50)

Based on the residential building database and site reconnaissance, the features of the residential buildings of the study area are summarised as follows:

1) 45% of the buildings are steel and brick structures, 40% are steel structures, 10% are RC and only a small percentage are adobe structures.
    a) There has been a recent increase in the number of steel-structured buildings. 60% of them have been built during the last few decades.
    b) At the moment resisting frames of the steel structures are recognised as being effective in the current seismic design code. On the other hand, the pillars and beams are connected with welding[35] rather than bolt which leads to a low reliability of connection.
    c) Many steel pillars are not of adequate size for many reasons such as cost cutting or using builders rather than engineers and most of the RC pillars do not have adequate reinforcement.
2) There are two types of RC structures. One type has RC pillars and walls. Another type has RC pillars and brick walls. RC structures, not brick structures, are expected to serve as shear walls.
    a) There are only 10% of the buildings with adequate shear walls.

(JICA, 2000: 140).

Also, in the design-related criteria, the current seismic code was issued in 1990, which makes the buildings constructed before 1991 different as far as earthquake resistance is concerned. Most of the structure’s components are not tied to support walls; this has been the main cause of building damage in many incidents in the past (Asudeh, 1982).

8.6 Damage Estimation Method for Tehran’s Residential Buildings

Structural weakness or overloading, the distance from the fault line, dynamic vibrations, the building and population density of the area, in-plane and out-of-plane deformation and settlement are amongst the major reasons for the failure of buildings to withstand earthquake motion (ISG, 2004), although most of the above-named factors affect only reinforced masonry (URM) structures or steel structures: these can collapse if the construction method is not followed properly, or all standards are not met equally (Kuwata et al., 2005).

[35] Annan et al. (2010) believe that on many occasions, the quality of the welding is not good enough and is not properly assessed by construction engineers during the build. Therefore, they have acted as the weak point of the building structure in an earthquake, according to the Bam (2003) earthquake damage survey (Sanada et al., 2005).

Table 8.2: Number of casualties based on the building structure in district b, Bam, 2003 earthquake (Kuwata et al., 2005:7)

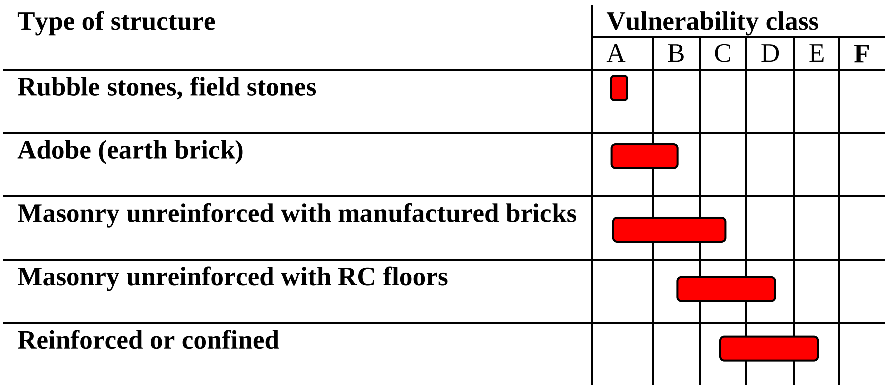
	Deaths	*Injuries*
Adobe masonry structure	500	39%
Brick masonry structure	440	52%
Reinforced concrete structure	10	1%
Steel structure	80	8%

According to the studies regarding the damage which occurred to buildings during previous earthquakes in Iran (Bam, 2003, is the most recent example), the vulnerability of the buildings is as follows:

- Adobe (bricks and clay mortar): vulnerability class A (Table 8.2), which is the weakest type of building for seismic motion;
- Simple masonry (manufactured brick with cement mortar but no reinforcement): vulnerability class B;
- Masonry with steel frame (manufactured bricks and cement mortar with reinforcement of steel frame): vulnerability class C;
- Masonry with RC frame (bricks and cement mortar with reinforcements of RC frame): vulnerability class D;
- Steel frame (moment-resistant steel frame): vulnerability class D or E;
- RC frame (moment-resistant RC frames): vulnerability class D or E.

(Hisada et al., 2004:85)

Table 8.3: Vulnerability class, European Macroseismic Scale, 1998 (EMS98) (Hisada et al., 2004:84)



Legend: A: 100%-80% damage and highly vulnerable, B: 80%-60% damage, C: 60%-40% damage, D: 40%-20% damage, E: 20%-5% damage and F: 5% to very minor non-structural damage

This develops the assumption that since building material and construction methods are similar all around the country, Tehran can also use the same methods.

Table 8.4: The European Macrozoning Scale category of masonry and concrete buildings damage (Sinha and Goyal, 2010: 6)

	Classification of damage to masonry buildings	**Classification of damage to reinforced concrete buildings**
Grade 1: Negligible to slight damage (no structural damage, slight non-structural damage)	Hairline cracks in very few walls; Fall of small pieces of plaster only; Fall of loose stones from upper parts of buildings in very few cases	Fine cracks in plaster over frame members or in walls at the base; Fine cracks in partitions and infills
Grade 2: Moderate damage (slight structural damage, moderate non-structural damage)	Cracks in many walls; Fall of fairly large pieces of plaster; Partial collapse of chimneys	Cracks in columns and beams of frames and in structural walls; Cracks in partitions and infill walls, fall of brittle cladding and plaster, falling mortar from the joints of walls
Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage)	Large and extensive cracks in most walls, Roof tiles detach, chimneys fracture at the roof line, failure of individual non-structural elements (partitions, gable walls etc.)	Cracks in column and beam-column joints of frames at the base and at joints of coupled walls; Spalling of concrete cover, buckling of reinforced bars; Large cracks in partitions and infill walls, failure of individual infill panels
Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural damage)	Serious failure of walls (gaps in walls), partial structural failure of roofs and floors	Large cracks in structural elements with compression failure of concrete and fracture of rebars, Bond failure of beam reinforcing bars, tilting of columns; Collapse of a few columns or of a single upper floor
Grade 5: Destruction (very heavy structural damage)	Total or near total collapse of the building	Collapse of ground floor parts (e.g. wings) of the building

Based on another category by the European Macroseismic Scale (EMS98), A, B–F are defined in Grade 5-1 damage classification. Table 8.4 represents this coding system in, for example, masonry and RC buildings. The extent of damage to a building usually fits within one of the above structural categories, but is different in reality, and is due to many other factors. The area in which the building is located, how the welding of steel columns, beams or braces are done, the construction skills or even the mixture of concrete used for the frames are amongst these factors (*ibid*). Tavakoli and Tavakoli (1993) were amongst those who studied the damage of villages located near the epicentre of the 1990 Manjil earthquake in Iran. They compiled the relationship between PGA and building damage as Figure 8.8.

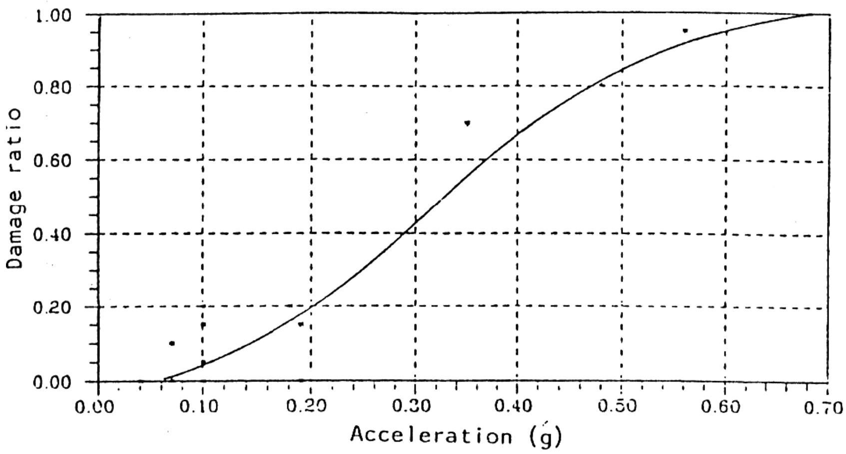


Figure 8.8: Fragility curves for residential buildings during the 1990 Manjil earthquake (Tavakoli and Tavakoli, 1993:22)

Therefore, the estimation was carried out accordance with the construction conditions. In another study, by Zeraati (2004), it was found that during the 2003 Bam earthquake, almost 100% of adobe masonry structures, 100% of brick masonry structures without concrete frame, 90% of brick masonry structures with concrete frame, and 90% of brick and steel structures in the area collapsed. However, this cannot be expanded to all the existing buildings in Tehran, as there are properties built by various methods in various conditions. For instance, steel-frame buildings which were assembled by a qualified steel fabricator are more resistant to shake than those that do not follow any engineering standards and were built by professional builders, but still fall into the steel structure category.

As stated previously, the available building information in this study is the structural type, construction year and the number of storeys. Based on this information, the buildings in the case study area were categorised into the following nine types (i.e. slightly different to the previous classification system). This includes the date of construction and the number of floors which has a major impact on the quality of structure and the method that the building was built. 1) Brick and steel or stone and steel MMI ratio of 0.3; 2) Steel 1: steel structure built after 1992, with one to three storeys, MMI ratio of 0.5; 3) Steel 2: steel structure, built before 1991 or with more than four storeys, MMI ratio of 0.4, 4) RC 0: RC structure with more than six storeys, MMI ratio of 0.5; 5) RC 1: RC structure, built after 1991 and with one to two storeys, MMI ratio of 0.5; 6) RC 2: RC structure built after 1991 or with more than three stories, MMI ratio of 0.7; 7) All wood, MMI ratio of 0.2; 8) Cement block with any type of roof, MMI ratio of 0.2; 9) Sun-dried and brick and wood, MMI ratio of 0.1 (JICA, 2000:140).

Although all existing buildings fall into one of the above categories, the relationship between the seismic force and damage ratio is not always the same, even if the buildings are basically similar to each other (*ibid*). Vertical or horizontal motion, the distance from the centre of the earthquake, and the duration of the force, etc. all affect possible seismic damage (Tavakoli and Tavakoli, 1993). The report of Tavakoli and Tavakoli (1993) (Figure 8.8) was one of the few numerical studies that presented the relationship between damage ratio and seismic motion for buildings in Iran. Therefore, the same relationship is used as the basic function to establish damage functions for other types of structures. Figure 8.9 is a summary of residential building vulnerability function in Tehran carried out by JICA (2000).

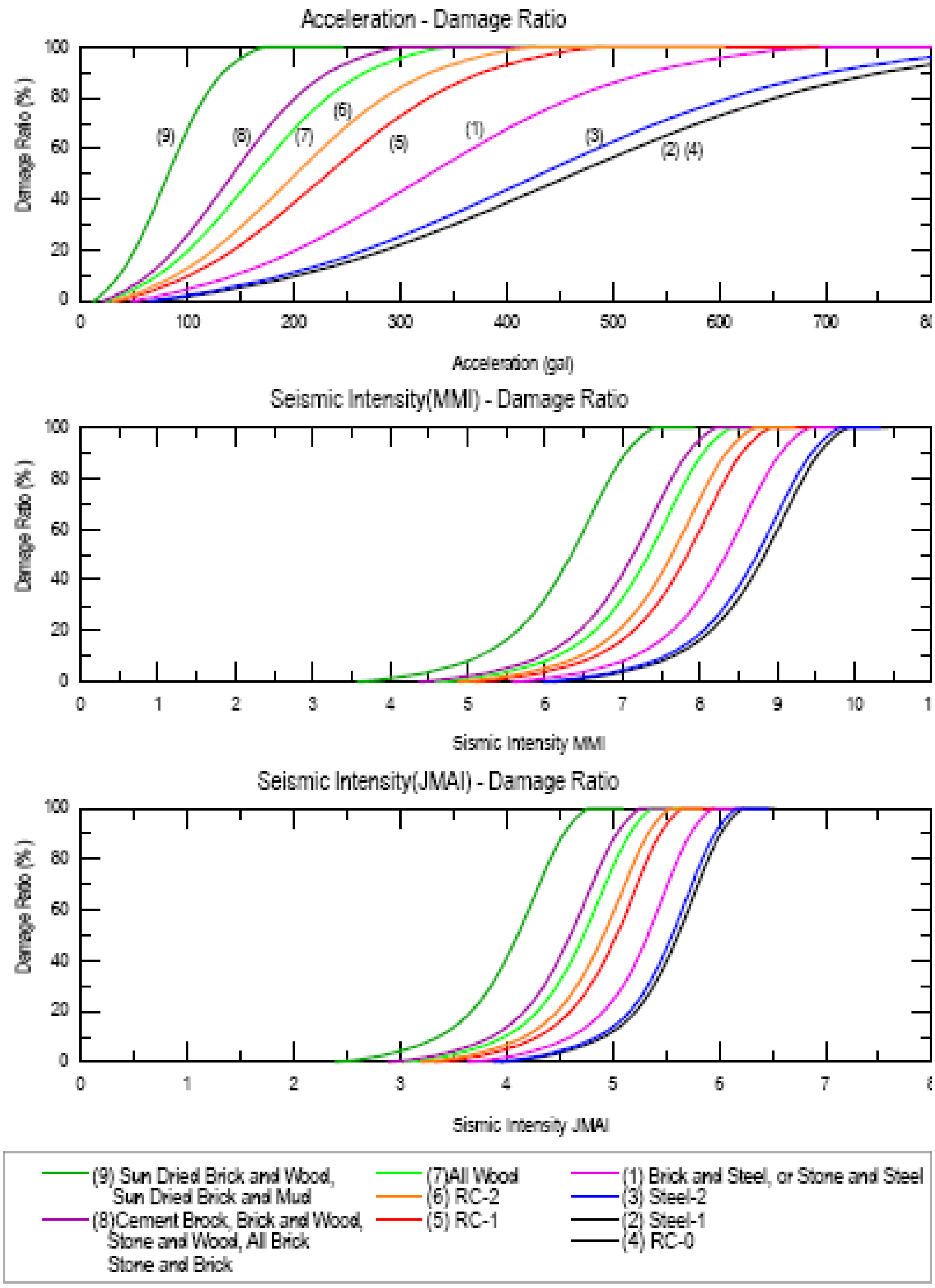


Figure 8.9: Vulnerability function of residential buildings applied in Tehran (JICA, 2000:141)

Based on the previous damage experiences and studies, most of the damaged buildings belong to the brick and steel, block and brick and adobe categories. To assess the built environment's vulnerability, residential buildings, commercial and administrative buildings, and other major public buildings such as hospitals or schools, as well as urban infrastructure, for example bridges and roads, fall into this category. The development of social vulnerability to natural hazards is relatively small in Tehran, as is a reliable approach to preparedness, response, recovery and mitigation in the local, district or city area (Cutter and Emrich, 2006:102). The inventory database used for non-residential buildings was also prepared according to the housing census data of 1996 without any specific approach towards natural hazards. Some data, however, needed some modification to be applicable for seismic disaster estimation due to some limitations.

8.7 Damage Estimation for the Ray Fault Scenario

Studies show that the Ray Fault scenario could be the most devastating of all four of Tehran's possible earthquake scenarios (Ray Fault model, NTF model, Mosha Fault model and floating model) (JICA, 2000).

Table 8.5: Residential building damage by district, Ray Fault model (JICA, 2000:153)

DISTRICT	RAY FAULT MODEL	
	Number	Ratio (%)
1	11,665	30.4
2	26,980	41.3
3	13,974	40.5
4	23,060	28.0
5	18,996	35.8
6	13,842	45.0
7	23,061	51.4
8	26,115	51.4
9	11,936	58.2
10	27,450	68.1
11	25,920	78.6
12	22,118	77.1
13	17,958	50.8
14	31,484	57.6
15	48,707	65.7
16	26,673	77.2
17	28,025	82.2
18	27,446	77.5
19	18,437	75.0
20	29,306	78.6
21	7,009	46.9
22	2,051	30.7
Total	483,212	55.2

Considering an earthquake of magnitude 7.5 and an area affected within a circle 3050 km across, the extent of damage to the residential buildings is shown in Table 8.7. Approximately 480,000 buildings would be damaged across the city, with a ratio of 55% (Figure 8.10).

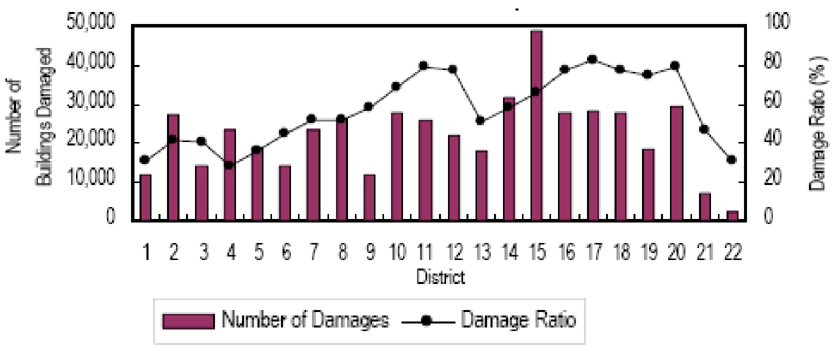


Figure 8.10 Ray Fault model, residential damage ratio (JICA, 2000:155)

The damage ratio is of a high value in Districts 15, 17 and 20 as they would be closer to the centre of the earthquake. In these areas there are steel-brick structures, built before 1991, and these are some of the most densely-populated areas. It has been estimated that the MMI would be 9 (IX) which is dangerous and alarming.

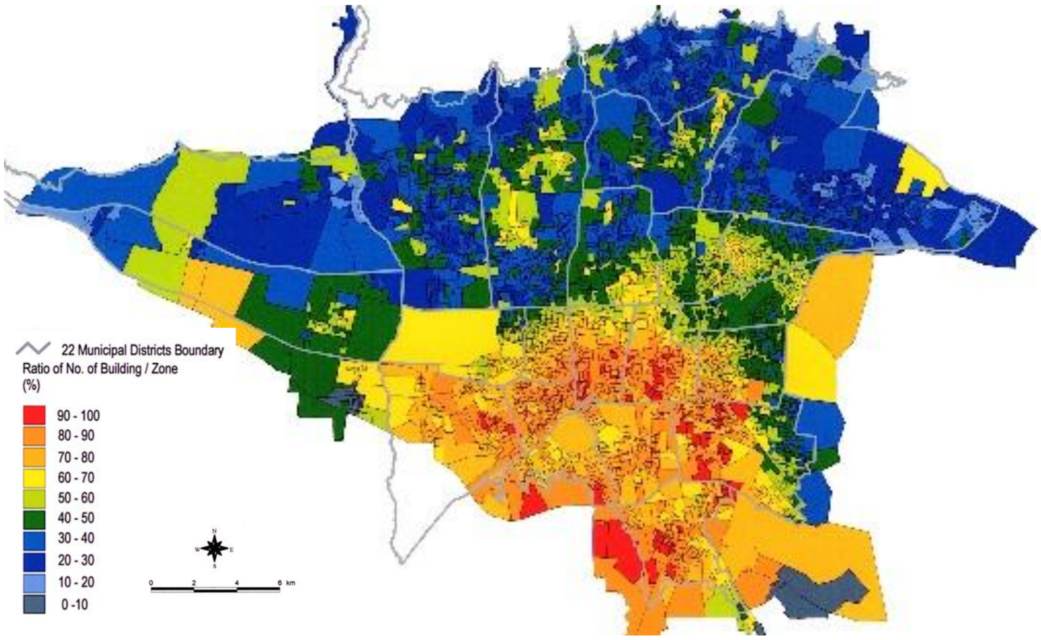


Figure 8.11: Heavily damaged or collapsed building ratio for the Ray Fault model (JICA, 2000:160)

The collapse of buildings, fire, and other post-earthquake hazards are considered to be the main causes of human casualties in Tehran. It is worth mentioning that landslides and tsunamis are less likely to be a big issue in the event of an earthquake in Tehran, due to the building structure, distance from the sea, and geological quality of the ground. In order to estimate the number of casualties, the 1996 population census, the post-earthquake damage records, and the building functions were used (JICA, 2000). The evaluation formula (Figure 8.12) is borrowed from Coburn et al. (1992).

Evaluation Formula: $Ks = Ds \times M1 \times M2 \times M3 \times (M4d + (1 - M4di) \times M5)$

Figure 8.12: Evaluation formula (Coburn et al., 1992)

where *Ks*: human casualties, *Ds*: number of collapsed buildings, *M1*: number of people in each building, *M2*: occupancy at the time of the earthquake, *M3*: number of occupants trapped by collapsed buildings, *M4d*: death ratio at 0-hrs after the collapse of buildings, *M5*: post-collapse mortality.

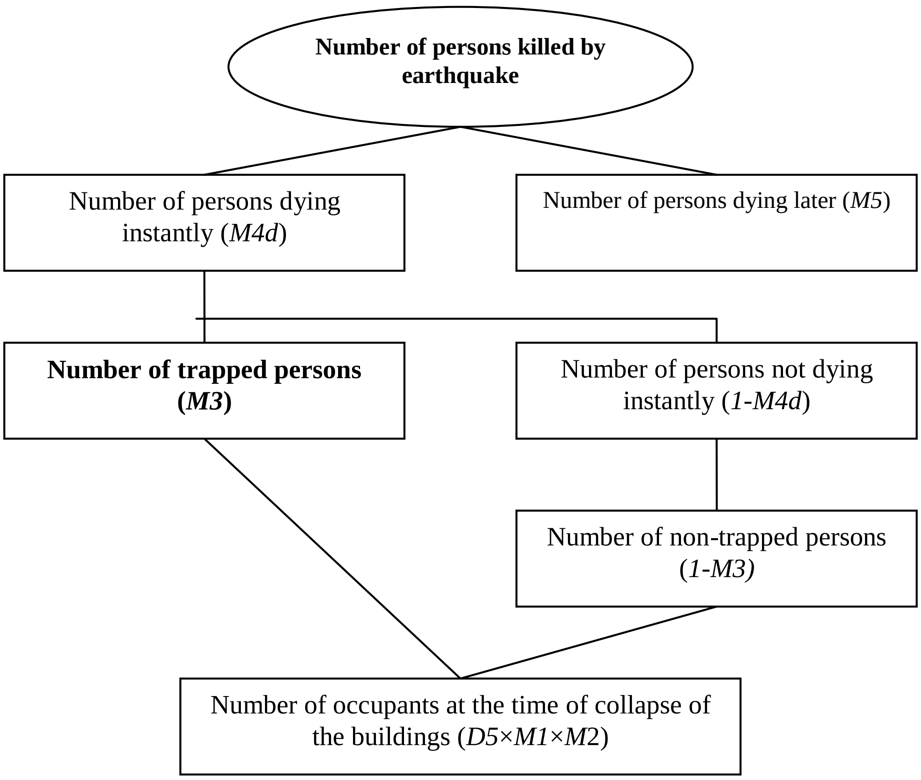


Figure 8.13: Casualty estimation (Coburn et al., 1992:112)

The census data for the numbers occupying each building applies to the night-time when everyone is at home. For the daytime, the previous earthquake damage was taken into account. Table 8.6 is an example of the death ratio in some of the past earthquakes in Iran.

Table 8.6: Death ratio in previous earthquakes in Iran (JICA, 2000:169)

Earthquake	**Ghir**		**Tabas**			**Golbaft**		**Sirch**		**Manjil**		**Ardakan**	
Year	1972		1978			1981		1981		1990		1997	
Time	6:36		20.06			11.45		21.52		1.30		12.27	
Daytime/Night-time	Night-time		Night-time			Day-time		Night-time		Night-time		Day-time	
Major structure	Adobe, masonry					Adobe		Adobe				Adobe, masonry	
Data for each village	MMI	Dead	MMI	Dead	Injured	MMI	Dead	MMI	Dead	MMI	Dead	MMI	Dead
	9	67.1	10	84.3	3.8	7	9.2	9	57.1	6	0.795	10	2.7
	9	20.4	9	42.8	4.2			9	32.1	6	0.103	10	13.4
			9	19.2	4.0			8	9.8	6	0.0	9	23.1
			8	8.7	3.9			8	2.1	9	90.0	10	45.5
								7	0.08	10	90.0	8	6.5
								7	0.8	7	9.0	8	11.0
										10	66.7	8	1.7
										8	13.3	7	5.8
												8	3.0

There are many factors such as:

- A lower number of people in a residential building during the daytime;
- Being occupant in a more resistant building such as a school or office;
- Being able to escape in the daytime;
- Being more aware and concentrating in the daytime.

These can change the figures dramatically. Rescue activities are usually run by the community, emergency teams and experts; however, this can change based on the circumstances. Considering all of the elements, the number of casualties due to the Ray Fault has been summarised in Figure 8.14, using JICA (2000) as the main resource.

The high number of casualties is largely derived from the quality of the buildings in the southern districts of the city. Besides the damage to residential buildings and injuries to their occupants, the extent of possible damage to the city's infrastructure, public buildings and supply lines are also important when considering of the hazard mitigation plan. The damage analysis for bridge structures is for instance summarised in Figure 8.14.

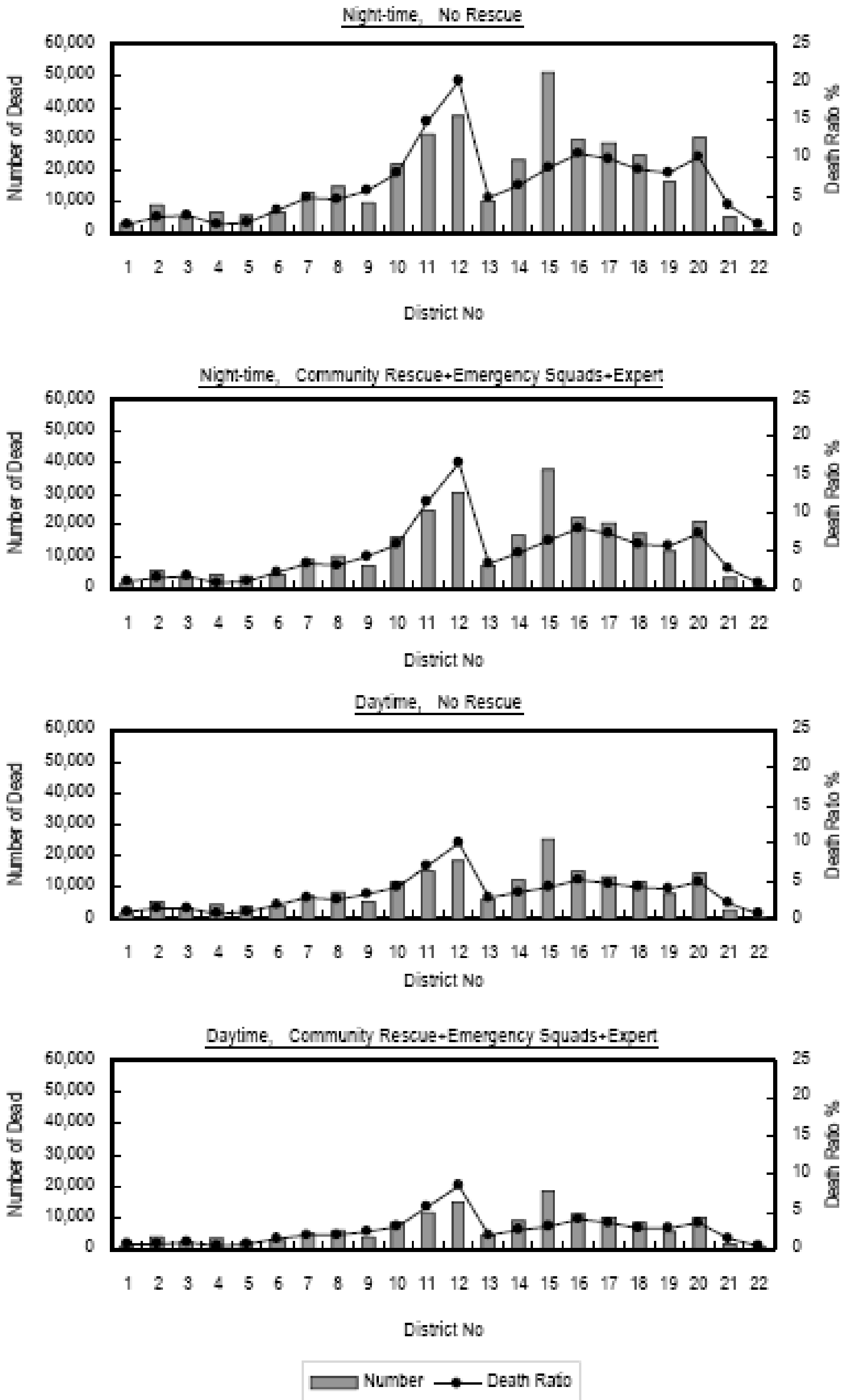


Figure 8.14: Distribution of casualties by district, Ray Fault model (JICA, 2000:184)

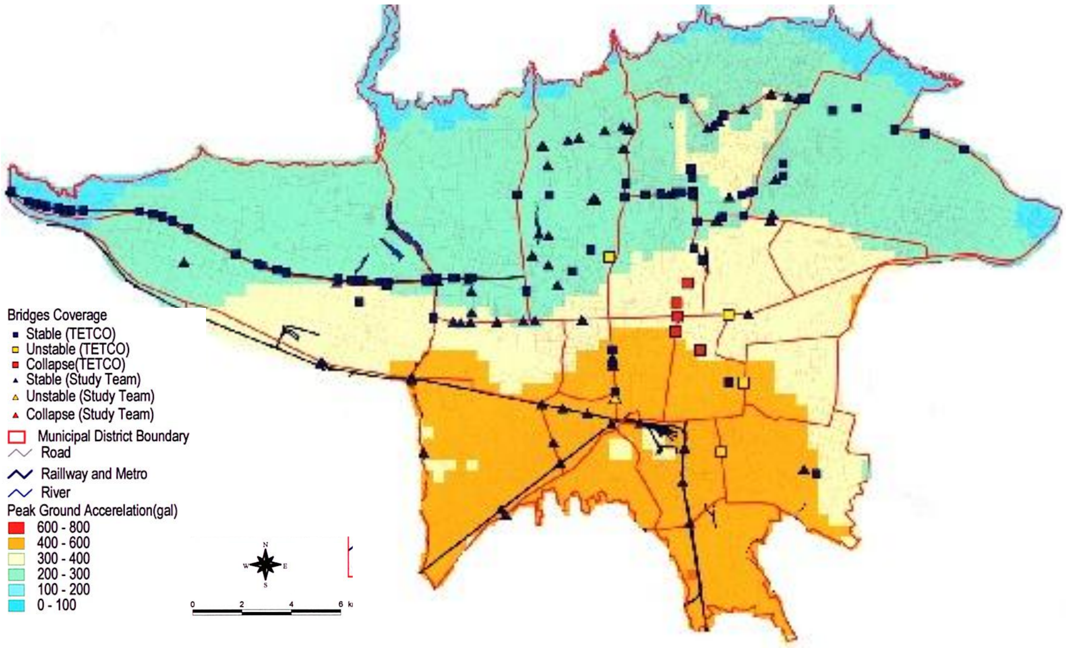


Figure 8.15: Damage to bridges, Ray Fault model, location map (JICA, 2000:204)

As the figure shows, a large number of bridges will collapse or become unstable if the Ray Fault earthquake scenario takes place. Collecting information regarding the main public facilities is also crucial for disaster management and planning. The method of damage estimation for major public buildings is similar to the residential, and considers the structural type, year of construction, number of occupants, and number of stories. Table 8.7 and Figure 8.16 show the numbers and damage ratio of damaged public facilities in Tehran under the Ray Fault model.

Supply lines, including water supply pipes and the gas/electric supply, are also influential factors in the disaster management system, which are considered as follows. Due to the quality of pipes, cables, their joints and the shut-off system of the main gas and water stations, the city, especially in its southern areas, will be facing a catastrophic disaster if the Ray Fault causes an earthquake.

Table 8.7: Damage numbers and ratios of public facilities, Ray Fault model (JICA, 2000:215)

District	Number of Damage and Damage Ratio (%)																	
	Govern-mental Facility		Police		Traffic Police		Fire Fighting		Hospital		Elementary School		Intermediate school		High School		University	
1	2	(18)					0	(15)	0	(13)	24	(36)	12	(34)	18	(42)	4	(33)
2	1	(28)	1	(24)	0	(22)	2	(37)	1	(21)	37	(35)	37	(37)	35	(37)	9	(36)
3	0	(23)	3	(22)			2	(43)	2	(30)	15	(39)	13	(34)	17	(35)	13	(32)
4			1	(20)			1	(32)	2	(27)	22	(29)	20	(32)	17	(28)	5	(30)
5	0	(23)	1	(39)	1	(58)	2	(40)	1	(23)	17	(38)	21	(44)	18	(37)	2	(24)
6							2	(40)	5	(35)					1	(22)		
7	3	(37)	4	(35)	1	(45)	1	(59)	6	(47)	24	(50)	17	(49)	16	(47)	9	(48)
8	1	(41)	1	(53)	0	(43)	2	(75)	3	(55)	33	(56)	19	(61)	25	(63)		
9	1	(43)	1	(43)					1	(43)	14	(41)	11	(41)	10	(42)	2	(46)
10	1	(62)			1	(61)	2	(50)	5	(53)	29	(75)	15	(77)	13	(74)	0	(38)
11	1	(69)	5	(91)	1	(61)	4	(66)	7	(70)	59	(84)	40	(76)	30	(71)	10	(74)
12					1	(100)	2	(61)	4	(61)	8	(73)	8	(69)	10	(65)	2	(57)
13			1	(52)			1	(38)	1	(64)	33	(50)	23	(51)	11	(52)	2	(56)
14	2	(49)	2	(48)	0	(39)	1	(51)	7	(55)	24	(57)	11	(60)			1	(46)
15	4	(47)	1	(39)	1	(55)	2	(73)	2	(81)		109			(73)			
16							1	(59)	4	(70)	45	(75)	31	(79)	27	(76)		
17	1	(65)	2	(77)			1	(100)	2	(81)	25	(82)	10	(87)	18	(77)		
18			1	(68)			1	(100)	4	(65)	33	(66)	27	(72)	21	(75)	3	(69)
19							1	(63)			15	(82)	17	(77)	6	(66)		
20	1	(64)	4	(83)			2	(90)	1	(86)	55	(76)	33	(76)	43	(82)	4	(67)
21			0	(41)			1	(45)			3	(81)	2	(75)	5	(64)		
22							1	(28)			1	(64)	1	(27)				
sum	18	(40)	27	(43)	7	(52)	28	(52)	56	(50)	623	(57)	369	(54)	340	(52)	66	(42)

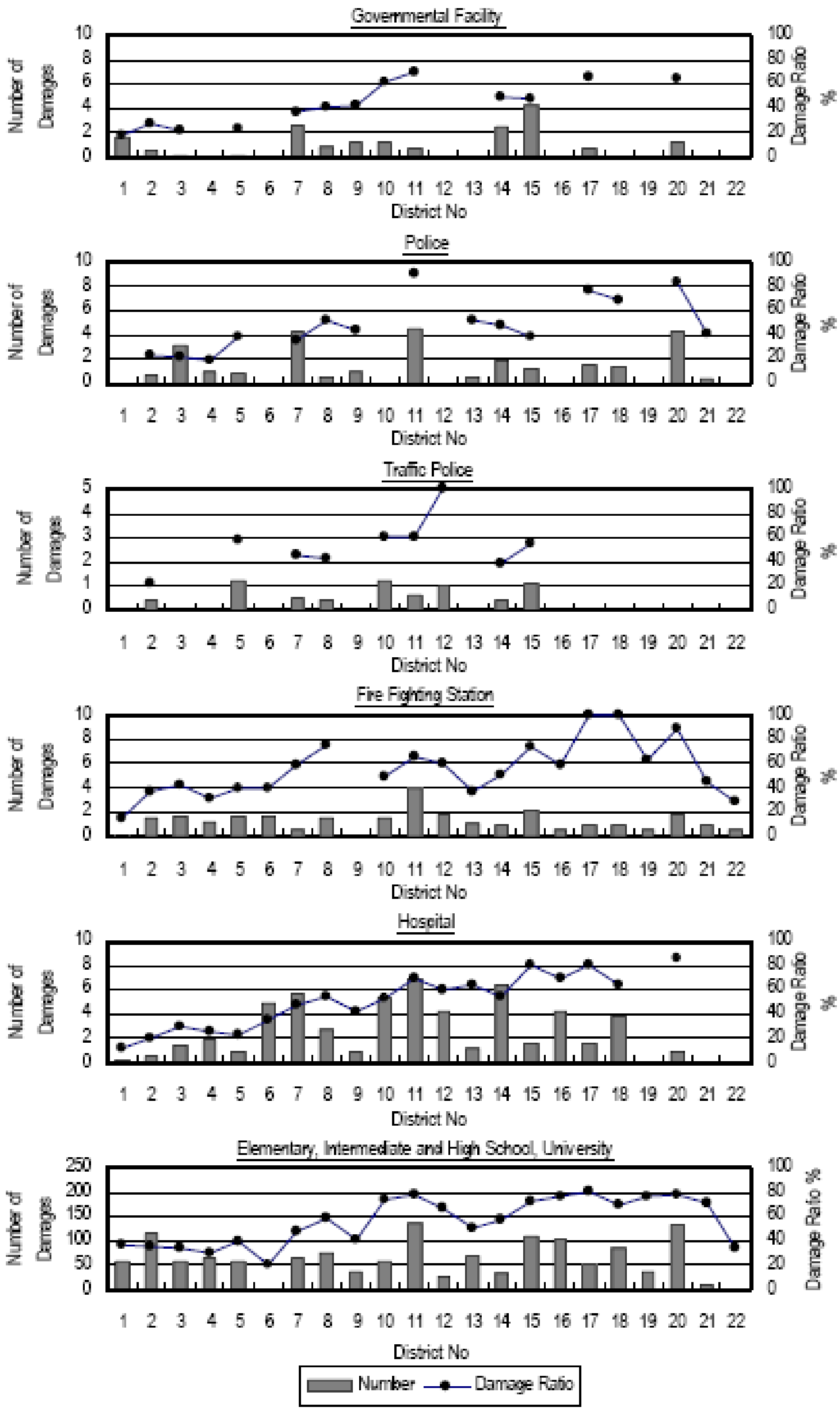


Figure 8.16: Damage and damage ratio of major public facilities, Ray fault model (JICA, 2000:218)

The possibility of fire spread from hazardous facilities such as garages and warehouses of chemical materials has made some areas highly vulnerable, as illustrated in Figure

8.17. The situation is more vulnerable for the southern districts as there is a larger concentration of warehouses and hazardous industries around their boundaries.

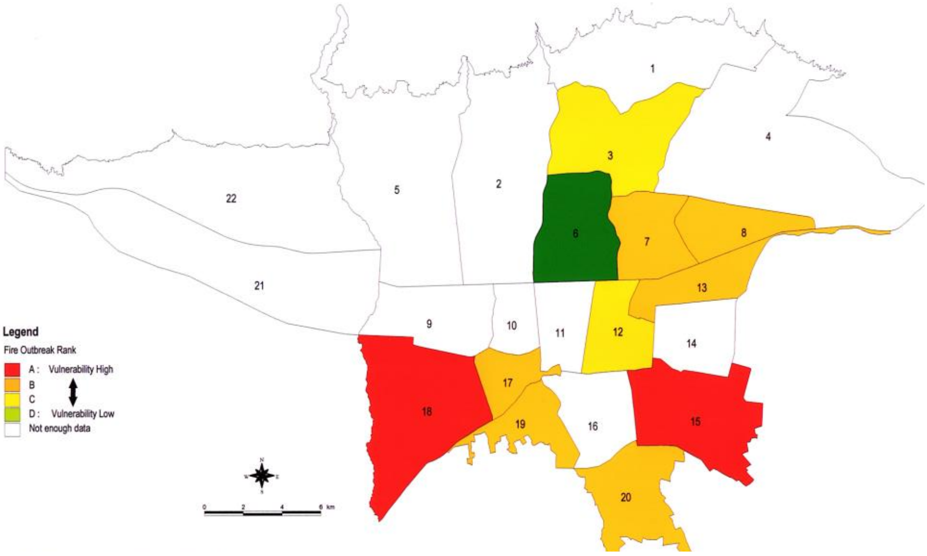


Figure 8.17: Fire outbreak rank from hazardous facilities, Ray fault model (JICA, 2000:239)

8.8 The Extent of Risk in the Study Area

D17, as highlighted previously, is located at the top of the chart in terms of the most vulnerable, with a lesser capacity to deal with disaster. The two main sectors of the VCA tool are the social and physical assessments, which helped to illustrate the vulnerability of the area and discuss its capacity. Table 8.8 simply demonstrates the total score for D17, which is quite close to total damage (score 30).

Table 8.8: Evaluation criteria of risk items (JICA, 2000:256)

Item	***Seismic Hazards and Damage***			***Social Condition***		
Rank	Average seismic intensity (MMI)	Residential buildings damage ratio (%)	Death ratio (%)	Population density (person/hectare)	Open space	**Narrow roads ration (%)**
5	8.67–9.93	69.68–82.20	16.22–20.10	291.73–362.43	0.00–0.49	**55.12–66.85**
4	8.41–8.66	57.16–69.67	12.34–16.21	221.05–290.72	0.50–1.99	**43.39–55.11**
3	8.15–8.40	44.64–57.15	8.46–12.33	150.37–221.04	2.00–9.99	**31.66–43.38**
2	7.89–8.14	32.11–44.63	4.58–8.45	79.68–150.36	10.00–14.99	**19.3–31.65**
1	**7.63–7.88**	**19.60–32.11**	**0.70–4.57**	**9.00–79.67**	**15.00–182.73**	**8.20–19.93**

This is the direct result of:

- Physical and social conditions of the area in terms of building structure, topography, location of hazardous sites, narrow roads;
- Population density;
- Rescue resources;
- Open spaces;
- Social conditions;
- Human mobility; and
- Many others.

Having a population density of 465 per ha and buildings made of steel, and steel and brick, has made D17 extremely vulnerable to earthquakes. Figure 8.18 shows the location and detail of the Khazaneh neighbourhood within D17.

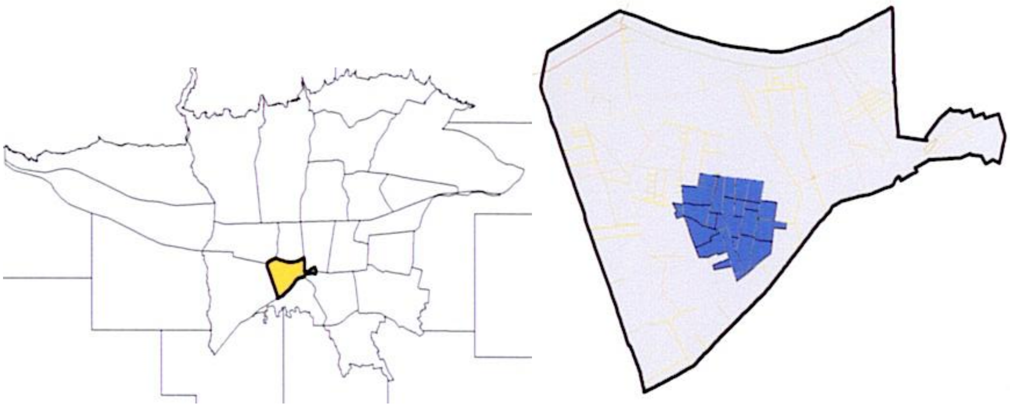


Figure 8.18: (left): location of D17 in Greater Tehran (right): location of Khazaneh neighbourhood in D17 (JICA, 2000:271)

It has been estimated by various studies, especially JICA (2000), that the damage ratio of the Khazaneh neighbourhood would be over 80%. Figure 8.19 is the collapse ratio of the existing buildings in the Khazaneh neighbourhood.

Table 8.9: Evaluation criteria of risk items (JICA, 2000:256; researcher's observation)

Khazaneh neighbourhood	Number of buildings	Population	Density (p/ha)	Building structure			Residential	Schools	Commercial	Medical	Public buildings	Others
				Steel	Steel & Brick	Others						
	4,464	38,130	803	1,573	2,838	53	4,332	13	47	17	25	101

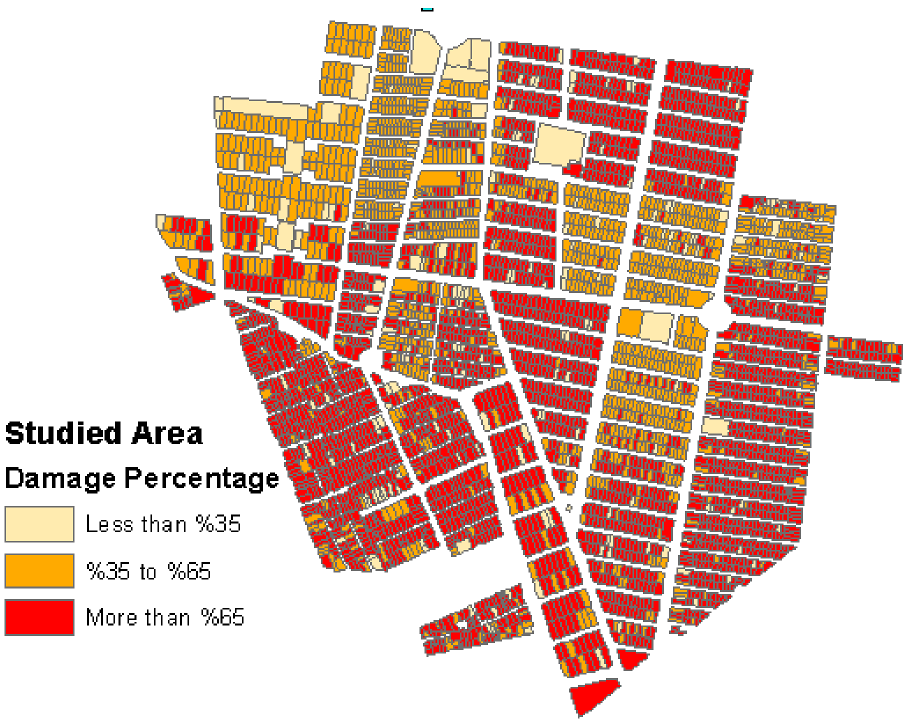


Figure 8.19: Damage ratio of Khazaneh neighbourhood (Motamed and Hosseini, 2006:13)

This is largely due to the building structures in the area, which could cause a high human casualty rate. It can range from 3,000 in the worst case scenario at 7.8 MMR to 2,000 people if it were to happen in the night-time and rescue assistance arrived ten minutes after the earthquake (JICA, 2000). If the public buildings in the neighbourhood could be used for refuge centres, there might be enough space for temporary shelter; however, the following factors make it difficult to use them accordingly.

School buildings: As Figure 8.20 shows, out of the 13 schools which exist in the Khazaneh neighbourhood, only one of them is of RC structure, which makes the rest highly vulnerable to earthquakes. Out of the vulnerable schools, only 1, 3, 5, 6, 7 and 13 have potentially enough open area within their boundaries to be used for safe open space if they can be equipped for disaster preparation purposes. However, only School 13 has adequate space to be used for a rescue operation.

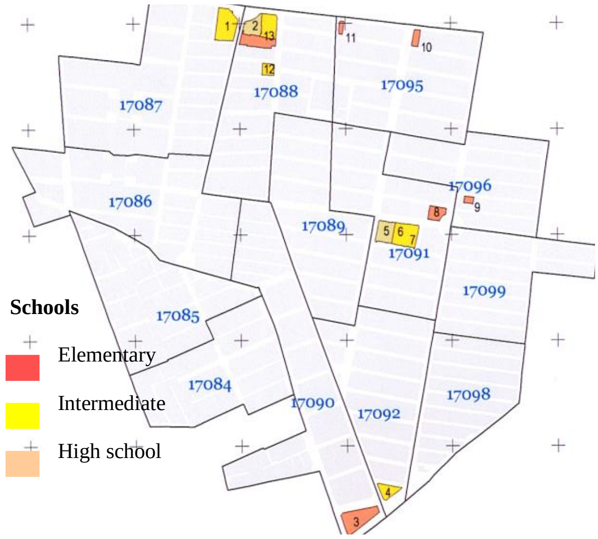


Figure 8.20 (above): Schools' locations in Khazaneh neighbourhood (JICA, 2000:277)

Picture 8.1 (below): School in the Khazaneh neighbourhood

Hospitals and Medical services: fortunately, one of two available clinics in D17 is located in the Khazaneh neighbourhood. However, firstly, the structure of its building is not resistant enough to survive a high ratio earthquake; and secondly, it is basically a dental hospital with a limited amount of equipment useful in an emergency situation. It does not have any beds, and is closed at night. In order to be used for emergency services, it needs to be equipped with water, an emergency electric generator, and other supplies. None of the other private doctors' surgeries can serve in an emergency situation due to their building structures, lack of equipment and space.

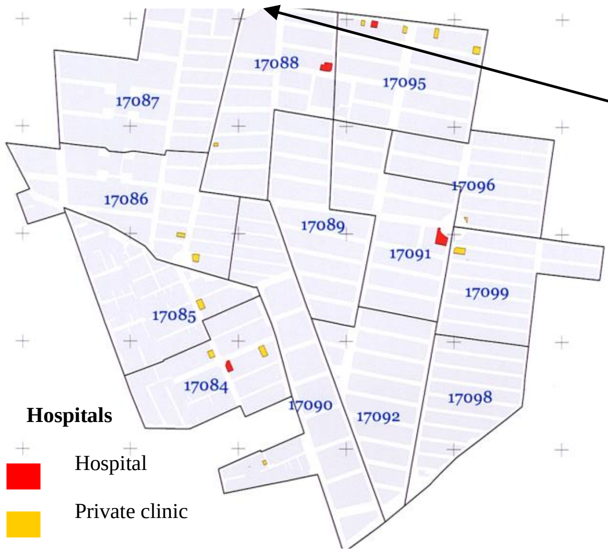


Figure 8.21 (left): Hospitals and doctors' surgery locations in Khazaneh neighbourhood (JICA, 2000:279)

Picture 8.2 (right): Sabaghian Hospital in Khazaneh neighbourhood

Roads: as discussed before, one of the major causes of the high vulnerability rate in D17 in general, and the Khazaneh neighbourhood specifically, is the absence of wide roads, which makes the accessibility of rescue teams and local residents almost impossible if the building damage is added to it. Those roads 6 m or less in width are distributed in the area between the residential buildings; this calls for immediate design of evacuation routes. This will be discussed in more detail within the next chapter.

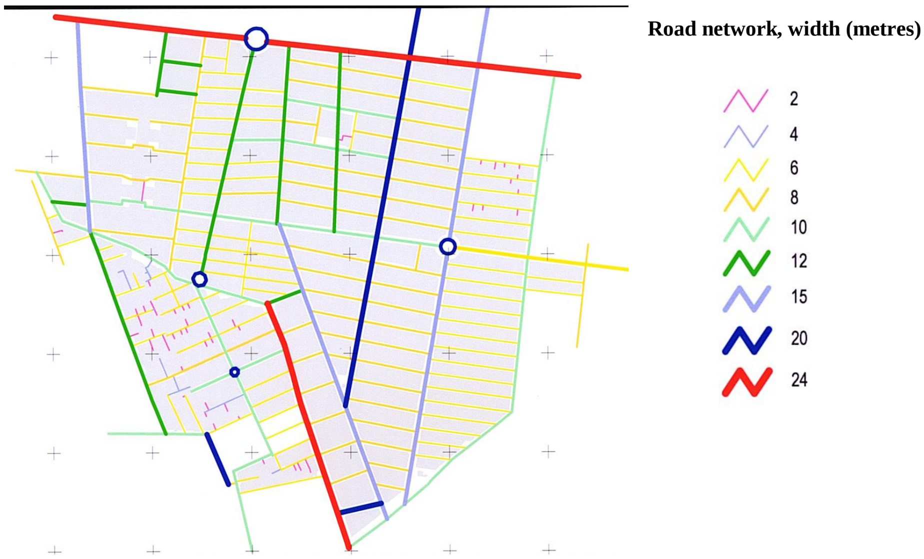


Figure 8.22: Road network in Khazaneh neighbourhood (JICA, 2000:281)

Picture 8.3: Roads of 4, 12 and 16 m width in the area

Parks and Open Spaces: Figure 8.23 shows the location of available parks and open spaces in the area, which are concentrated in the northern part. Size-wise, they are small and basically act as playgrounds with a very low capacity for accommodating refugees (Chapter 9). They are also surrounded by residential buildings and narrow local roads which makes them hard to reach, and even vulnerable to disaster. In fact, the only park in the north is too small to be used in earthquake planning or as a possible evacuation site. In order to have an analytical study into the social functional and physical use of open spaces in this area, four unique but typical open spaces (Figure 8.23) have been selected for analysis in the next chapter. The criteria for selection of each individual open space were:

OS1 is located next to the only hospital in the neighbourhood, is of a decent size in comparison with other available open spaces of the area, is close to the wider roads and is used by many local residents during the day because of its availability, facilities and greenery.

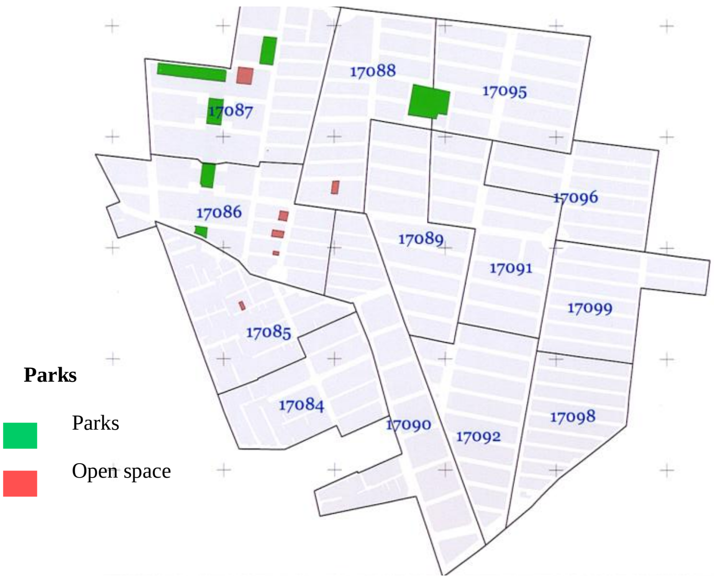


Figure 8.23: Parks and open spaces in Khazaneh neighbourhood (JICA, 2000:284)

Picture 8.4: Three open spaces of different scales in the case study area

OS2 is basically the only open space in the heart of the populated residential area of the neighbourhood. It is surrounded by roads, used regularly by local residents for relaxation purposes, has a strategic location for serviceability and provides a contrast as a large open space in this dense neighbourhood.

SA1 is the largest green space in Area 2 of D17, just outside Khazaneh neighbourhood, with easy access to the main roads and motorway, adjacent to some public buildings, capable of giving services to the larger areas and more residents than any other open space in D17.

SA2 is also a decent-sized open space, having the potential to become a safe and serviceable area, next to the densely-populated neighbourhoods, accessible by fast roads and used frequently by residents.

8.9 Community Group and Residents' Survey

The community plays the major part in enhancing capacity, reducing social and physical vulnerability and benefiting from spatial environment improvement. Thus, assessment of the community's capacity in terms of their knowledge of disaster and disaster management, experiences, community profile and involvement in risk reduction is as important as improving the physical built environment and building resistance. In the interview with local residents, four main subjects were used to extract data and public knowledge. Each category covered a range of information that was relevant to the VCA criteria. Some of the most relevant notes are used in the next chapter to enrich the case study analysis. A sample of the questionnaire is provided in the appendices.

8.9.1 Question Group One: General Demographic Information

The most common age group in this neighbourhood is between 19 and 60 years old, which makes it mainly young and middle-aged. This is as discussed before: the general picture of Khazaneh neighbourhood due to its social capacity and economic deficiency: "In my neighbourhood, not many families have children. My neighbours are mainly middle-aged. But people in my sister's street have more children. They play outside so often." (M.R.42). However, the employment figure is influenced by a variety of factors such as rental values in the area, public administrative and governmental buildings, the construction industry, the safety of working areas, etc. 74% out of the 51% male population work within or outside the neighbourhood.

Picture 8.5: Main roads are usually busy and full of traffic

Picture 8.6: The District 17 municipality building

Only 21% of the 49% population of participants in the survey have a job (full or part-time). This makes the daytime population in the area busy, if the number of young children is added to it. Having busy roads and traffic in and around narrow inter-neighbourhood roads decreases the chance of good communications and can prevent public access to safe areas: “It takes up to 20 minutes to get to the motorway from my street which normally should be only 3 minutes. It gets worse on some junctions towards the southern district, such as Mehdi Street.” (M.R.24). The schools in the area also have over 4,000 students (JICA, 2000) occupying them during the working day; not only local people: “A number of students come from District 19. The quality of schools in here is better.” (F.W.30).

Picture 8.7: Two typical schools in the neighbourhood. The one on the left is a converted residential building

Their daily travel, by every means of transportation, adds to the area’s traffic congestion. Around 85% live locally. In terms of ownership, 67% own their properties whilst 29% of them are tenants. The rest are there on a temporary basis (guests). This affects their knowledge about their surrounding built environment which will be discussed in another group of questions: “The majority of people who I know either bought or built their houses. It is hard [due to high rate of inflation] in more affluent areas than this neighbourhood.” (M.R.51). Also, the buildings are not of a high quality. The former is a good point for those residents who have been living in the area for a long period of time. The latter can compromise the safety of residents during a disaster. In order to illustrate how the social life of people has developed locally, their economic activities also were analysed. This can affect the quality of their living environment and the percentage of physical damage.

8.9.2 Question Group Two: Main Economic Activities

The unemployment rate in here is almost similar to the city as a whole, which is 30% (SCI, 2008): “The young generation prefer to have an office job or easy job. They would rather live at home with their parents and do nothing. Of course they need support to stand on their feet. But this does not give them the excuse to be unemployed.” (M.R.50). 29% of those who work are employed, whilst the rest have some kind of self-employment status. They have to use local routes to get to work every day, on average a distance of 1 to 5 km, which includes heavy rush hour traffic.

Picture 8.8: The small land plot size and narrow roads make the network of connection highly vulnerable to earthquakes

The number of people who work locally is very low, because the majority of the area is residential. This is a negative point in many ways. First, the quality and size of the buildings is not good. Second, population density is high especially at night. Third, this increases road traffic congestion. Fourth, the roads are packed with parked cars at night: “The high density residential buildings of Khazaneh neighbourhood are the most vulnerable point. Even in a normal situation there are places that the fire engines cannot pass.” (Interviewee F). Because there are few public-sector buildings in the area, except for schools, the number of people who are present in the area for employment reasons is limited.

8.9.3 Question Group Three: General Knowledge about the Area in which they Live and Work

The residential nature of this neighbourhood, with the majority of occupiers owning their properties, would have a major impact on the number of possible casualties in the Ray Fault scenario model, if the local residents’ awareness and knowledge could be improved. This group of questions was about the public buildings, roads and supply lines. An overwhelming majority of participants (98%) knew the location of the only hospital in the area, as well as a few private clinics: “Except for one occasion when I needed a hospital operation, generally speaking I see local doctors. They are handy and even cheaper than some other doctors in the northern area of the city.” (W.R.28). Knowing the location of these clinics is important for people. But there is uncertainty about the structure of the clinic buildings.

Picture 8.9: A dental surgery in the area

As discussed before, the majority of them are converted residential buildings not specifically designed to survive an earthquake. They were familiar with the location of at least one school, but not necessarily Ghods Primary School or Somayeh High School, which have larger open spaces that can be utilised for other purposes: “My children both go to school locally. One is ten years old and the other one is 17. I also studied in the local school which was replaced by a new building.” (W.R.40).

Picture 8.10: The fire station building in D17

The school buildings, based on my assessment and observation, and JICA’s report (2000) fall into the vulnerable buildings category. They would have to be improved structurally to save a large number of children’s lives. People’s overall knowledge about the location of other services such as police or fire stations was limited, as only

39% knew their approximate location: “I didn’t know if we had any fire station in the area.” (W.R.23). It might not be necessary for local people to know where these places are, but the routes leading to these buildings could play a crucial part in facilitating fast access to the neighbourhood: “There is a police station four streets away from my home. But I never had to go there. It is an old building with a small yard in front.” (M.R.26). A large number of the respondents (85%) were not familiar with the road pattern and networks, except the ones that they usually use, which is a prime factor in them to being able to reach the proposed refuge locations. They were not typically happy about the amount of traffic, the road management system, the extensive number of cars parked on the road, and also the pedestrian zones and public transport network which do not cover the neighbourhood: “Except for a few houses facing north, the majority of neighbours do not have a garage to park their car. It is hard to drive in narrow roads.” (M.R.41). Roads are designated in a rigid pattern, but there are obstacles such as drains, street lights and trees that reduce the roads’ width. These could have a serious adverse effect on the network of connections in an emergency situation.

The lack of knowledge about major hazards and essential gas mains, fire hydrants and public telephone boxes were also apparent by the answers to the questionnaire. Only 9% knew the location of telephones and the other two elements were a completely new subject for them: “I don’t think if I have ever seen any fire hydrants in this area. There are water pipes in the parks but not for fire.” (W.R.33). For such a densely-populated and physically vulnerable area this urban equipment is essential. This shows, despite the long residency of some of the interviewees (over 40 years), they have never come across these facilities or been informed of their existence.

8.9.4 Group Four: Community Rescue

This group covered a range of questions, from general background knowledge about past disasters to the rescue planning and hazard management system. Knowing what to do and where to go is as important as rescuing people. Residents’ knowledge about rescue planning and management procedures can dramatically reduce the number of casualties. Historically, those who have been in other earthquake-hit places (3%) had experienced seismic shock. The majority of them (86%) only talked about past earthquakes that did not have a substantial impact on city life and their neighbourhood. “I hope we will never have an earthquake in Tehran. I don’t know how bad it will be, but I have heard how it did devastate people’s lives.” (M.R.41). Precisely this does not reduce the necessity of an increase in public awareness.

Investing in people, in terms of improving their ability to survive a disaster, is a prime approach in the disaster management system approved by many countries, such as Japan (see Chapters 3 and 4), and is decisive for this area. They all (99%) predicted that a devastating earthquake would occur in the city; however, they were not sure about the organisation responsible for rescue operations or hazard mitigation. 37% classified the rescue procedure as the provincial governor’s responsibility, whilst only 20% thought that the municipality had to act in this regard. “I heard there is a committee in the provincial governor’s office that has to deal with an emergency situation. The municipality is not capable of providing all the services needed.” (M.R.35). But a city this large requires an integrated management system consisting of the main local authorities. Having each organisation act or plan independently will reduce government capacity. In an interesting statement, a local resident stated: “In the Bam earthquake, I personally experienced the horrifying momentum when people were desperately in need of help, but there was no strong leadership and management for the operation. People were stuck in the hospital with no equipment as the roads were damaged and reaching the city was hard.” (M.R.48). If ordinary people know what organisations play key roles in disaster management, this can help them to understand the procedure and contribute towards its improvement. Whoever they thought was in charge of rescue operations, hardly any of them had been introduced to a very important document called the *Tehran Disaster Mitigation and Management Plan*. Only 12% had heard of such a plan, without having any basic knowledge about its context. 65% of respondents had been trained in simple first aid and in the procedure to seek refuge once in their lives. However, there was overall agreement on the vulnerability of their living environment to an earthquake. Therefore, their preferred point of refuge was the street, which would be safer and easier for them to access.

The outcome of the above four groups is very important for this research, as it provides a general portrait for mitigation, preparedness and emergency actions in Tehran and this neighbourhood. The lack of general public awareness about emergency operations, systems, planning and prevention can put the lives of innocent people in danger. This can be minimised by multi-aspect planning and practice; the next chapter will look at one such simple but essential system experienced in other countries, which could work in Iran.

8.10 Conclusion

The chapter aimed to illustrate the extent of damage to the buildings, infrastructure and urban life of Tehran in general and District 17 in particular, based on the Ray Fault scenario. It was understood that the extent of damage would be higher in some parts of the city, such as District 17, whose residents urge local organisations, including the municipality, to take action and revise the planning policies. The urgency of paying special attention to disaster planning and management was backed by the result of the questionnaire and interviews carried out by myself. This leads us to the next level, which is to propose a disaster scenario for Khazaneh neighbourhood to discover the criteria of a safe open space that can operate at the neighbourhood level.

Chapter One................................ **Introduction**

Chapter Two............................. **Conceptual Framework**

Chapter Three......... **Evaluation of Damage and Risk due to Earthquakes**

Chapter Four.................... **Open Space and Diversity of Services**

Chapter Five............................. **Research Methodology**

Chapter Six.... **Identifying the Spatial and Geographical Structure of Tehran**

Chapter Seven. **Use of Urban Risk Assessment Tool for Main Planning Resources**

Chapter Eight.. **Evaluation of Risk in the Study Area**

Chapter Nine. **Open Space Design Criteria for Refuge Areas**

Chapter Ten...................... **Conclusions and Recommendations**

9.1 Introduction

In the previous chapters, many aspects of urban planning, disaster management and damage to the urban area were discussed, by first looking at some of the most relevant literatures and past experiences, and then assessing the vulnerability and capacity of the city of Tehran, District 17, and the Khazaneh neighbourhood. The method used for the analysis was simple but quite clear in looking at the existing spatial characteristics and distribution of buildings (residential and public), roads, open spaces and the geographical characteristic of the region. This part of the study contributes to the planning process before the earthquake occurs. This consists of context analysis in terms of social, functional, perception and techno-physical dimensions of the selected open spaces.

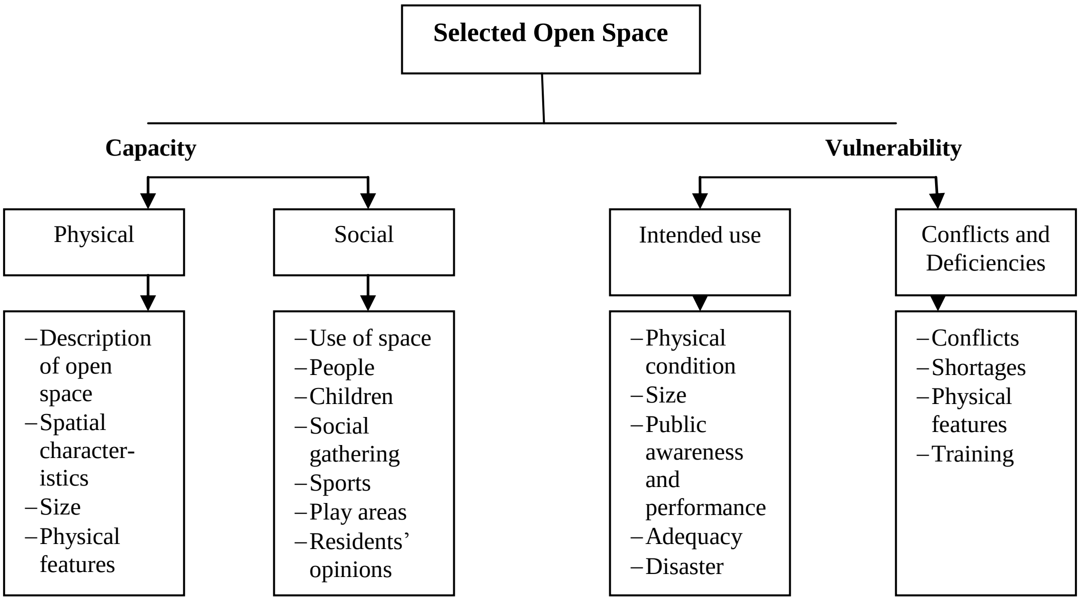


Figure 9.1: The analytical framework of the selected case study

This will mainly be about their use, intended use and the conflicts between physical morphology of the open spaces (including their surrounding areas) and the safe open space criteria. Figure 9.1 summarises the general characteristic of the analytical study of selected case studies.

The same framework will be used for each open space but based on its individual use, location and quality. It will assist the rational planning of the utilisation of the refuge area as well as the identification of the neighbourhoods that need more open spaces.

9.2 Safety and Serviceability: the Two Main Parameters

In order for the emergency services to use an open space, a park, land or the back yard of a public building, one should consider the capacity of the space, and the level of services which it aims to provide. In the study area, based on past disaster experiences and the pattern of the neighbourhood fabric, open spaces are categorised into two main categories, a Safe Area and a Serviceable Area. Each would have to provide certain services to refugees and have its own characteristics in terms of design, facilities, capacity, accessibility, protection and coverage area. Figures 9.2, 9.3 and 9.4 summarise the general features of typical safe and serviceable areas in this research.

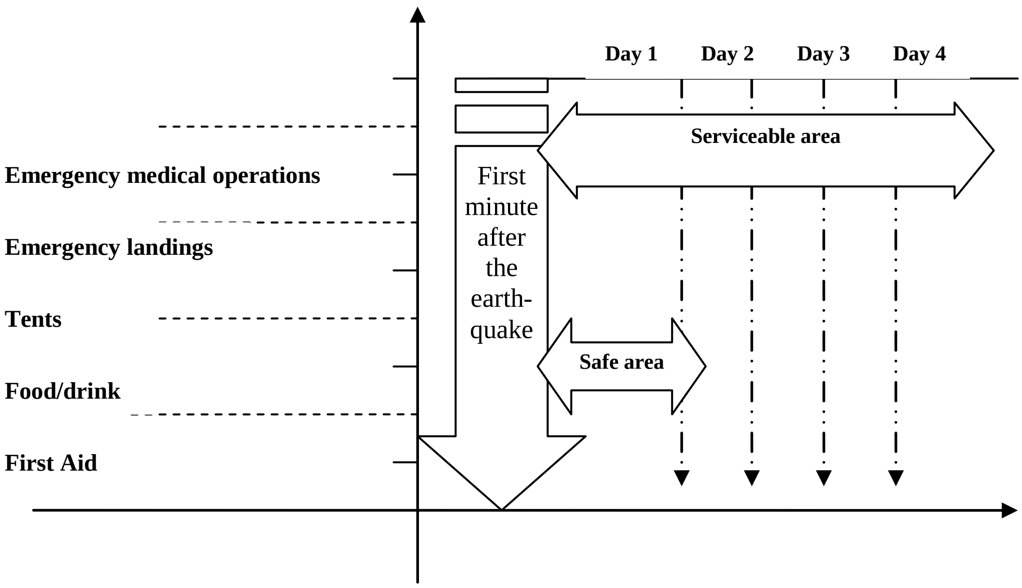


Figure 9.2: Safe and serviceable area requirements

As Figure 9.2 indicates, there are differences between the safe area and serviceable area in many aspects. The parameters that simply govern the allocation of emergency open spaces for residents to get to these areas are (Tarabanis and Tsionas, 1999:189):

- The proximity of the open space to one's home;
- The degree of safety;
- Whether the area is already full or not;

- The quality of the accessibility of routes;
- How familiar residents are with the place;
- The facilities (medicine, food, drink, decent temporary accommodation).

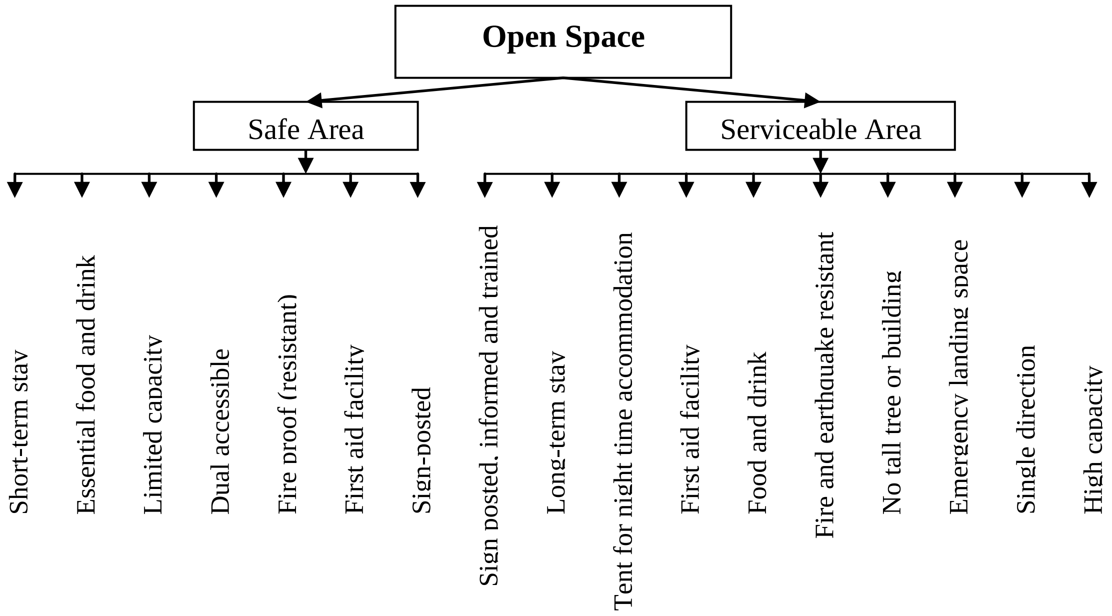


Figure 9.3: Safe and serviceable area specifications

For each parameter there are assessment criteria which affect the design, facility and allocation of each category of open spaces. Figure 9.4 schematically highlights these parameters.

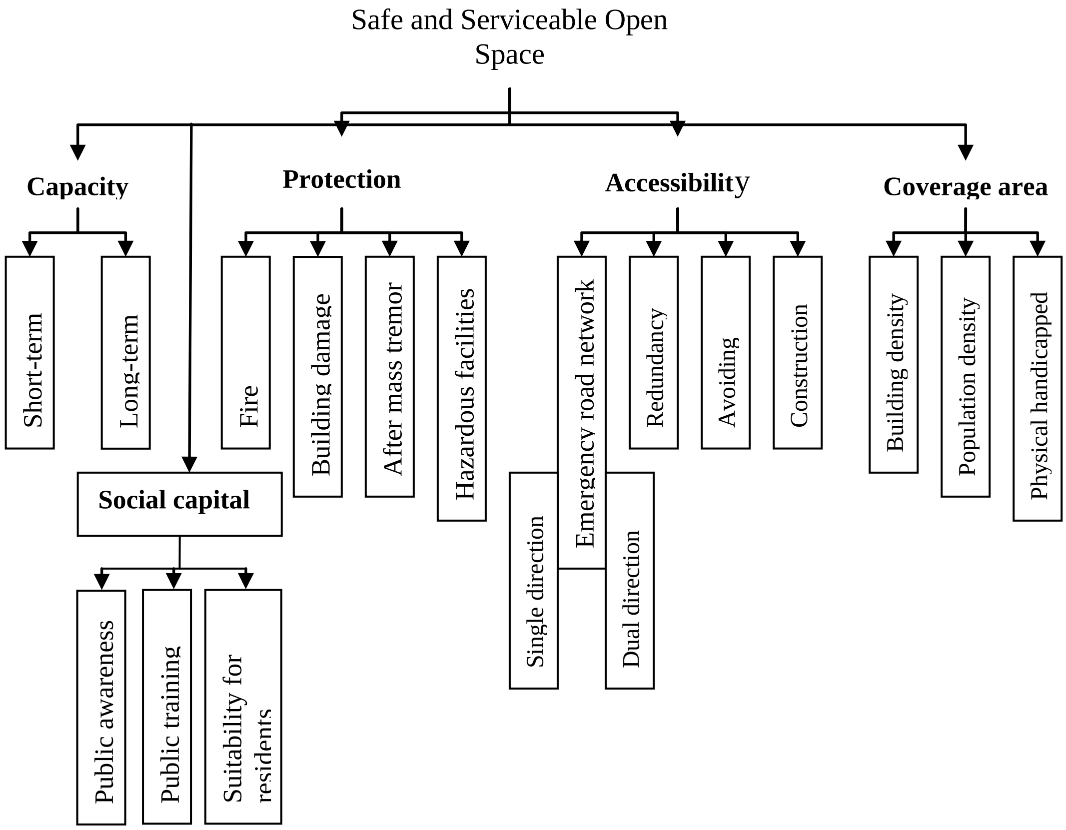


Figure 9.4: Assessment criteria of safe and serviceable open spaces

The above criteria have been categorised based upon the existing available open space and the proposed open space in the Khazaneh neighbourhood. Figure 9.6 simply shows the existing open spaces in the pilot study area and its surrounding parts. The following table (Table 9.1) has been used for the data required for the capacity of the open spaces in the neighbourhood. Using Figure 9.5 to work out the number of people in each street of the Khazaneh neighbourhood indicates that open spaces 3 and 4 need to become larger.

Table 9.1: Data required for open space capacity and their resources (Tarabanis and Tsionas, 1999:189)

Parameters	Sources
Spatial distribution of population	Estimated from the building coefficient at the block level
Routes along which people travel to get to safe areas	Constructed with CAD from lines representing blocks of buildings
Safety of open space	Subjective classification of the safety of an open space based on personal visits
Capacity of open space	Calculated as the total free area of each open space
Preference to select safer areas	Indicates increased performance for high safety areas initially set for all spaces
Maximum distance from home	Based on standards

The capacity of open spaces is calculated by the following equation.

$$C(n) = (Et\text{-}Eu)/2$$

Figure 9.5: Capacity calculation equation (Tarabanis and Tsionas, 1999: 191)

where *Et* is the total area of open space, *Eu* is the area covered by trees or other obstacles which prevent setting up tents; 2 m² is the minimum space needed for each person. The number of people who can evacuate their homes and use roads to get to a safe open space is higher on some roads.

Table 9.2: The capacity of roads in Khazaneh neighbourhood

Open Space	1	2	3	4	5	6	7	8	9	10
Area	4,800	700	400	420	1,100	600	33,800	8,400	1,100	600
Capacity	2,300	300	200	200	400	250	15,650	3,600	500	300

Open Space	11	12	13	14	15	16	17	18	19	Total
Area	2,000	4,800	300	1,000	2,400	900	420	760	800	65,300
Capacity	980	2160	150	400	1120	400	200	350	400	29,860

Figure 9.6: Existing open spaces and their categorisation as refuge areas

This supports the above idea of increasing the open space area:

$$Ui\ (0) = Area \times Population\ Density$$

Figure 9.7: Basic evacuation equation (Kanamori et al., 2007:3)

Where $Ui\ (t)$ = Number of population of the ith street at time t

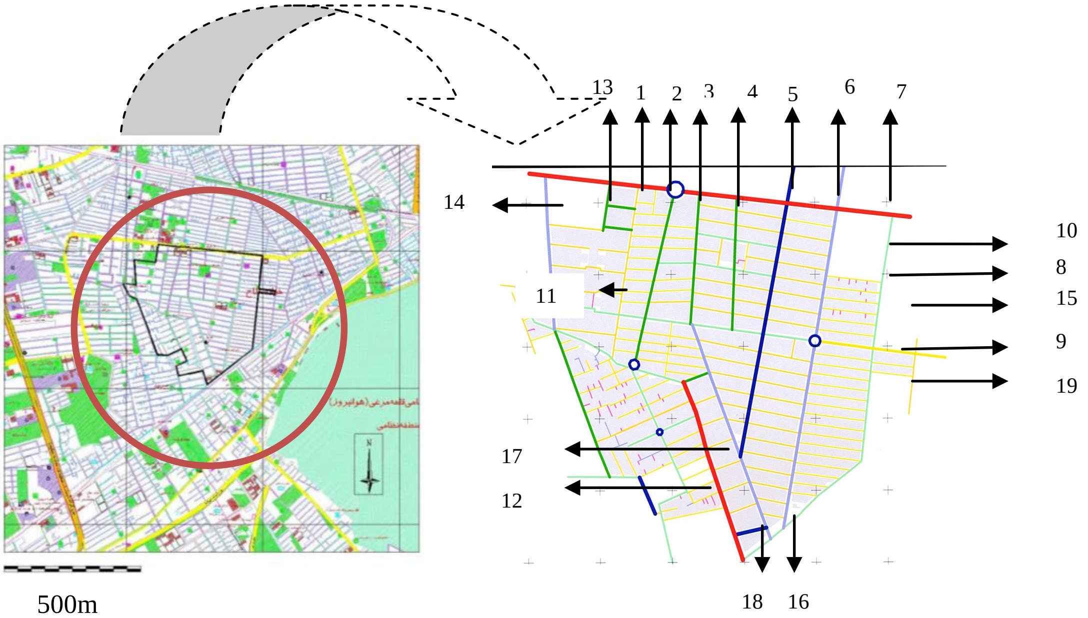


Figure 9.8: Roads with more people to direct to safe open spaces

In order to prepare an open space for the event of an earthquake, one scenario of dual evacuation directions for the two open spaces within the Khazaneh neighbourhood and two outside the neighbourhood boundary, but within Area 2 of D17, will be analysed in this chapter. It is worth remembering that the pilot study area and its surrounding districts are analysed based on the Ray Fault model (Chapter 7), building damage (Chapter 8) and the capacity of the Khazaneh neighbourhood (Chapters 6, 7 and 8).

9.3 Context Analysis of Open Spaces

This individual approach into planning for the use of an open space in the study area of this research was derived from the literature review and examples used in other experiences, as well as those that are specific to this research. The functional role of each space and its ties with residents on a daily basis have an extensive impact on the functionality and suitability of each space for disaster preparedness. Therefore, observing the quality of public engagement with the space can help to design what is best and avoid a poor fit of that space to its recommended use. This section starts with the identification of the morphology of each individual open space (physical description), followed by its social functionality (use of space) followed by the earthquake scenario (the intentional use of space), and finally what initial changes are needed.

9.4 Analysis of Open Space 1, Gole Sorkh Park

Due to the strategic location of Open Space 1 (OS1), which is close to the dental clinic in the north-west corner of Khazaneh neighbourhood, the space could potentially be a prime location for emergency uses. Thus, its physical and spatial characteristics are analysed first.

9.4.1 Physical Features

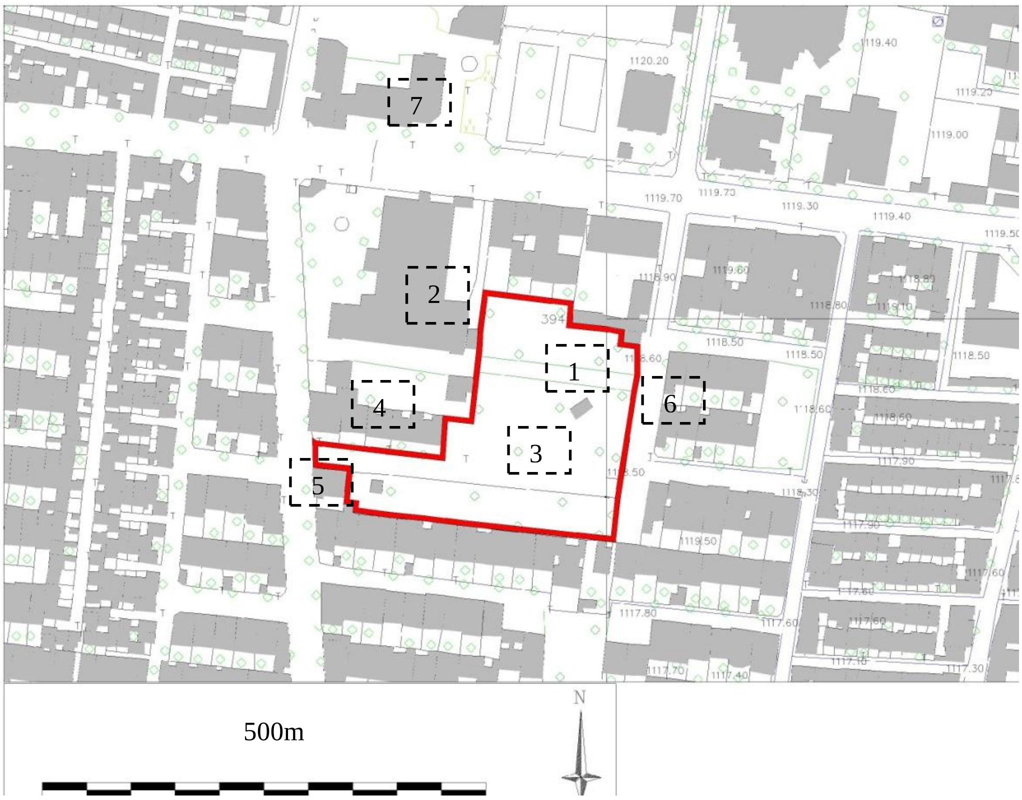


Figure 9.9: Open Space 1 (OS1), 1: Gole Sorkh Park, 2: Ziyaian Hospital, 3: Helicopter Landing, 4: Residential Buildings, 5: Behbudi Street, 6: Mahdi Street, 7: Somayeh High School

OS1 is a combination of green space and concrete pavement, approximately 782,315 m² in area (Figure 9.9). It is bounded by Mahdi and Behbudi Streets. Ziyaian Hospital is to the north of it. The space has worked closely with the hospital and the neighbourhood in terms of providing them with required green space and refreshment. 65% of the total area is covered by trees and only 35% of it is paved. The access from park to the hospital is only available for pedestrians and is partially clear from obstructions. But there is an emergency helicopter landing space in the middle of the park with wider road access to the hospital.

Picture 9.1: Gole Sorkh Park (1 in Figure 9.9)

Picture 9.2: Public access to Gole Sorkh park (6 in Figure 9.9)

Picture 9.4: Buildings near the park next to the hospital (4 in Figure 9.9)

Picture 9.3: Ziyaian Hospital (2 in Figure 9.9)

Picture 9.5: Buildings in Behbudi Street (5 in Figure 9.9)

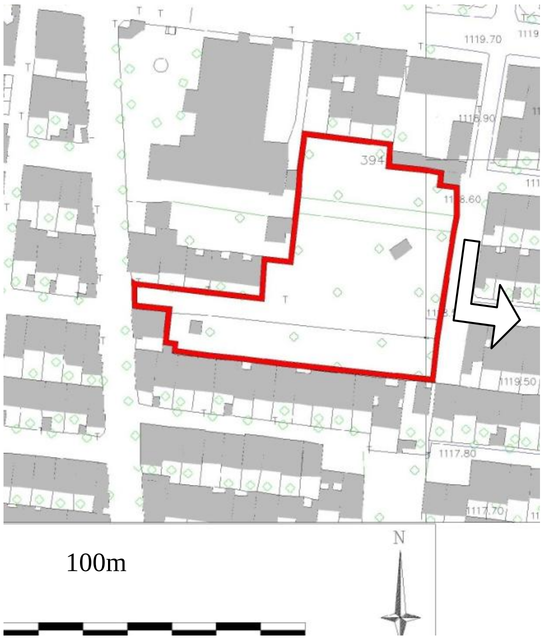
Picture 9.6: The emergency helicopter landing pad (3 in Figure 9.9)

The public can directly reach the park by using a 12 m wide road (Mahdi Street) on the east side of the park. But the southern border of the park is closed by multi-storey steel and brick residential buildings that fall into the possible damaged categories of the Ray Fault scenario. Based on this research's observation, these and five other blocks on the west side of the park pose serious danger to the possibility of use of this space for disaster safety services. The only building on the park site is a brick structure used as a public toilet and is not of reliable structure to withstand an earthquake tremor.

Picture 9.7: OS1 is surrounded by multi-storey buildings

Picture 9.8: There is no access for cars except for emergency purposes

Access to the northern side of the park is also blocked by buildings, but it is quite close to Somayeh High School. Mahdi Street is a relatively wide (12 m) road; nevertheless it ends just before the corner of the park, redirecting traffic to the east. The access from the western road (Behbudi Street) is also blocked as it approaches the park. Therefore, the park only has partial access from west and east which limits its capacity in a vulnerable situation. However, this has not reduced its functionality for those who live in the neighbourhood.



Picture 9.9 (below): Mahdi Street, on the east side of OS1, redirects the traffic to the east

Figure 9.10 (left): Access to the park from Mahdi Street

9.4.2 Social and Functional Use of OS1

The use of outdoor public space is a traditional and cultural activity commonly carried out by local residents and, in many cases, by non-local residents, who use the space for a variety of purposes. Chapter 4 looked at some of the uses in different settings. But in this specific case, the survey and observation revealed who and how benefits from this green space. The quality of space, in terms of its greenery, sanitation and maintenance, facilities, accessibility and safety has a direct impact on the number of people who use the space, their age groups, the time of use and the extent of activities. It consequently influences the residents' social relations and community engagement. Their interaction and knowledge exchange is important in promoting the social capacity of the neighbourhood and hence, in many ways, their reaction in an emergency situation. As previous studies about disaster management carried out by Japan and the UN (see Chapters 3 and 4) revealed, the deeper local knowledge about methods of preventing the disaster and cooperation for a quick recovery after it, the better they could deal with the situation and be prepared for it. It was also discussed in the previous chapter that the majority of local residents do not have an in-depth knowledge about the facilities around them, or how a park can be related to a disaster, despite the studies done by the municipality and other organisations: “I used to play in a field not far from my home and my children do the same in the local park. An earthquake is about building damage, not where a park is located. If an earthquake takes place I will run into the streets.” (M.R.57).

Although the physical environment characterises the built environment, and affects the number and quality of users of public places, the social relations created in these spaces promote or discourage the mutual physical quality: “During the holidays, my kids play in the park most of the time. And their friendship with other children has made us closer to our neighbours. My wife socialises with their mothers, which is good, so we get to know each other better.” (M.R.48). However, the kind of use differs from place to place and will be discussed in the next few pages.

Picture 9.11: Children play in the playground in OS1 with adults supervising them

Picture 9.10: Sports equipment in OS1 for the promotion of public health

Picture 9.12: The park is equipped with seats and other facilities to attract people

Picture 9.13: A mixture of greenery and paved routes promote the quality of OS1 for local residents’ use

Picture 9.14: Local people use the park for passing through and walking

Picture 9.15: OS1 is regularly maintained by the municipality

It has been observed that the municipality's attempts to create a decent green space is appreciated by children who live locally. They spend part of their time (but not much) playing in the park. One of the advantages of this park is that except on one side, there is no traffic passing by, which makes it safe. In a statement, a parent commented that: "my flat overlooks the park. Therefore, I feel comfortable and safe sending my children to play in the park. It is good for them to do some outdoor activities." (F.R.37). The suitability of this place, in a different statement, was questioned by other residents, who found OS1 is not good for children as the facilities provided in the playground were not safe. Although the number of children who play outdoors and in the park is not high, it is surely part of their living environment, as one staff member working in the dental clinic stated: "I think this park has found its place amongst local residents, especially children. I can see they ride their bikes in the park from my room's window which has a view to the park. I do not live locally but I might consider bringing my child to play here." (F.W.29).

Picture 9.16: Local people use the park for socialising with each other

Picture 9.17: The green spaces and grassed area is part of OS1's physical features

Picture 9.18: The sports facilities in the park encourage local residents to come there

Picture 9.19: OS1's view of the hospital has been blocked in some places

But the main category of residents who use the park are adults. Firstly, it lacks diverse playground and play facilities for children; secondly, it has an adequate pedestrian area for walking, sitting (benches) and cycling, which creates an attractive, relaxing environment for adults. They socialise there, especially in the evenings, by spending time in the park and chatting to each other: "Days are long and sometimes warm. I usually prefer to go for a walk in the evenings almost every day to meet my neighbours. I have kept doing this for the past six years since I retired. I did not have a chance to see my neighbours like this before." (M.R.67).

Picture 9.20: Local residents use the park to spend their time and socialise

There is not much more activity to occur in this place due to its size, location, facilities and access. There is no sports pitch or opportunity for economic activities in the park. Therefore, its clients use it for limited social interaction. It has been emphasised by one of the District 17 Municipality officers (Interviewee D) that except for two of the area's parks, the rest are small and cannot accommodate many different facilities: "They only satisfy our local statistics in terms of green space. We try to encourage people to use the parks if they look for limited sport and general leisure zones." My own observations supported this claim.

9.4.3 The Intended Use of OS1 and the Conflicts over this Use

Considering the physical condition of OS1 and its surrounding built environment and illustrating the general use of the space by local residents is part of a greater goal which is to assess its suitability to become a safe space for disaster preparation purposes. A combination of direct observation, surveying residents and local authorities, as well as the physical criteria assessment, has revealed that this space lacks many conditions of becoming a safe space.

9.4.4 Scenario 1: Dual-Direction Evacuation Routes in the Khazaneh Neighbourhood

Using the open space for disaster rescue operations requires a great deal of raising public awareness and physical adjustment: “It is not clear how the municipality or any other relevant organisation intends to use a park for earthquake. Do they want to erect tents in there and wait for earthquake shake or build storage and keep them there? It is a complicated matter.” (M.R.54). It has become obvious that the natural disaster committee and/or municipality has not focused on using social capital and training people to act appropriately in an emergency situation. OS1 is a typical green space covered with trees and grass, with paved areas and benches. Its location is known to those who live quite close to it. But the lack of roads around it has made its presence unknown to those who live a bit further away in the other corners of the neighbourhood: “I never knew that there is a park next to the hospital, I actually don’t use this dental clinic. But there is a massive park just next to Baharan Street which has a good landscape.” (F.R.25). Being familiar with the open space is a critical element in developing the suitability of OS1 for a combined use. In order to analyse the suitability of OS1, an earthquake scenario is developed and discussed as follows:

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Road	*Ui* (1)
1	569
2	821
3	1056
4	938
5	1340
6	2412
7	2012
8	251
9	753
10	151
11	148

Table 9.3: Roads in Khazaneh neighbourhood in the first minute after the earthquake

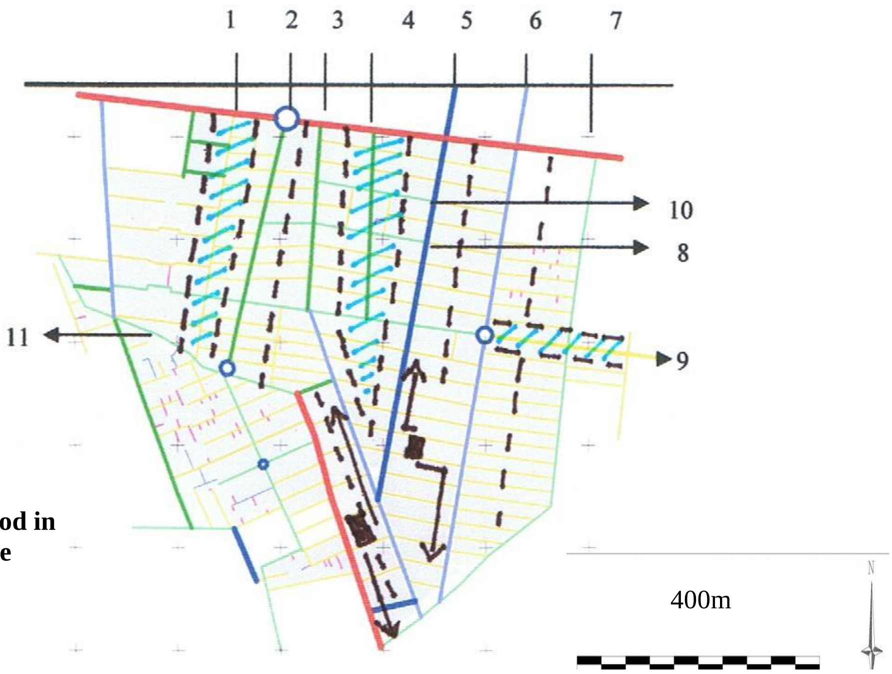


Figure 9.11: Dual direction movement of refugees in Khazaneh neighbourhood to safety

In this scenario, people would be directed in both directions, which are clearly signposted. Having pre-disaster preparation in mind, the management of the event is crucial: “I have never heard of special training for people to be prepared for an earthquake. As far as I remember, the staff in the Red Crescent and Tehran Municipality Fire Brigade get regular training. I was only told to escape the building if there is an earthquake.” (F.R.39). Information regarding the available spaces, their facilities and how to get there is part of the training needed locally.

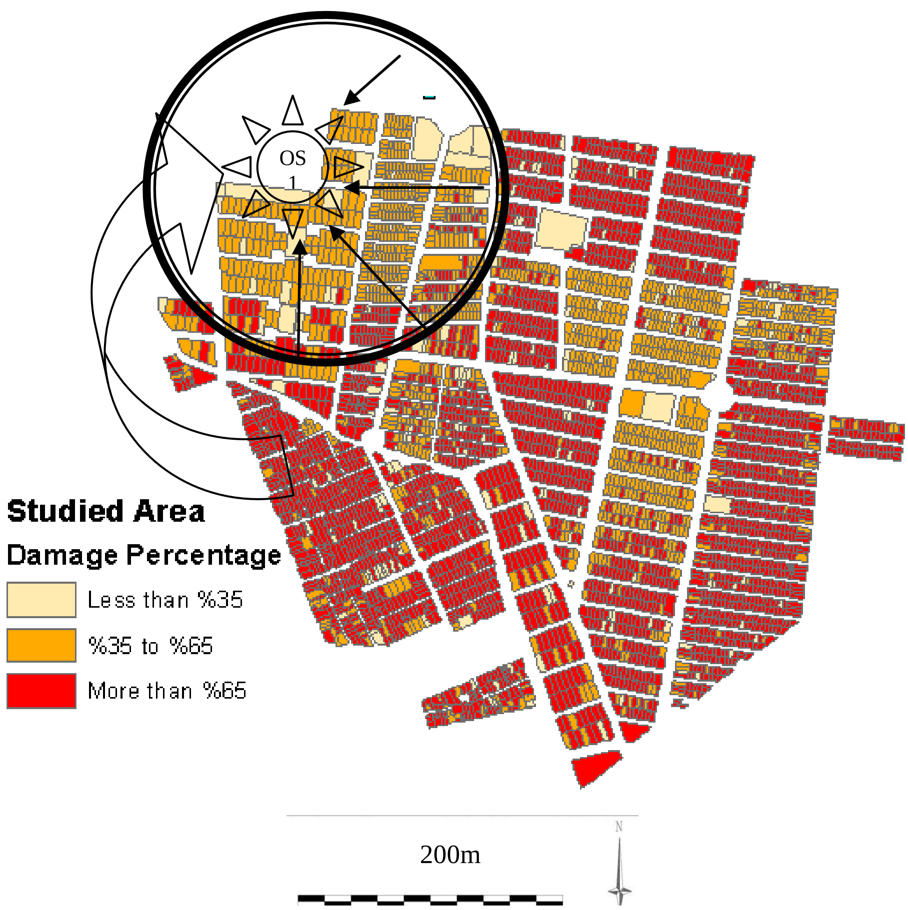


Figure 9.12: Evacuation towards OS1 from surrounding residential areas

People are guided to the nearest safe area no more than 0.5 km from their homes. They are encouraged to use the open space allocated to the population of neighbouring houses. A bigger area of feed is considered to be a way of directing and accommodating residents to the safe and then the serviceable open spaces. In peak time (night-time, when the majority of people are at home, the *Ui* (1) of roads are shown in Table 9.3 and Figure 9.11. As the table indicates, and due to the building damage pattern in Figure 9.12 which shows how eastern and central parts of the neighbourhood would face the worst damage, OS1 would be one of the first and prime locations to accommodate approximately 25,500 people in the early hours of the earthquake. Over 65% of buildings around OS1 would be damaged. Its coverage area is shown in Figure 9.13 and its capacity, based on the building damage in Figure 9.12 and *Ui* (1) of Table 9.3, is shown in Figure 9.11.

9.4.5 OS1

As Figure 9.13 shows, OS1 should be able to accommodate 15,600 people. Its size at the moment is adequate for people sitting, standing and lying down; however, the following elements should be improved in order to make it a safe place:

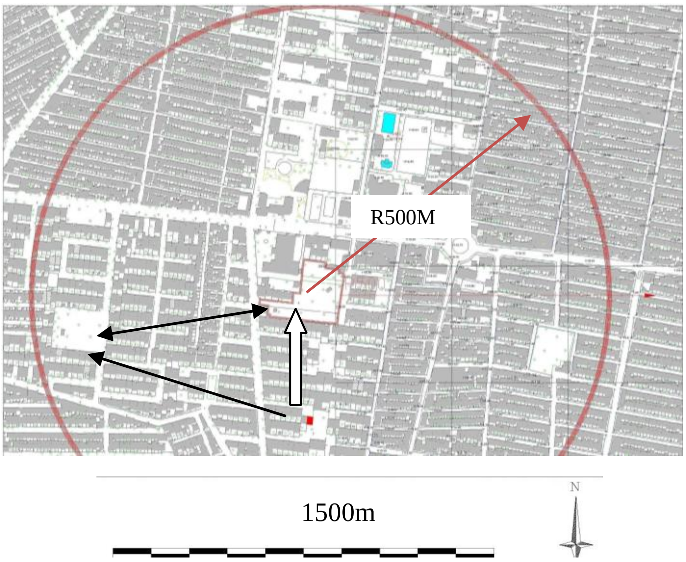


Figure 9.13: Coverage area of OS1

1) Buildings around OS1 are estimated to get between 35% and 65% damage. These buildings are the priority to be improved and become resistant to an earthquake tremor of 7.5 MMI in the Ray Fault model. For example, in Figure 9.14, block A is a two-storey residential building with a steel and brick structure, constructed before 1991. This building needs to be improved so as not to collapse and block the road T3. In an attempt to illustrate local people's

knowledge, one of the residents in the multi-storey flats was asked about their knowledge about earthquake damage: “I am aware that some buildings will collapse. Mine could be lucky one and stand. But this is a building with over 25 families who live here in these flats. I do not see how they can participate financially in structural betterment, it is required.” (M.R.56). As the figure shows, the park is only bordered by multi-storey buildings on the north and south sides.

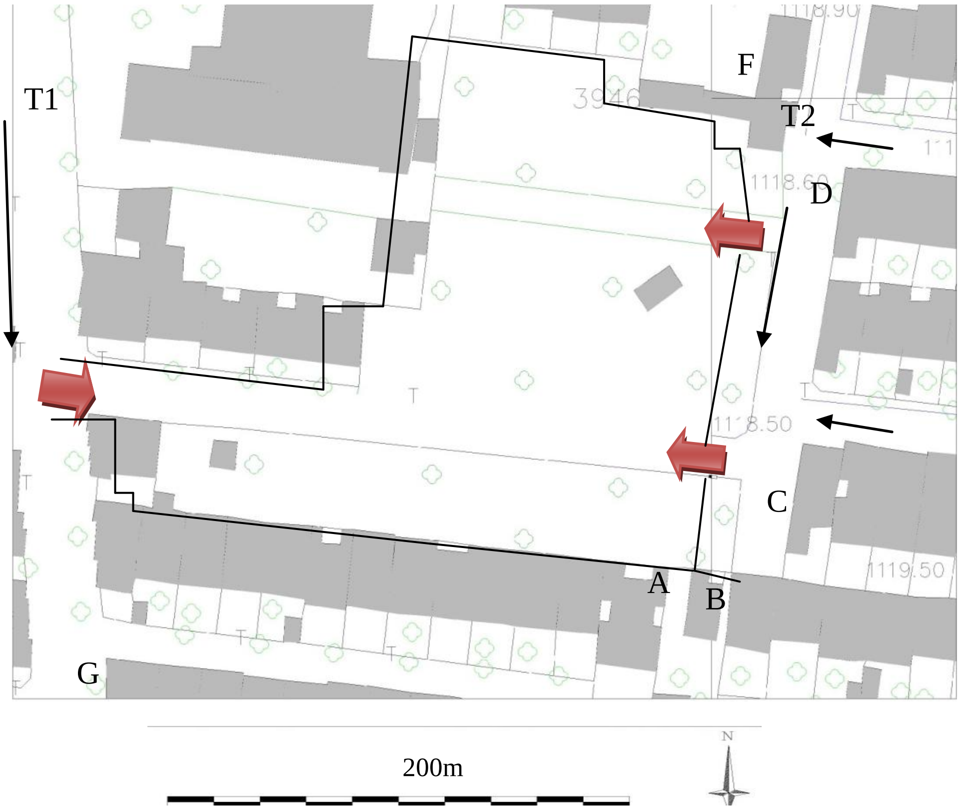


Figure 9.14: The detail of urban fabric around OS1

Picture 9.21: OS1 within the heart of the neighbourhood; buildings A, B and C

2) Roads T1 and T2 are 12 m and 6 m wide and will potentially have to direct 1,650 people to OS1 in the first few minutes after the earthquake. Access for this number of people could be jeopardised by the extent of building damage on the edge of the road, cars parked on the road, the usable width of the road without any blockage, and the direction in which people need to go to get to the safe area. Therefore, the road T1, for instance, is in need of reorganisation in many aspects. Firstly the blocks B, C, D and E should be improved so as to have minimum damage, so they will not block the junction. Secondly, in places where the roads are narrow, they should be redesigned and widened. Furthermore, again at these points, car parking should be banned both in the day and at night. There should be clear signposts for people to see and read how to be directed to OS1. The shop mobility regulations should be applied to the pavements so that elderly and disabled people, who are about 5% of the population according to the survey, can have access to the open space.

Picture 9.22 The view from the park towards building F and its surroundings

Picture 9.23: Building G at the side of Behbudi Street

3) People who reach OS1 should be protected from building damage and danger from fire. They also need to have access to simple first aid services and drinking water. Large pieces of equipment, such as tall slides or other playground equipment, should not be considered in this open space. Also, having a tall or an old tree on the site can cause danger for refugees. At the moment, there are trees in the central parts of the park which, due to their small size, will not pose any danger to people. It is also recommended to have fire hydrants to prevent any fire spread on the site. The distance between OS1 and hazardous facilities increases the possibility of a fire in and around this space.
4) The capacity of this space is predicted to be about 400 people, which is quite small. However, a large number of these people are expected to stay there for only a few hours after the earthquake. It is important that their short stay is safe and comfortable. Therefore, although they are not recommended to be equipped with overnight facilities such as tents, blankets and so on, the area to be used should be easy to clean and made of grass (in order not to be rough).
5) In terms of public buildings and their location and capacity, as mentioned in Chapter 8, only School 13 can be used for admitting people temporarily. It may not be a spacious place; however, as there are not many open spaces around, and as so many local people are familiar with the school's location, and also if its building structure could be improved and be made earthquake-resistant, then it could accommodate 500 people.

Picture 9.24: Access to the school from views A and B

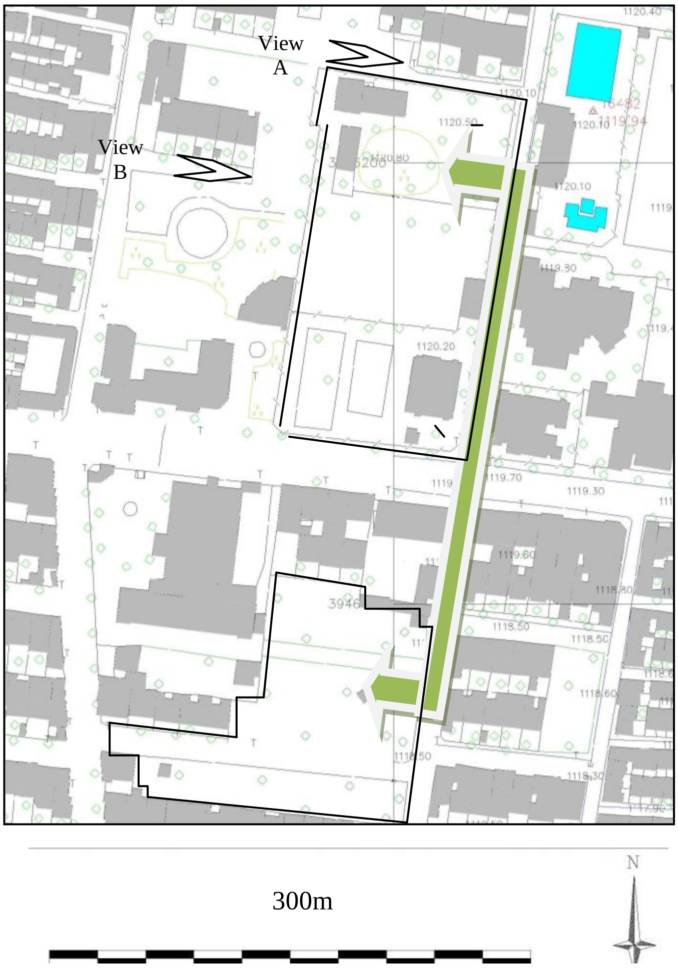


Figure 9.15: The location of School 13 (Somayeh High school) at a short distance from OS1

6) The one available hospital is located in the north-western corner of the Khazaneh neighbourhood. It is close to the densely-populated area, and has good access as the majority of roads around it are wide enough. However, the hospital itself requires some improvements in terms of its building structure, its equipment, and possible night-time emergency services (Figure 9.16).

Picture 9.25: Access to car park of Ziyaian hospital from the main road

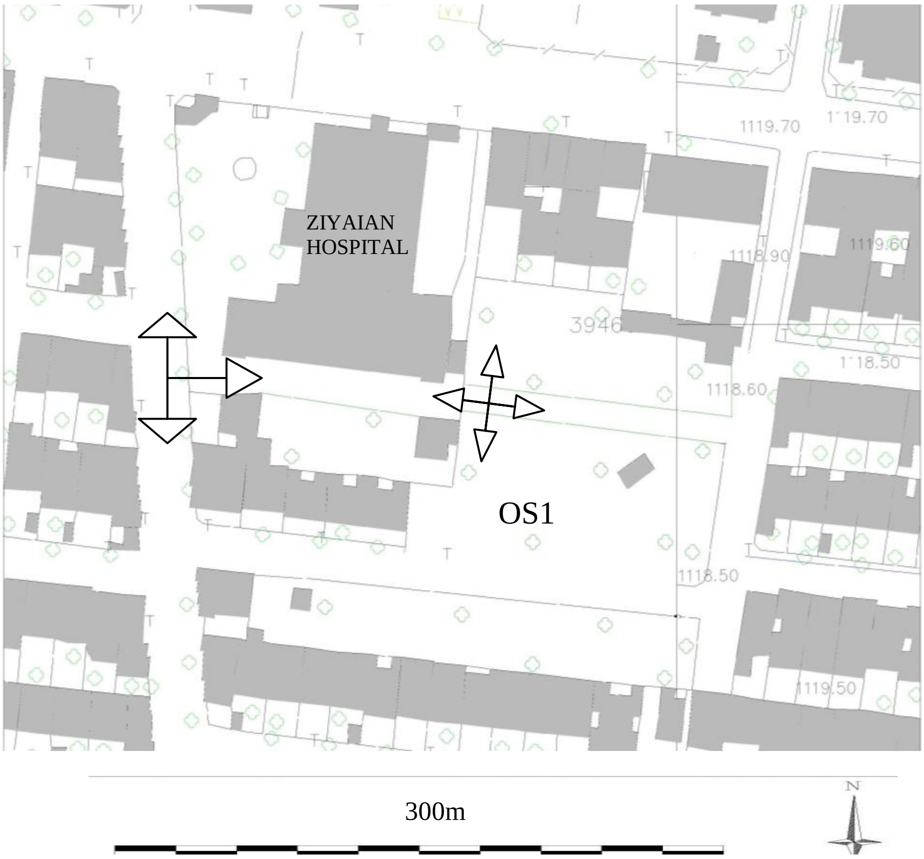


Figure 9.16: Access to the hospital from OS1

9.5 Analysis of Shohadaye Ghomnam Park, Open Space 2 (OS2)

This space is, unfortunately, the only open space for the dense residential area of the eastern part of Khazaneh neighbourhood. For many houses, it is over 3 km away, but still the nearest one. It is also small in size, but there are no buildings next to it as on all four sides it is bordered by public roads: Karimfard (on the south), Akbari (on the north) and Firouzi (on the east and west) Streets.

Picture 9.26: View from the park to buildings A & B

Picture 9.27: View from the park to buildings C & D

Figure 9.17: Shohadaye Ghomnam Park (OS2), in the heart of Khazaneh neighbourhood, surrounded by streets widely used by local residents

Trees have almost covered the whole park and the only building on site is a small shop run by the municipality. It is not an old structure and is used during the day by many people: "The cooperative shop is quite handy for local people. It doesn't have much variety, but it is the only busy place in the park." (F.R.42).

Picture 9.28: View from the park to the surrounding buildings (Building H)

Picture 9.29: View from the park to buildings F & G; the shop attracts people to the park

Picture 9.30: Public facilities in the park for residents' use

Picture 9.31: On-street car parking is one of the most disastrous obstacles that can block people's way to the safe places. Unfortunately, it is one of the main features of this neighbourhood

Picture 9.32: The spatial characteristics of the narrow roads around OS2 with poor structure and accessibility

Picture 9.33: New four-or-more-storey buildings built around the park lining the narrow streets

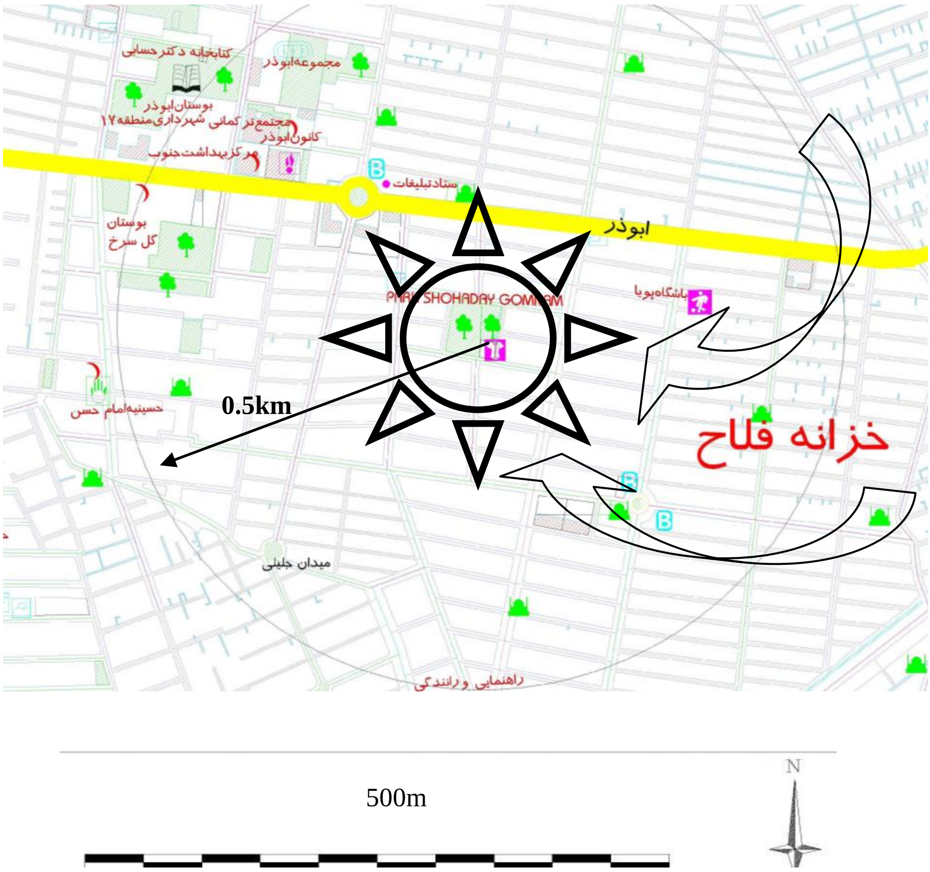


Figure 9.18: Coverage area of OS2 and the buildings with access to it

The roads giving access to the park are either 4 m or 6 m wide, which are not suitable widths. It has also been noticed that many residents park their car on-street. Almost all the buildings are three or more storeys and accommodate a large number of people (the building density is 465 people per hectare; Table 7.3): “The land plots are small and the houses are smaller. When this area was built in the past, it was located outside the city boundary. Therefore, it has inherited its urban structure from illegal subdivision of land.” (Interviewee D).

Figure 9.19: Access to OS2 is via narrow roads surrounded by multi-storey and vulnerable buildings.

The park does not have any special features and hence does not fully contribute to the daily life of local residents. There is a limited amount of playground equipment and a paved pedestrian area. Its underdeveloped role has been mentioned by those people who live nearby. Observing the park also revealed that the quality of trees in the park is not good enough to survive an earthquake and could reduce the possibility of using the park for emergency operations.

Picture 9.34: The park is covered by tall trees that might be vulnerable to disaster and make the area unsafe

Picture 9.35 (above): The park is poorly equipped and is not suitable for children

Picture 9.36 (right): Despite the narrow roads and small land plots, even mentioned by local residents, the municipality allows people to build four-or-more-storey buildings and increase the population density

Houses on the other side of the road mainly face north or south and have vulnerable walls that may be damaged in an earthquake. They feature the typical type of building in the region: "Most buildings were built by ordinary builders. Following the engineering requirements is a cost issue and is not affordable. Many of the new buildings are also built for profit and cannot be trusted. These together with the narrow roads put the area in a highly vulnerable category for disaster." (Interviewee G).

Picture 9.37: New buildings should be built based on engineering requirements, but they do not follow the regulations fully

Picture 9.38: The physical features of the roads leading to the park are not very promising

Accessibility to the area is another vulnerable element identified by this research. The roads could easily be blocked due to building damage. Although residents' knowledge of the area could find a way around this problem, it is an issue amongst those who do not use local facilities, as is discussed next.

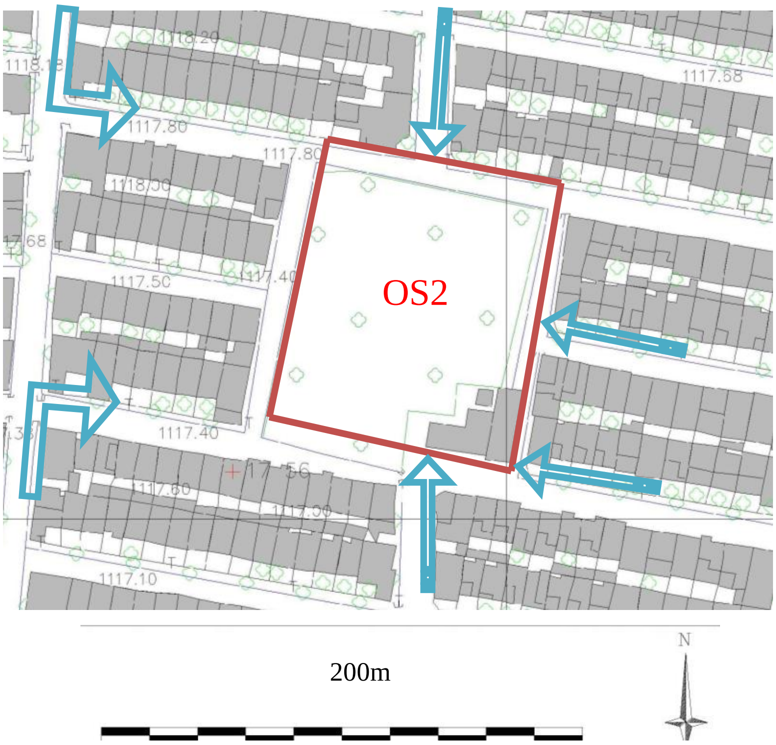


Figure 9.20: The roads leading to OS2

9.5.1 Social and Functional Use of OS2

The strategic location of OS2 has made it a place of social interaction for many children who live a short distance away. This equally disadvantages those residents who live further away and are not familiar with or interested in such a small park. This was stated in the interview with local people: "The proximity of this park to my street invites my children to go and play there regularly. They enjoy spending their time in the park instead of sitting at home. I will be happier if the municipality could make the park more attractive by adding some playground facilities." (F.R.33). This idea was opposed by another interviewee who claimed she did not know that there was such a green space in this neighbourhood (F.R.29). This gives mixed messages in terms of the use of this small park for safety purposes.

Picture 9.39: Spending time in the park despite its lack of equipment for young residents is a common feature of local residents' social life

Children are the main users of this space, whilst adults are a secondary group. In an interesting statement, a local man claimed how having a view of the park from his house helped him to feel happy every morning (M.R.60). There is no other major activity that takes place in the park, as it does not contain any sports pitches or fields for the children and their parents. This situation does not usually occur in other parks, which have more variety and attractions.

Picture 9.40: The park has become the "back garden" of local residents and a place of socialising

Picture 9.41: Local residents, especially the retired generation gather in the park to chat and spend some quality time together. This is one of the advantages of this park and its social capital

Being surrounded by residential buildings has raised the park's role from a green space to a "back garden" for the majority of flats with no private garden. The council's shop has helped the park to invite more people for shopping purposes and economic activity and has been supported by the local community. "Since the opening of this shop by the municipality I have become a regular visitor. The shop does not have a rich variety [of goods], but is still handy." (F.R.45). This has, in fact, opened the park to a group of residents who were strangers to the park before. Other than that, there are no other commercial or cultural activities, social gatherings or major sport activities taking place in the park. Especially when the interviewees were asked about the suitability of the park as a disaster refuge, neither local residents nor local authorities had thought of this: "The idea of using the park as a refuge area is not practical because it is small and surrounded by old buildings." (Interviewee E). The next few paragraphs will analyse the intended use of the space.

Picture 9.42: The corporate shop is not busy, but encourages people to use the park

9.5.2 The Intended Use of OS2 and its Conflicts

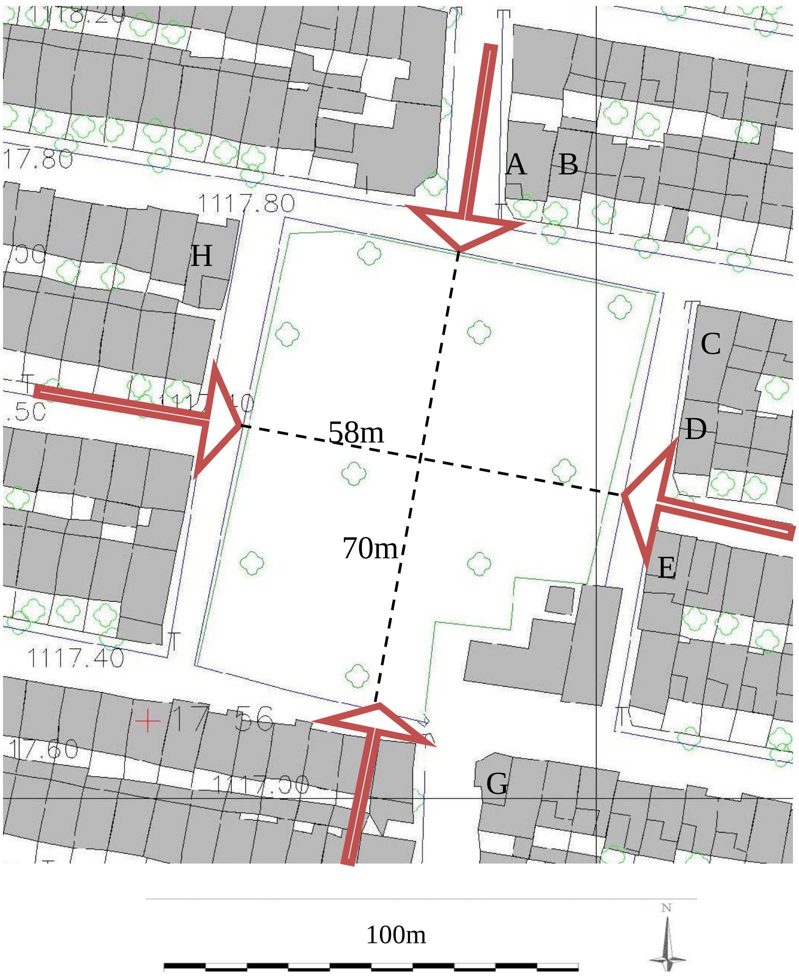


Figure 9.21: The area of OS2 and the buildings around it

The situation in OS2 is slightly different. There are no buildings adjoining the open space, which makes it much safer than typical parks in the middle of residential areas; however, there are other points that should be noted and improved upon in this example. OS2 is quite spacious in comparison with other available green spaces in the Khazaneh neighbourhood, and as there are no other possible safe areas around, it should have a capacity of a minimum of 2,300 people, as Figure 9.23 indicates.

$$Ui(1) = 2.45 \times 335 = 821$$

Figure 9.22: Number of people who are in the street 1 minute after the earthquake

Figure 9.23: Radius of serviceability and coverage area of OS2

The quality of the majority of buildings within the coverage area of OS2 (Figure 9.23) are brick and steel, which makes them highly vulnerable to the earthquake; they may have a damage ratio of over 65% (Figure 9.24). The following parameters should be considered if the local people reach this space from different directions:

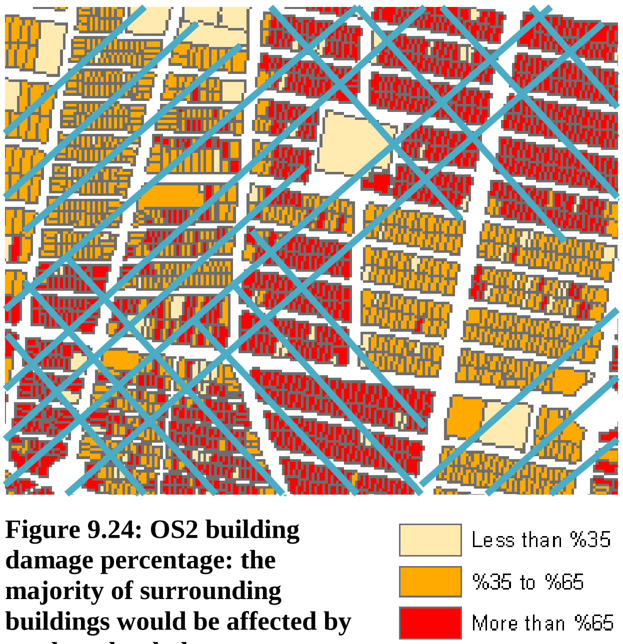


Figure 9.24: OS2 building damage percentage: the majority of surrounding buildings would be affected by earthquake shake

Picture 9.43: Some of the buildings in the neighbourhood are predicted not to withstand an earthquake

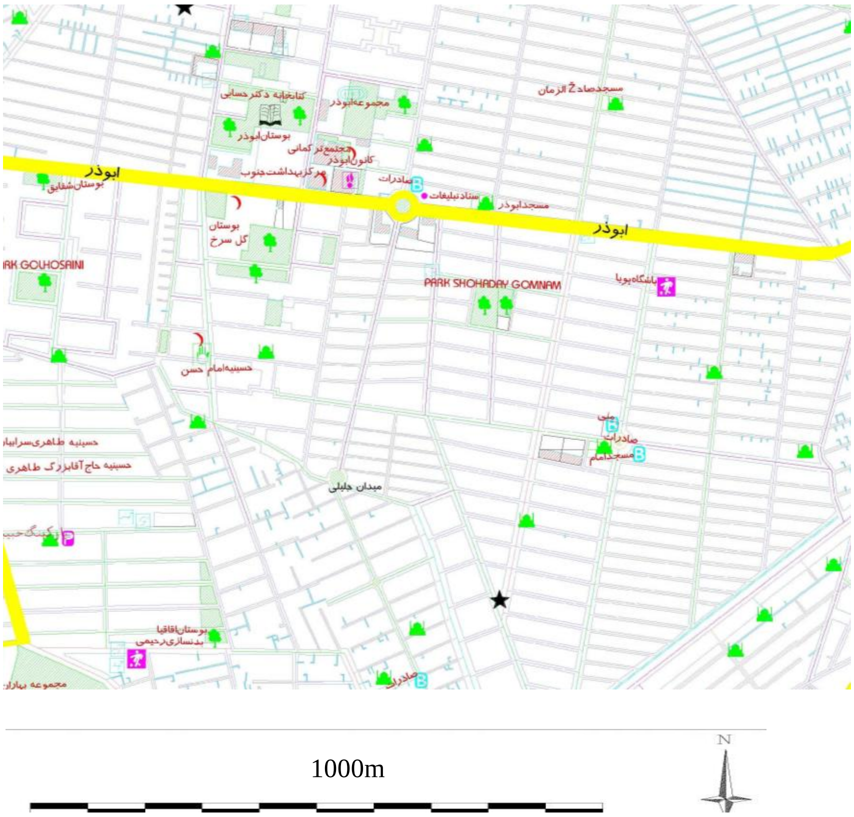


Figure 9.25: The size of OS2 is too small for the number of refugees, so the park would either be expanded or people have to be redirected to other available spaces

1) The space is for a short-term stay: a safe place immediately after the earthquake. Based on the average of over 65% damage, and 2,250 people who would probably seek refuge in OS2, it would need to have an area of 510 m^2, which is bigger than its present size (300 m^2). The surrounding buildings should be added to that. However, if part of the population could be fed to other available safe spaces, there would be no need to increase its area. Nevertheless, as people are clearly directed to this place and as it is the only space within the 1.5 km distance, its area needs to be increased.
2) OS2 would protect people from earthquake damage and possible fire. Its special location, which is at a distance from buildings, has the advantage of being less open to the danger of falling bricks or buildings and heavy objects. However, in order to increase its safety it is recommended to minimise the space’s vulnerability by having no tall trees, and installing a fire hydrant, a fresh water tank and initial medical equipment located on the site. The location of the only fire station in the eastern part of the district gives the Khazaneh neighbourhood the chance of quicker service from it in the event of an emergency (Figure 9.26). The main problem for this essential element is its capacity to be used for the whole area, which has a population of over 250,000, and its location close to hazardous facilities within and around the district.

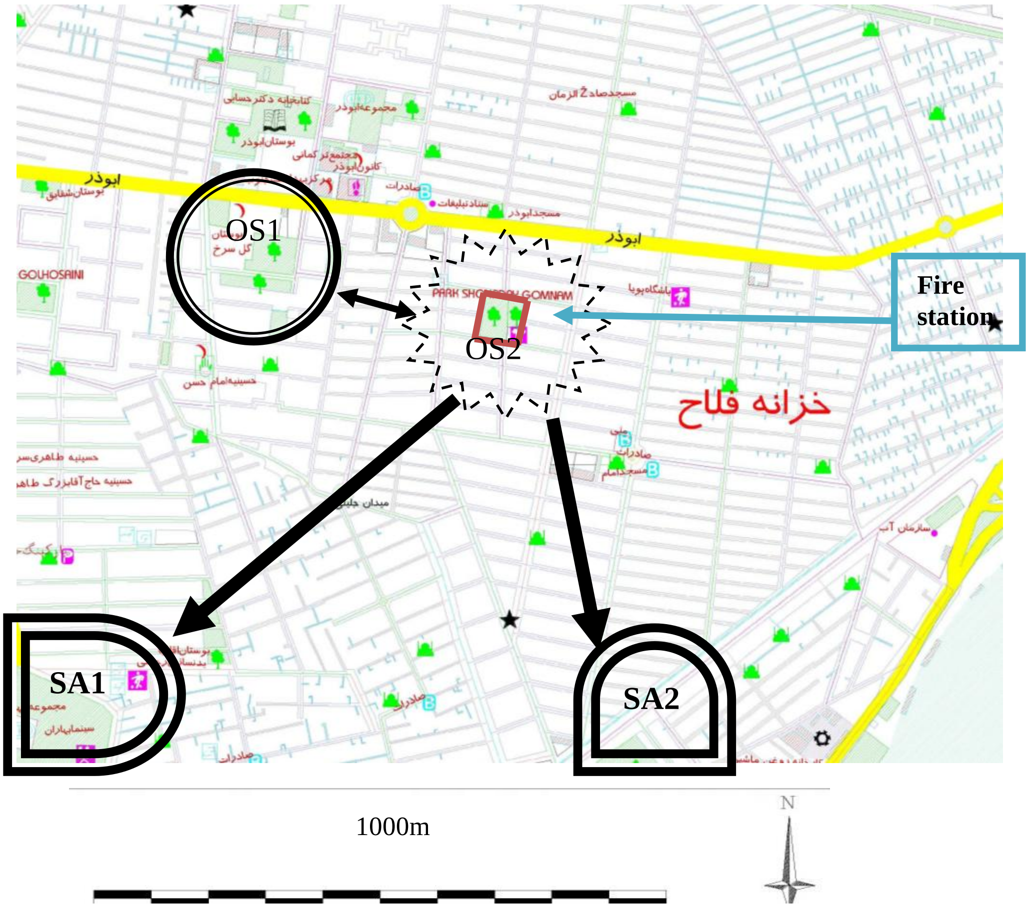


Figure 9.26: the location of the only fire station, OS1 and serviceable areas

3) As Figure 9.27 shows, the widths of the roads surrounding OS2 are between 4 m and 12 m, which is not ideal in the event of an earthquake. If there are not many obstacles, such as cars and building damage, the roads might facilitate easy access for pedestrians and emergency squads. Some of the buildings, such as block E, are multi-storey, and would need to be improved in terms of their seismic resistance.

Picture 9.44: Building E, which could pose danger to the area due to its structural vulnerability

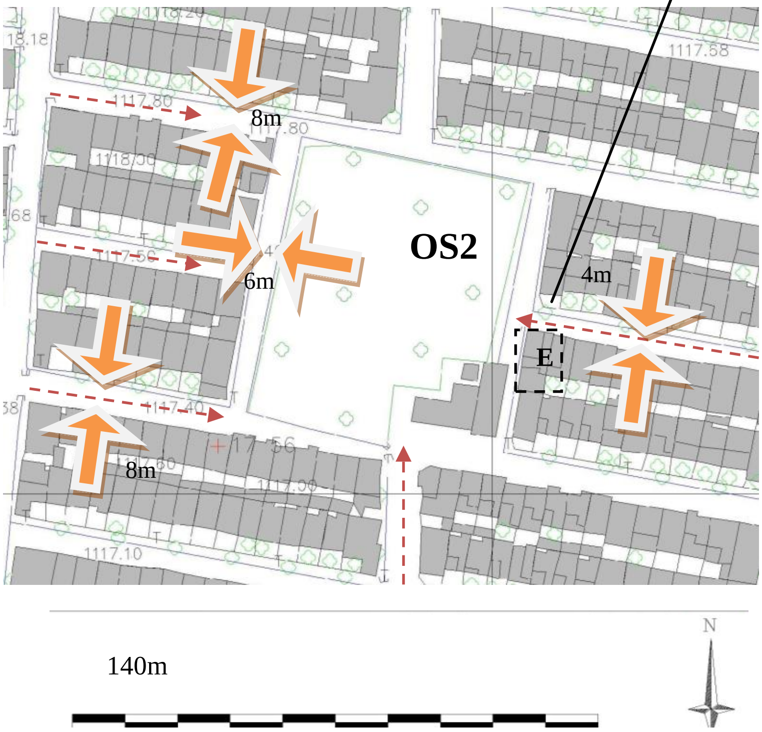


Figure 9.27: Narrow roads with vulnerable buildings alongside can reduce the capacity of OS2 as a safe area

Also, as there is a flow of busy traffic in the area, an organised traffic management system could improve the accessibility to the space. In addition, if the roads were noticeably signposted, this would decrease the possibility of confusion amongst users.

Picture 9.45: The networks of connection are busy with local traffic most of the time

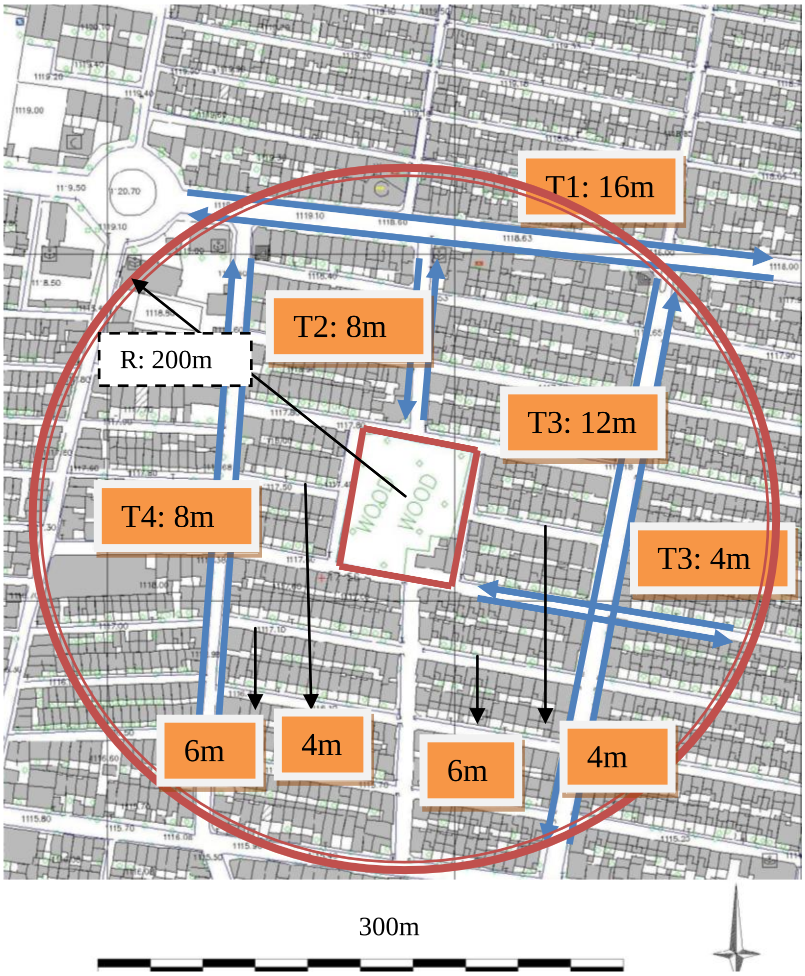


Figure 9.28: The widths of the roads around OS2 and the conflicts over the accessibility to the park

4) As the previous sections mentioned, there is no open space in the eastern and southern parts of the neighbourhood that could act as a safe area. This puts extra weight on OS2 to be perhaps one of the spaces in most demand. Only in part of the southern section of OS2 is there a 20 m wide road which can act as a safe "tunnel" to lead people to OS2 (Figure 9.28). However, the connecting roads are only 6 m or even 4 m in width, so they will not function during a disaster. They might be of secondary importance for usual accessibility, but they act as the final routes to get to the safe open space. Hence, it is necessary to keep them open for emergency purposes. One solution is forbidding on-street car parking. The other could be to use the municipality's power of compulsory purchase, or by expanding the roads' width by density bonusing. These particular roads could be visibly marked as emergency routes.

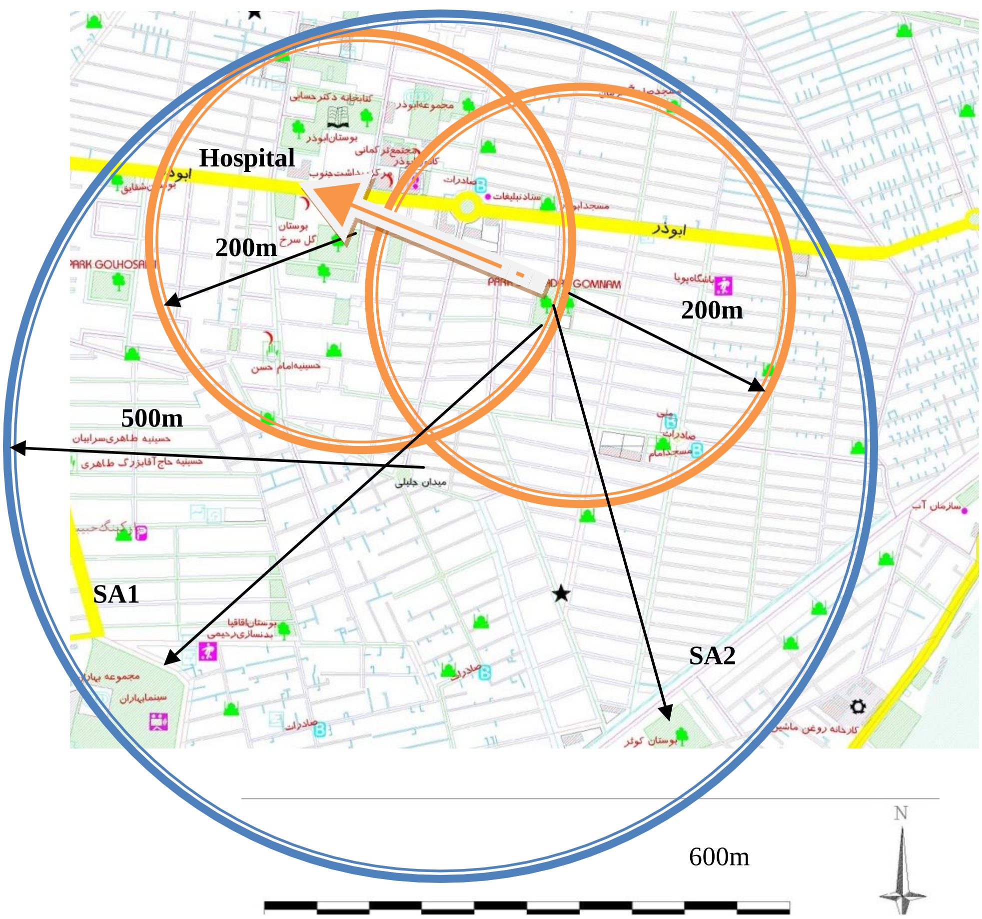


Figure 9.29: Serviceability of OS2 and its connection with other main parks

5) The coverage area of OS2, despite its wide area, is very important but small for the number of people it has to accept. As Figure 9.29 illustrates, OS2 is located

within the heart of one of the most densely-populated areas of the neighbourhood. It must provide adequate emergency-related services to the local population, so even as an initial safe area, it needs to be larger. However, considering the couple of green spaces in the south-east of the neighbourhood, just outside the borders of the area, the existing space can work closely with the safe spaces. This will be discussed later on in this chapter.

9.6 Wider Prospects for Serviceability of Open Space

The previous section demonstrated how OS1 and OS2 could function in an earthquake scenario. Their capacity, accessibility and coverage area would be subject to minor and major alterations and improvements if they were to be used as safe areas. However, in a real earthquake scenario, two levels of service are needed, short-term (safe) and long-term (serviceable) open spaces. SA1 and SA2 are two of 16 available green spaces that can provide refugees with food, water, temporary shelter, medical services and long-term accommodation. In order to use their best potential, their physical, social and spatial features will be identified and analysed first.

9.6.1 Physical Characteristics of Baharan Park, Safe Area 1 (SA1)

Picture 9.46: The park is surrounded by multi-storey buildings

Picture 9.47: There are some buildings in the park for different uses

SA1 is a decent-sized park with good access to the main roads in the western neighbourhoods. It is a well-known park for many people, as it is located next to a big supermarket and Baharan Square. The municipality has provided a variety of activities and facilities in the park. The 24,750 m² area of the park is divided into different sections, including a children's play area, a sports pitch, an area for walking and space for cultural activities. A large number of people use the park in different ways. Less than 30% of the area is covered by trees. Buildings also cover 5% of the park.

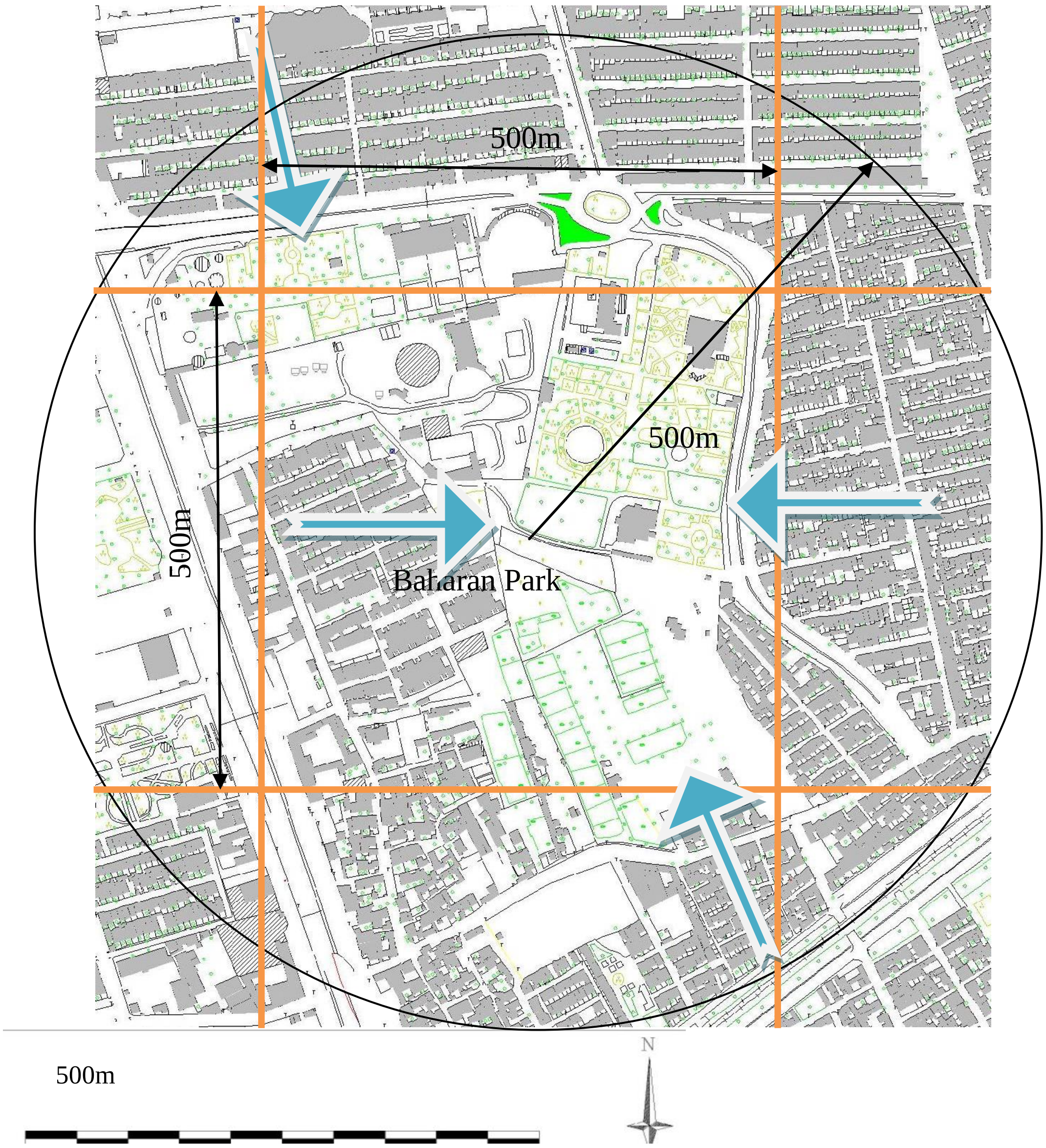


Figure 9.30: People would seek refuge in SA1 from many other places, especially from surrounding residential areas

Car access from the northern and eastern sides of the park would give an opportunity to the users to get there easily. But the western and southern sides are blocked by residential and office buildings. They are again the typical four-to-eight-storey buildings with either steel and brick or concrete structure. Except for one new engineering-built building, next to Fardi Mohammadi Street in the south, there is a high possibility of damage to the surrounding buildings. The alleys in the west are all cul-de-sacs and do not allow access to the park, even for pedestrians. The municipality buildings are used by people on a daily basis, but based on my observation, they are not designed for safety purposes.

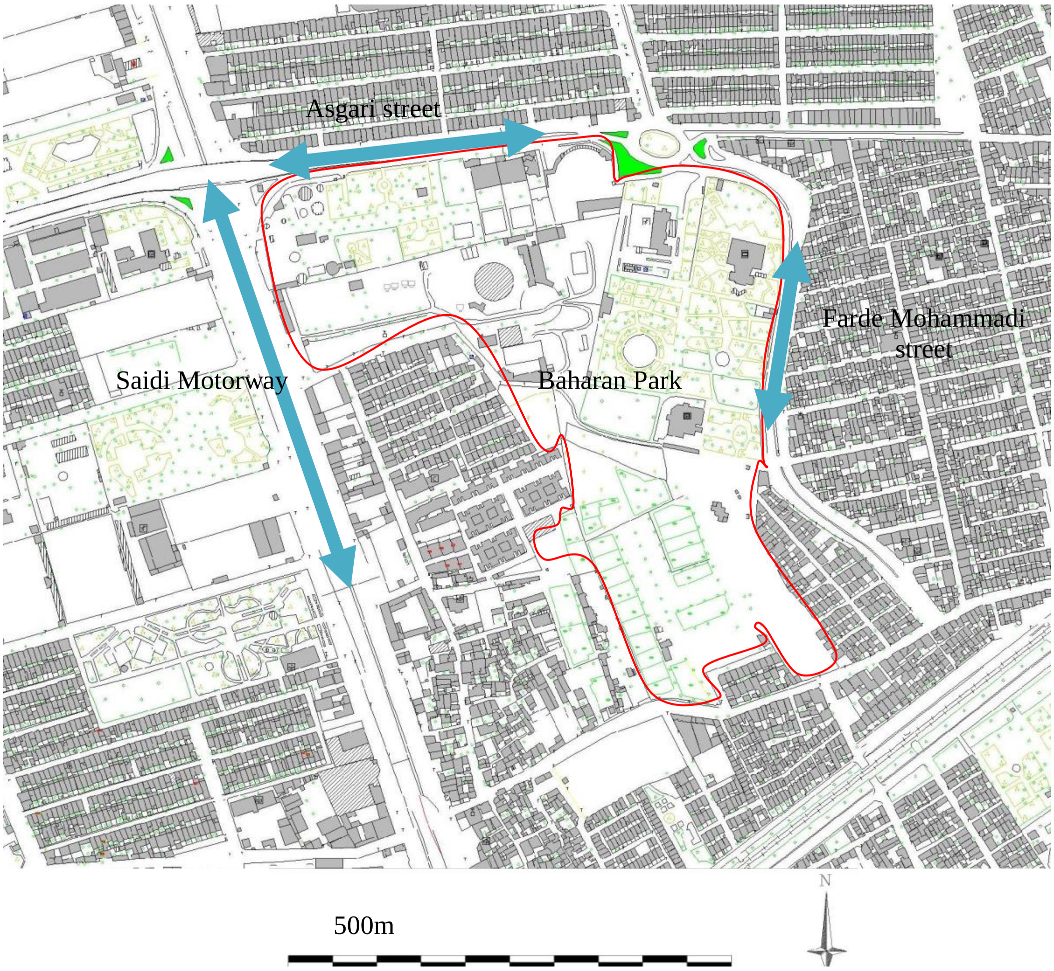


Figure 9.31: Baharan Park (SA1) and its surrounding streets

There are also small designated wooden seats in the park for people to sit. These structures are not strong enough to withstand earthquakes, but are not harmful enough either to put people's lives in danger. Due to the nature of the park and the variety of opportunities that it creates for local people, the next section has a more in-depth discussion in this regard.

Picture 9.48: Entrance to the park from Fardi Mohammadi Street

Picture 9.49: Entrance to the park from Baharan Square

Picture 9.50: Entrance to the park from Asgari Street

9.6.2 Social Relations and Baharan Park

Special attention was/is paid to this open space by the district municipality. The park demonstrates combined cultural, leisure, social and to some extent economic activities. Shahrvand store (Baharan branch) is a busy and popular shop that attracts people from other areas as well as local residents: “I do my weekly shopping at Refah supermarket. It is not in walking distance from my home, but it is easy for cars as there is a car park opposite the shop." (M.S.23). "When we come shopping to Refah supermarket, I usually take the children to the park whilst my wife does the shopping." (M.W.40).

Picture 9.51: SA1 manifests a combination of cultural and social activities

Picture 9.52: SA1 contains equipment for relaxation and social gathering

Picture 9.53: SA1 is a centre with various facilities such as a library for public use

Picture 9.54: SA1 has good access to the main roads in the neighbourhood

Picture 9.55: The community centre in SA1 is a social and cultural attraction for residents regionally and locally

Picture 9.56: Shahrvand shopping centre (Baharan), adjacent to Baharan Park, a centre for economic activities

The short distance between the supermarket and the park invites many people to the park. There is also a cinema in the park which creates another opportunity for people to come there: “During the summer, the municipality puts on shows and movies on the screen in the park which is very popular and supported by the local community.” (F.S.20). Although these kinds of cultural activities are not developed in Tehran, in recent years the government has actively tried to engage people in selected cultural movements.

Picture 9.57: Families enjoy spending time with their children in the playground

Picture 9.58: Children are the main users of the park facilities

Picture 9.59: There are various facilities in the park to keep the family busy

Picture 9.60: People use the park for relaxation and spending quality time

There is also a football pitch in the park that encourages people to undertake healthy activities. The pitch is maintained regularly and is occupied by local people most of the time. But the particular location of the pitch, next to the shopping centre and main road, attracts people from other areas: “We have a friendly football game very Thursday night in here. It has good access and is secured by a fence. The games improve our social relationships.” (M.R.21).

Picture 9.61: People of every age and gender enjoy the park

Picture 9.62: Local residents use the park for connection

Picture 9.63: The library is a building used by many people of all ages

Picture 9.64: Children enjoy using the park facilities

Also, all over the park there is fixed furniture and equipment for personal exercise. They are used by every age group. By utilising this approach, the government encourages health and social well-being for every citizen. A ping-pong table, for example, is another piece of equipment installed in the park. All these fixtures aim to enhance public health, which is appreciated by local residents: “Although I am not a big fan of football, I take my grandchild to the park for a bike ride. This gives me a chance to get fresh air and meet new people.” (M.R.47). Baharan Park is an example of a multi-functional open space, providing different opportunities for different interests. But the park has never been considered as a disaster refuge area or altered for this purpose. The next section will analyse the applicability of the idea of this park to be used as a serviceable area in a disaster.

Picture 9.65: Sporting equipment is part of the park's fixtures

Picture 9.66: The sports equipment is used by children and adults

Picture 9.67: The small cinema in the park demonstrates cultural activities

Picture 9.68: The football pitch is regularly used by local residents

Picture 9.69: The football pitch is a facility which attracts local people

Picture 9.70: The small chess centre is another attraction of the park to attract the residents of the local neighbourhood

9.6.3 The Intended Use of SA1 and its Conflicts

The size and location of SA1 gives it many advantages in becoming a safe and serviceable area. It has (not direct) access to the motorway, which would facilitate fast emergency communications to and from the area easily. It is also next to a big supermarket with a decent-sized car park, which could even serve as a possible helicopter landing point. As is shown in Figure 9.31, its connection with the surrounding built environment is good in general; however, SA1 requires the following improvements in order to be usable as a serviceable emergency area:

- It has to be reorganised in terms of its plain green space and the ground to create maximum space to accommodate over 22,000 people after an earthquake (Figure 9.32), during the post-earthquake tremors and even weeks after, until people are able to get back to their homes.

$$Ui(1): 685 \times 335 = 22{,}947$$

Figure 9.32: Formula for the number of people in the street in Area 2 after an earthquake

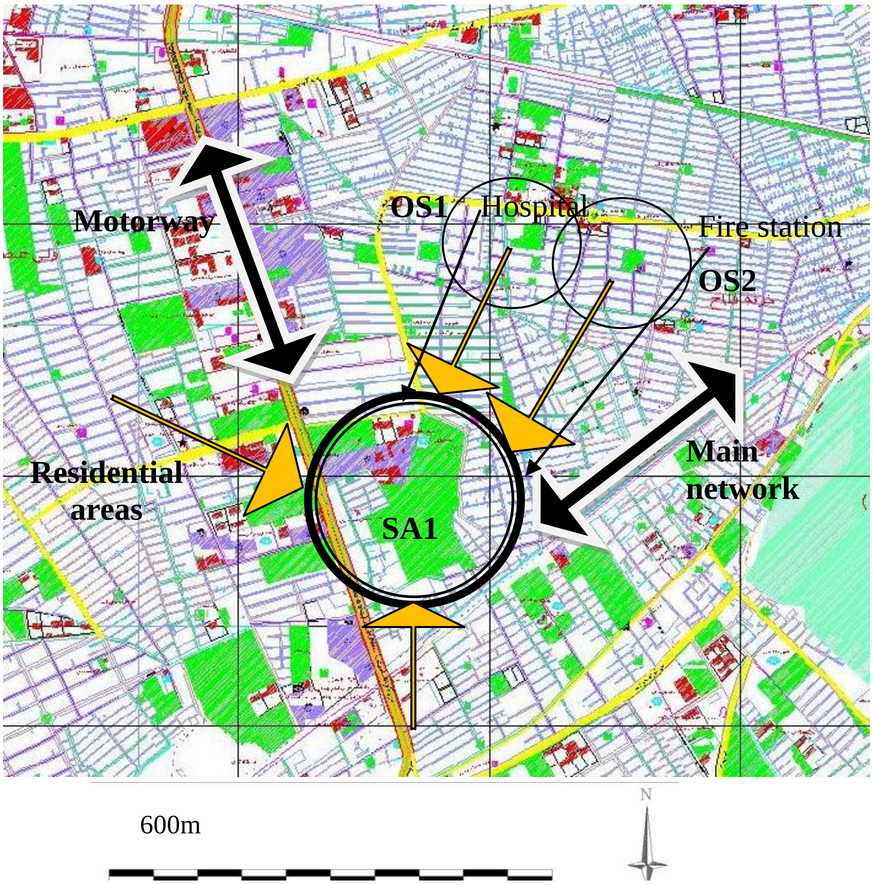


Figure 9.33: The major open spaces, hospital and fire station in Area 2 and in Khazaneh neighbourhood of D17

It has to be designed to be comfortable and to create a safe environment for a possible 25,000 refugees whose houses may be in need of improvement or rebuilding. The open space has to be equipped with drinking water, essential medical equipment, tents, and other emergency requirements. Having Somayeh High School, a hospital and a dozen small open spaces in the area, although not in ideal locations, enhances the capacity of the area to be prepared for an emergency situation. These are not adequate in quantity and quality (as assessed in Chapter 8), but they have the potential to be equipped, and with some investments by the government, local agencies, residents and international organisations, to create a safe place for people after a disaster.

- The main purpose of serviceable areas is to protect people from an earthquake and its devastating consequences. However, the location of SA1, adjacent to hazardous sites (Figures 9.9 and 9.34), puts the space in a highly vulnerable position to fire.

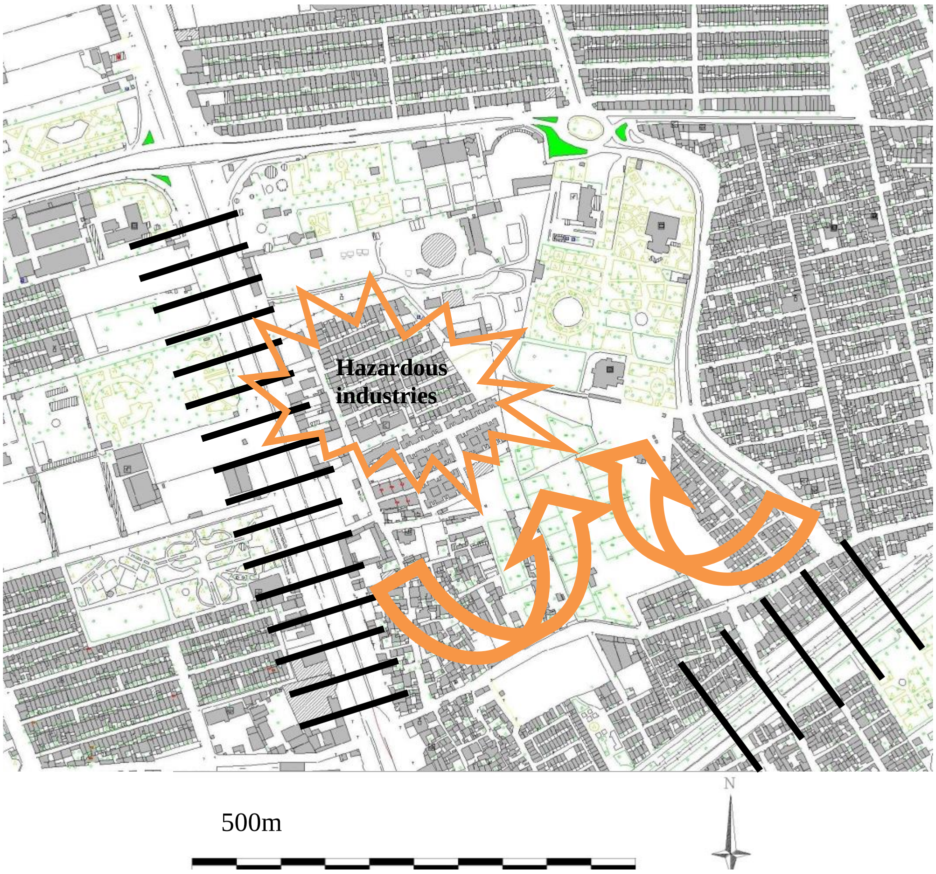


Figure 9.34: The location of hazardous industries next to the two main roads in coverage area of SA1 and the possibility of fire spread

Therefore, based on the prevailing wind from the west, the western parts of SA1 should be protected from fire spread. There is a fountain in the park which can be used to put out fires in an emergency.

Picture 9.71: The eastern entrance of the park and the buildings opposite it

Picture 9.72: The buildings at the side of the roads leading to SA1

Picture 9.73: The northern entrance of SA1 is also surrounded by tall buildings

Picture 9.74: The motorway close to SA1 on its western edge is always packed with cars

However, designing a waterway on the western edge of the space gives more protection to it. Considering a fire hydrant in SA1 would also be useful. Although its western boundary is blocked by residential buildings that might be obstacles to the emergency operation, the safer the space is, the better service it can give to people.

The location of the D17 fire station in the far east of the district reduces the chances of using local routes to get to SA1. Nevertheless, there is a high-speed road passing through Area 2 of D17 which has good access to this area.

3) SA1 is surrounded by wide roads at some points (Figure 9.35). Maintaining direct access to the park is easy for those who live quite close; however, for those who are located at the heart of dense residential areas or who want to be transferred (redirected) from OS(n) areas, finding a clear, wide path is difficult.

Accessibility and the avoidance of confusion is an imperative tool in disaster management planning. Also, as the answers to the questionnaires revealed, a large number of people have been living in the area long enough to know the location of some of the local parks: "For me, Baharan Park is a well-known place because it has got shops next to it, the football ground and the other equipments and kids playing area that keeps everyone entertained." (F.W.26). However, local people did not have any specific information about how the place can keep people safe from earthquake or even they can seek refuge in the park: "I live further along and I never imagine how I could get here through the narrow roads. For those who live close this might be an option, but for me it is almost impossible." (F.R.38). However people hardly attempt to use different routes to get to the park. This highlights, firstly, that raising public awareness and knowledge to identify and use the emergency routes, which will lead people to the safe and serviceable areas, is essential; and secondly, these connections should be reorganised and designated to function accordingly in the event of an earthquake.

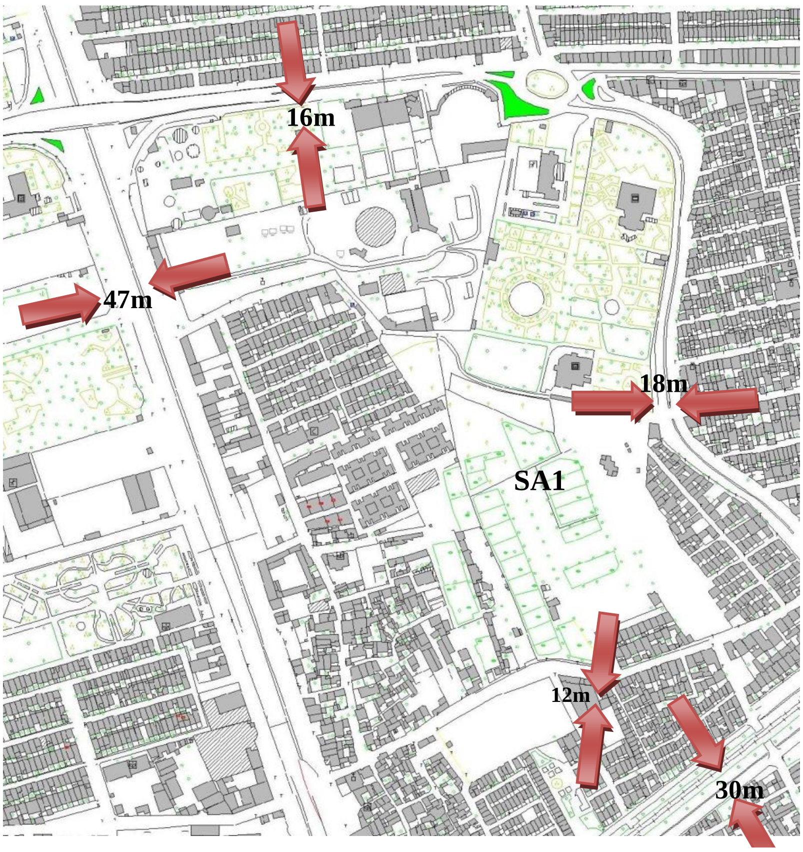


Figure 9.35: Widths of major roads around SA1 are suitable for emergency access if they are not blocked by collapsed buildings or other major obstacles

Picture 9.75: Buildings next to the park should be improved in terms of earthquake resistance and fireproofing

Picture 9.76: Buildings that are next to the motorway also need their resistance to disaster be improved

Picture 9.77: Although the immediate access to SA1 is via wide roads, the residential area adjacent to them contains narrow ones

On many occasions people are surprised by the relationship between the park and an earthquake: “Instead of using the park, I think government should design and build safe buildings. The government has to give medical services to people in those buildings.” (F.R.40).

4) In order for the former to happen, signposting and spreading brochures amongst local people, and advertising them in TV programmes or in local social gatherings, is needed. The latter point requires:

- Expert opinion and disaster management and planning;
- An increase in the structural resistance of some of the most vulnerable buildings that accommodate a large number of people;
- Avoidance of the possibility of building damage on those roads;
- A strict traffic management system for the main roads that would be used as emergency routes;
- A reduction in the number of possible obstacles for fast and convenient access to the designated open spaces.

As Figure 9.36 shows, routes P1, P2 and P3, for instance, have to be either widened or straightened, which is costly but necessary. In relation to SA1, according to Figure 9.30 and based on their location, the extent of possible damage to the buildings, population density and the routes that local people would possibly use to seek safety, they are wide enough.

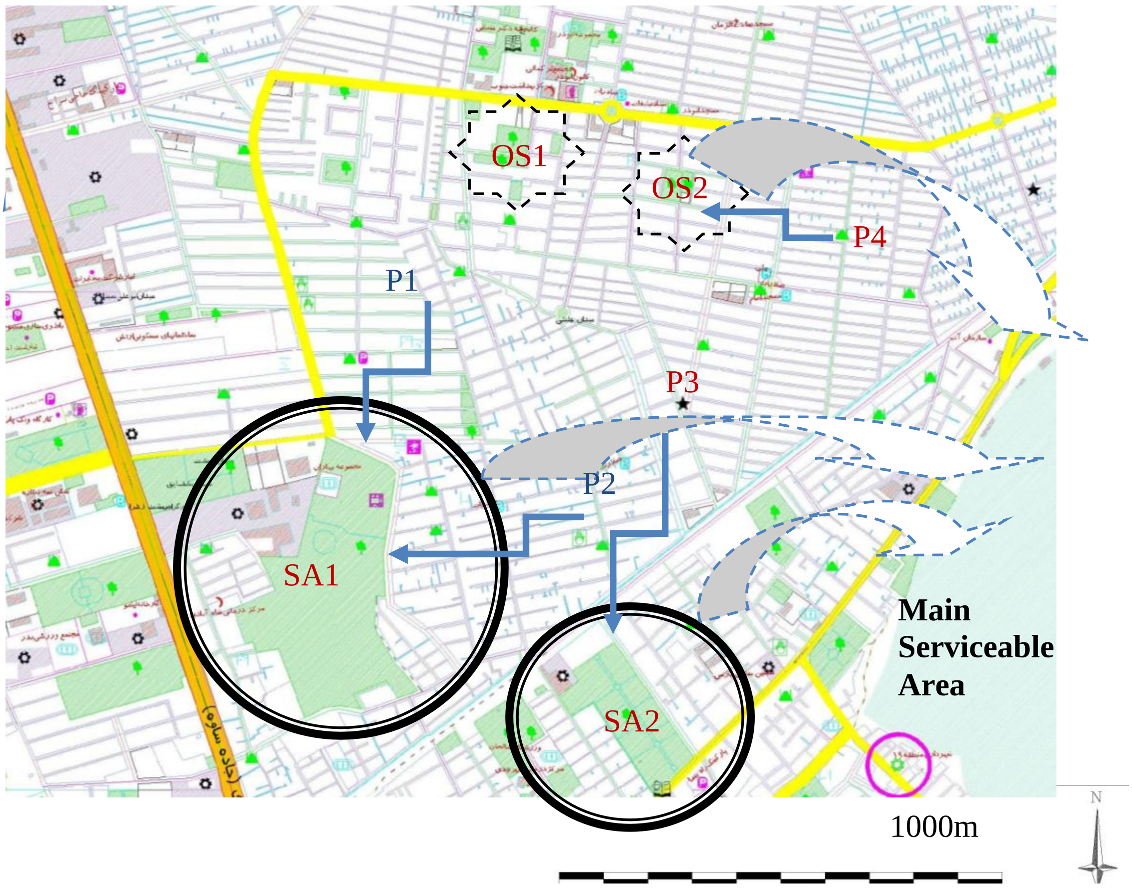


Figure 9.36: Location of SA1 and other safe areas, and the quality of accessibility to them

The figure shows how far they are from those who live in the north-eastern corner. Even if they could get to OS1 and then move to SA1, this would still be difficult for the very old and very young populations who live in this area (see Table 7.8).

Picture 9.79: View A to SA1

Picture 9.78: View B to SA1

Picture 9.80: View C to the road

Picture 9.81: View D to SA1

Proposing a spacious safe open space in the residential fabric of the north-eastern part of Area 2 is an impossible and extremely high-cost plan, which is not affordable by the district council.

Picture 9.82: view E to the motorway from fields not far from the park

However, route T1, which is a four-lane high-speed road with plenty of green shoulder, can act as an evacuation route with less possible disruption to get to Velayat Park, a post-military zone which was transformed into a district park, and can accommodate a large number of people for a longer period, and includes a temporary hospital for use by air ambulances and emergency services.

9.6.4 The Physical Characteristics of Zam Zam Park, Safe Area 2 (SA2)

Zam Zam Park is a familiar place and quite spacious park in D17 which is known for its location and proximity to a busy motorway passing Tehran towards its southern districts.

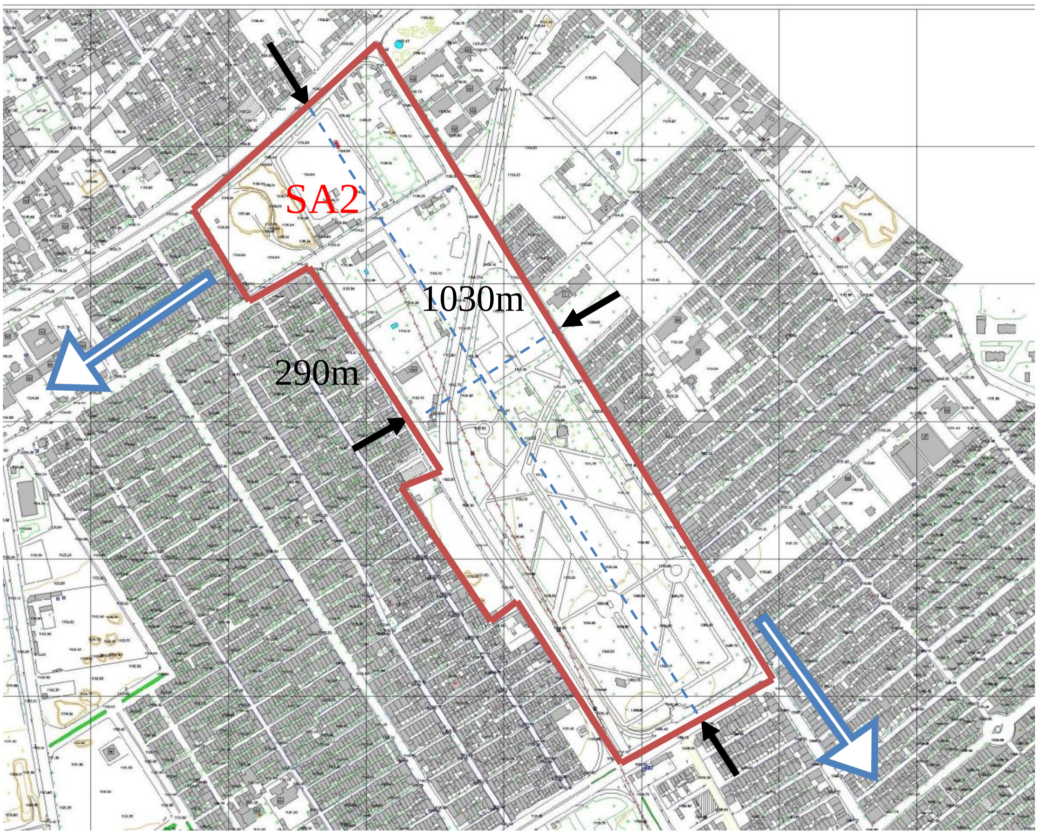


Figure 9.37: Zam Zam Park and its surrounding buildings

600m

N

Picture 9.83: The municipality building opposite SA2 and public transport has made the park known to many residents

The 301,700 m² park consists of two public buildings, two sports pitches and a children's play area. There is also a multi-storey car park opposite the park to the south. Inside the park, which has been designated for pedestrian and relaxation, there is equipment for promoting public health, which is widely used.


Picture 9.84: Children's play area in SA2, inviting families to spend quality time in the park


Picture 9.85: The sports facilities in SA2 include a football pitch and other equipment for personal health

The number of trees is fewer in comparison with other local parks and the park is mainly covered by grass and bare soil. Three sides of the park are surrounded by roads and it is only blocked by buildings on one side. The municipality has a community centre with sports facilities in the park. A number of people, especially from the younger generation, use these facilities. But the quality of the buildings' structures is still in question in relation to earthquake resistance.

Picture 9.86: The park has fewer trees and is covered by grass

Picture 9.87: Some of the buildings on the southern edge of the park

Picture 9.88: Two small public buildings in the park attract people as well, but they are not earthquake-resistant

Picture 9.89: The park enjoys various facilities in good locations and of a decent size

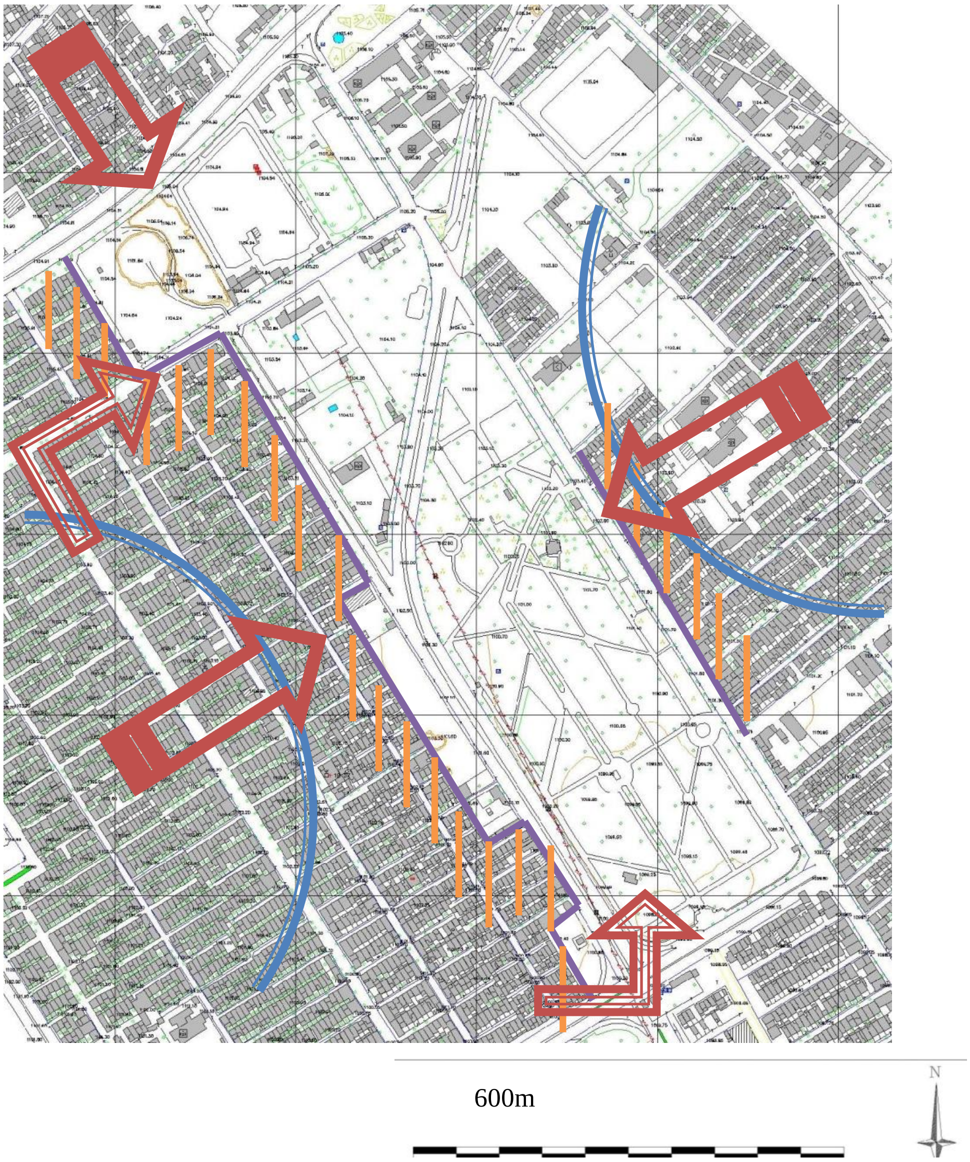


Figure 9.38: The vulnerability of the buildings on the east and west sides of the park could have a negative impact on the accessibility criteria to the serviceable area

Also, the residential buildings on the west side of the park fall into the vulnerable building category based on the JICA (2000) assessment. Therefore, they might not only collapse, but also block the access for people who live in the south-west neighbourhoods of the district. The 20 m and 16 m wide roads at the north-east corner of the park are two of the busiest roads in the area. There are a number of car parks on this side of the park, but this will not prevent emergency access to the park.

These are some of the general and long-term prospects to create safe and serviceable areas for local people who are socially, physically and financially vulnerable to earthquake. Making SA2 fireproof could also be vital; however, the distance between hazardous locations and the park reduces the possibility of it catching fire. Generally speaking, the park’s location, size, accessibility and variety of users make it a strategic and suitable place for a safe area. This is discussed further in the social assessment section from its users’ point of view.

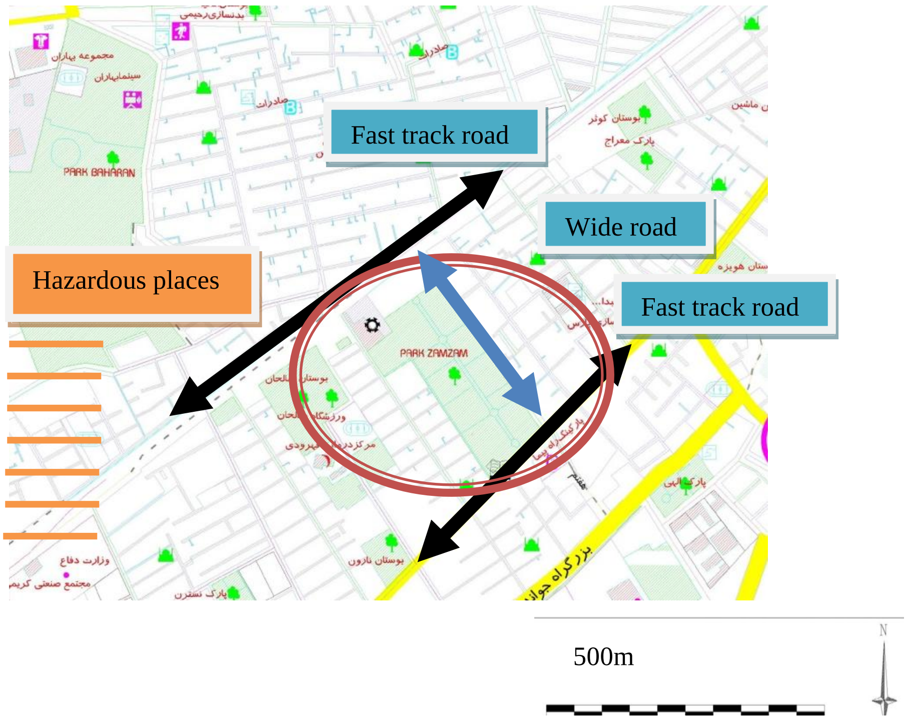


Figure 9.39: The distance of the park from hazardous places is an advantage coupled with its easy access to the motorway, which makes it suitable as a safe and serviceable place

Picture 9.90: Given the strategic location of SA2, the wide roads around it are an advantage

9.6.5 Assessment of the Social Characteristics and Relationships of SA2

The quality of the park's facilities and its view from the busy roads have been some of the positive points for the park and its popular attractions: "If the weather lets me I come to the park to visit my friends and chat with them almost every day. This helps me to socialise and spend my time." (M.R.61).

Picture 9.91: Elderly people are part of the local community using the park regularly

Picture 9.92: Children spend time in the park alongside the older generation and enjoy using its facilities

Its users range from very young children (who can play in the playground) to teenagers (who use the sports facilities) and adults (who can come for a walk or socialise). There are no economic activities in the park except a small shop. There is also a sandwich shop in the park, which expands the park's economic attraction: "My shop is packed with people every weekend. I serve people from every age group." (M.W.27).

Picture 9.93: The natural beauty of the park embraces different tastes and attracts local residents

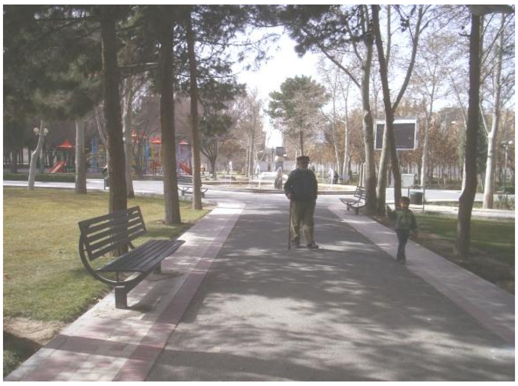
But its cultural impact on the community is inevitable: "When I was younger, I used to come to the community centre for various activities. It was first in the centre that I learned to use the computer." (M.S.25). By providing general courses such as drawing, drama, martial arts and many more (Interviewee D) a large number of people, either local or from other areas, know the park's location and its available facilities. The centre is also used by children who play in the playground regularly. As a result, for many local people and their families, the park is a memorable place. This was also emphasised by the interviewees: "I pass Zam Zam Park everyday to go to work." (M.R.41). Having the advantages of the park in mind, the intentional use of SA2 as a serviceable area has not been developed by local authorities. This is discussed in more detail next.

Picture 9.94: The community centre is a public place located adjacent to the park used by many local residents

Picture 9.95: A large number of people pass the park every day

Picture 9.96: The district municipality has equipped the park with facilities and furniture to create an attractive space for the public

Picture 9.97: Children enjoy playing in the playground of SA2



Picture 9.98: The role of SA2 as a local park has been supported by local residents

Picture 9.99: A combination of natural features and greenery has improved the spatial quality of the park

9.6.6 The Intentional Use of Zam Zam Park and its Conflicts

Although the park is far from the dense residential area of Khazaneh neighbourhood, the size of the park, the quality of its greenery with fewer trees, its location next to two busy roads and the diversity of its facilities which attract a large number of local people, make this park an ideal location for designing and equipping it as a safe and serviceable area in the event of a disaster. This idea requires modifying it, improving its safety standards and reducing the number of vulnerable points in the park. One of the most important elements is to introduce this new function of the park to the residents of the surrounding neighbourhoods. At this stage, it is not clear to people how the park can cope with this ambition: "If the park is capable of being used for safety after earthquake, then people should be informed." (F.R.32).

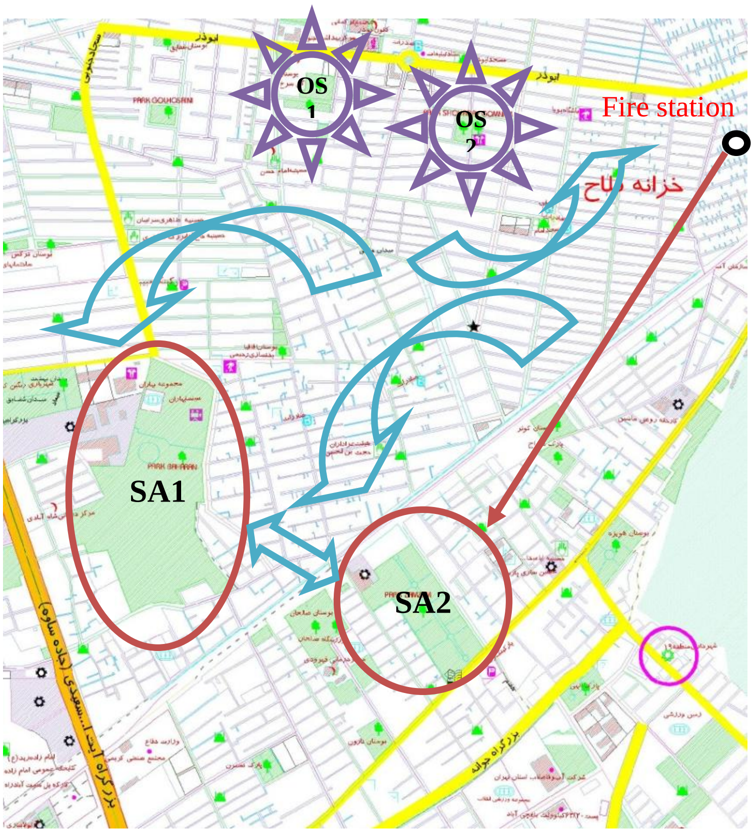


Figure 9.40: The distance between open spaces in Khazaneh neighbourhood makes access to SA2 difficult. There are a large number of people who will seek safety in these spaces

The present communication technique used by the municipality, the police or other local and regional management organisations is one-way and mainly through the press. However, such an important management approach in a disaster situation requires a mutual and long-term communication with local people. The size of the park is not big enough for the whole region, but if it worked together with other proposed spaces, it could be adequate. The followings should be considered for this specific park to make it a serviceable area:

1) The existing public building (the community centre) in SA2 is regularly used by the public. Hence, improving its structural resistance for earthquake and fire damage is important. The building can be used to store essential items such as

food, water and medicine, and also temporarily accommodate the injured. It is not usually used at night, but it has the potential to work as a place of safety.

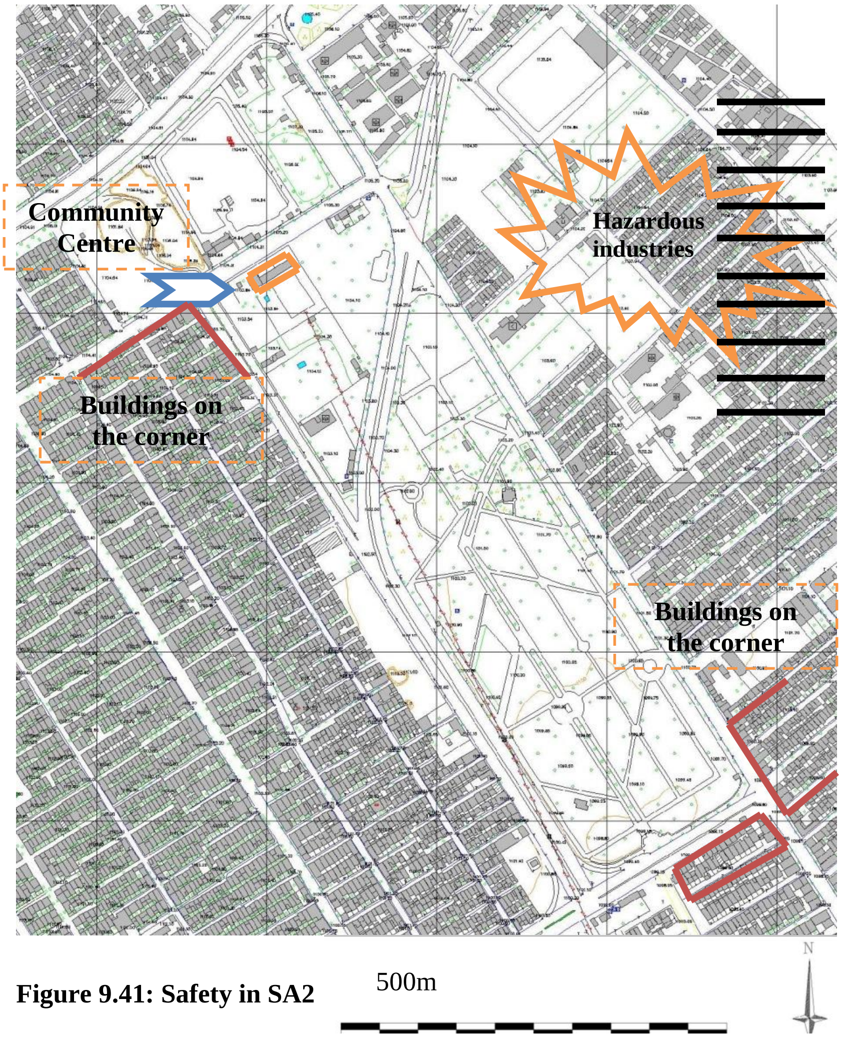
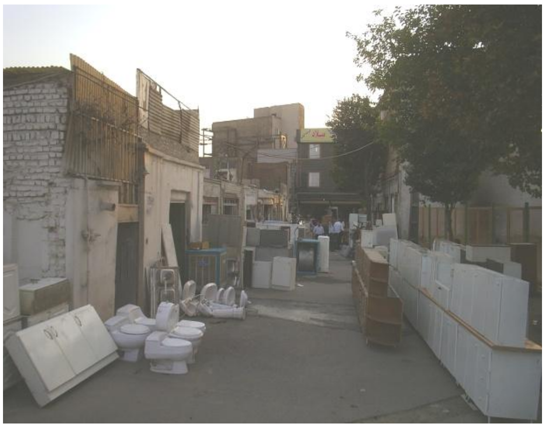


Figure 9.41: Safety in SA2

2) The proximity of the park to some hazardous industries could endanger the park from the perspective of fire spread. Thus, if the park became secure from fire, this would increase the safety of people who were seeking refuge there. Creating a stream designed to enhance the park’s landscaping is an option. The water in the stream could also be used to stop fire spreading.

3) The width of the roads around the park is suitable but problems can be raised when parked cars reduce the usable space of the road. A regular, restrictive traffic management rule should be enacted to increase the possibility of fast communication on the road network around SA2.

Picture 9.100: **The public building in SA2 could be a place of safety in an emergency situation**



Picture 9.101: There is a danger of fire to many buildings around the main roads

Picture 9.102: Roads around SA2 are mainly wide and suitable for fast accessibility. However, the situation is different in residential areas around the park

4) The buildings that are located at the corners of the park should be made safe and resistant to earthquake and fire. Their collapse could seriously compromise disaster rescue operations. Their improvement might not be a cost-effective operation for local authorities as they are mainly owned by private landlords, but in order to increase public safety, these options have to be taken into consideration.

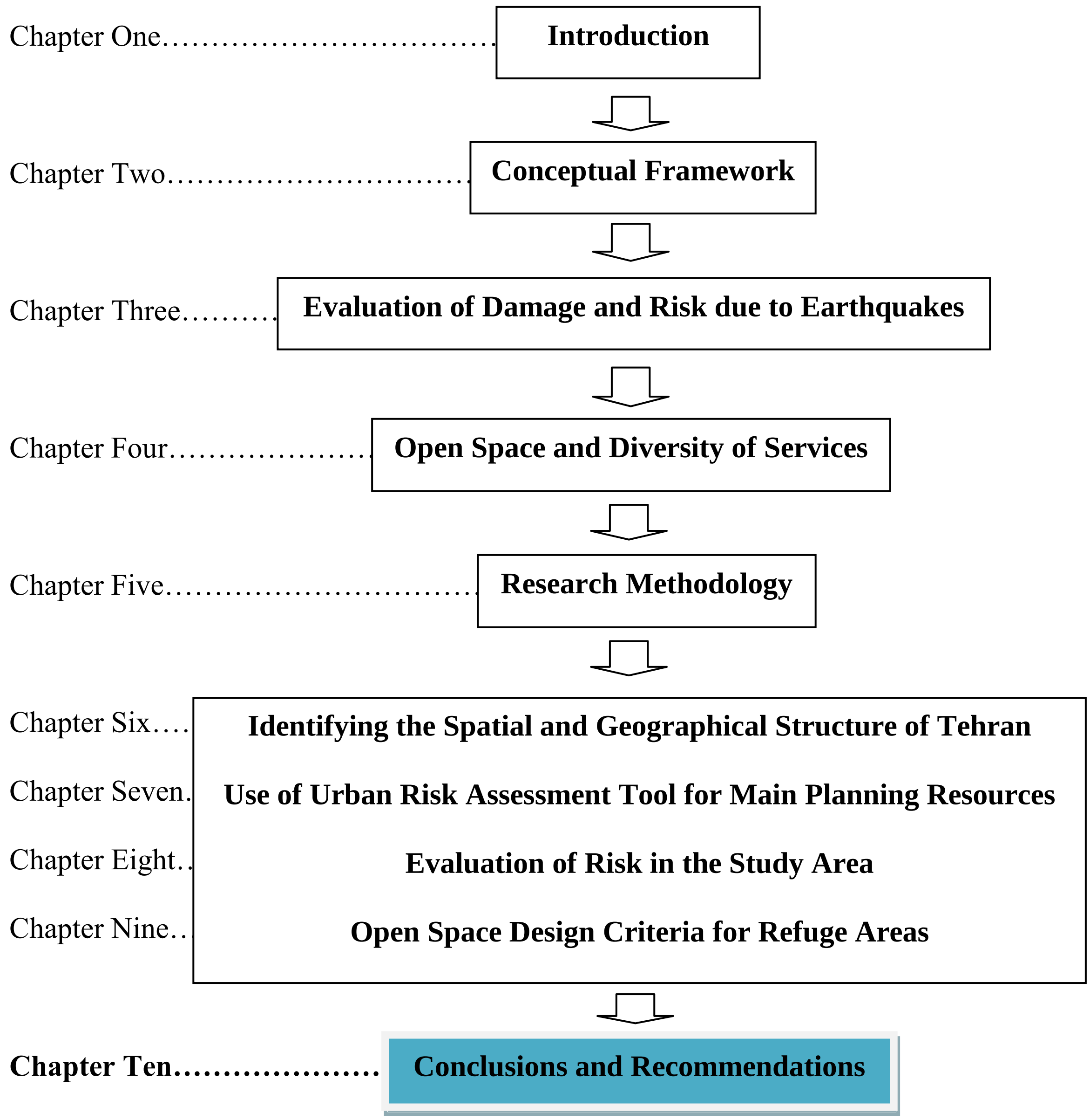
The above discussion gave examples of existing open spaces' advantages and disadvantages physically and socially. The concluding section will summarise all the findings and recommend changes to urban planning in the Iranian urban management system.

Picture 9.103: The spatial features of the surrounding residential area are varied and in many cases, based on previous vulnerability assessments, at risk

Picture 9.104: Buildings that are adjacent to SA2 have to be improved in terms of their resistance to disaster

9.7 Conclusion

This chapter intentionally used the methods and damage estimation tools explained in the case study chapters (7–8) and experienced by others in the literature review chapters (3–5). It was revealed that despite all the efforts made by some organisations, such as building controls, the extent of damage at the neighbourhood level is high; present green space locations might not function properly in the event of a disaster; there are some elements, such as the network of roads, that have to be redesigned urgently; some open spaces can act as safe and serviceable areas with minor improvements, whilst others need fundamental changes. Assessment of the capacity of the four selected open spaces revealed what initial improvements need to be carried out to make those spaces safe and serviceable as disaster refuge areas. The next chapter will conclude the research, bring the whole discussion together and draw recommendations for reorganisation of open spaces and consideration of disaster planning within urban design and management.



Chapter One
Introduction
Chapter Two
Conceptual Framework
Chapter Three
Evaluation of Damage and Risk due to Earthquakes
Chapter Four
Open Space and Diversity of Services
Chapter Five
Research Methodology
Chapter Six
Identifying the Spatial and Geographical Structure of Tehran
Chapter Seven
Use of Urban Risk Assessment Tool for Main Planning Resources
Chapter Eight
Evaluation of Risk in the Study Area
Chapter Nine
Open Space Design Criteria for Refuge Areas
Chapter Ten
Conclusions and Recommendations

10.1 Introduction

This thesis focuses on the need to create greater coordination between planning and disaster management and the capacities of open spaces to help mitigate disasters. Each chapter contributed to the aims of the research, which was to answer the main research question: *How can the gaps that exist between city planning and disaster management be bridged to allow urban spaces to increase urban resilience (the capacity of a city to absorb and adapt to disturbance) by providing safety and serviceability in the place where recovery occurs?* (see section 1.2). The thesis went through three main concepts of disaster, planning and open spaces to create a background base within the literature to facilitate the analysis of the case study and its evaluation. Following this, via fieldwork, direct observation and other methods, the research explicitly studied the case study situation, its vulnerability, the extent of damage to the urban context, and how the present capacity would cope. In this way, the research was able to pinpoint the shortcomings of urban planning and disaster management, and draw some lessons which will be discussed in this chapter. The following diagram (Figure 10.1) is a summary and structure of the concluding chapter's discussion, helping to comprehend the context of the thesis chapters and their connections.

10.2 Research Aim

The vulnerability of Tehran's urban environment to earthquakes has brought the preparedness of the city to the attention of the national and local government. However, the extent to which the city is prepared remains open to debate in terms of both integration and comprehensiveness. This is why the research raised the questions regarding the quality of the resilience of urban open spaces, their capacity, safety and serviceability. The aim of this research is to study and evaluate the different aspects of urban planning and disaster management. In order to answer this question, a series of questions aimed at each element relating to the main section were raised.

The first group of research questions pinpointed the quality of the existing connections amongst urban decision-makers and the plans they propose for the city (Chapters 1–4).

The existing framework for each category of planning (development and master plans), the disaster preparedness plan (under the category of disaster management) and rescue operation training work independently at present. The first chapters of this thesis focused on the interconnections which could promote the quality of urban design in the field of development planning and disaster planning. Furthermore, their accuracy and validity was also discussed.

Open spaces have recently become a common feature of city and disaster planning. They are redesigned and armed with relevant equipment to give service to the city in the event of a disaster. This has been identified as a useful tool in many countries. The research, therefore, aimed to answer the questions in connection with the land-use planning criteria and characteristics. The research also, via the experiences of other countries, developed an understanding and knowledge about the pre-disaster preparedness process. This was derived from the second group of research questions (Chapters 1–4). This opened a new chapter in the open space functionality discussion, which is not familiar to many countries' planning systems. Good examples of a couple of advanced countries, such as Japan, helped to illustrate how multi-functionality and the preparedness of urban spaces can prevent a disaster turning into a catastrophe. In this way, people would enjoy the advantages of having open spaces, giving their traditional service to society, along with the new and important safety that is required in an emergency situation. This also proved to help the organisation of the urban fabric and the promotion of urban environment quality. This, indeed, embedded the open spaces' capacity, connectivity, design and serviceability. Here the third set of questions came into use; they were about the detailed specification of safe open spaces, without getting involved in the rescue operation system.

Group three contained these questions: "What capacity do our open spaces need to have to make them safe and serviceable places? What must the planning authorities do to make an integrated multi-purpose space and act collaboratively?" The diversity of influential elements in making an open space a safe area demanded the study of many aspects of urban life, from characteristics to the extent of damage to the urban built environment. The population, buildings, public services, and road networks to supply lines were some of the subjects studied and evaluated in the case study section.

Therefore, answering this series of questions required a proportionate amount of effort at a local and neighbourhood level. Each section will be exclusively discussed as follows. However it is worth mentioning how conceptualising the assessment method for damage, vulnerability and capacity helped to organise and direct the research context.

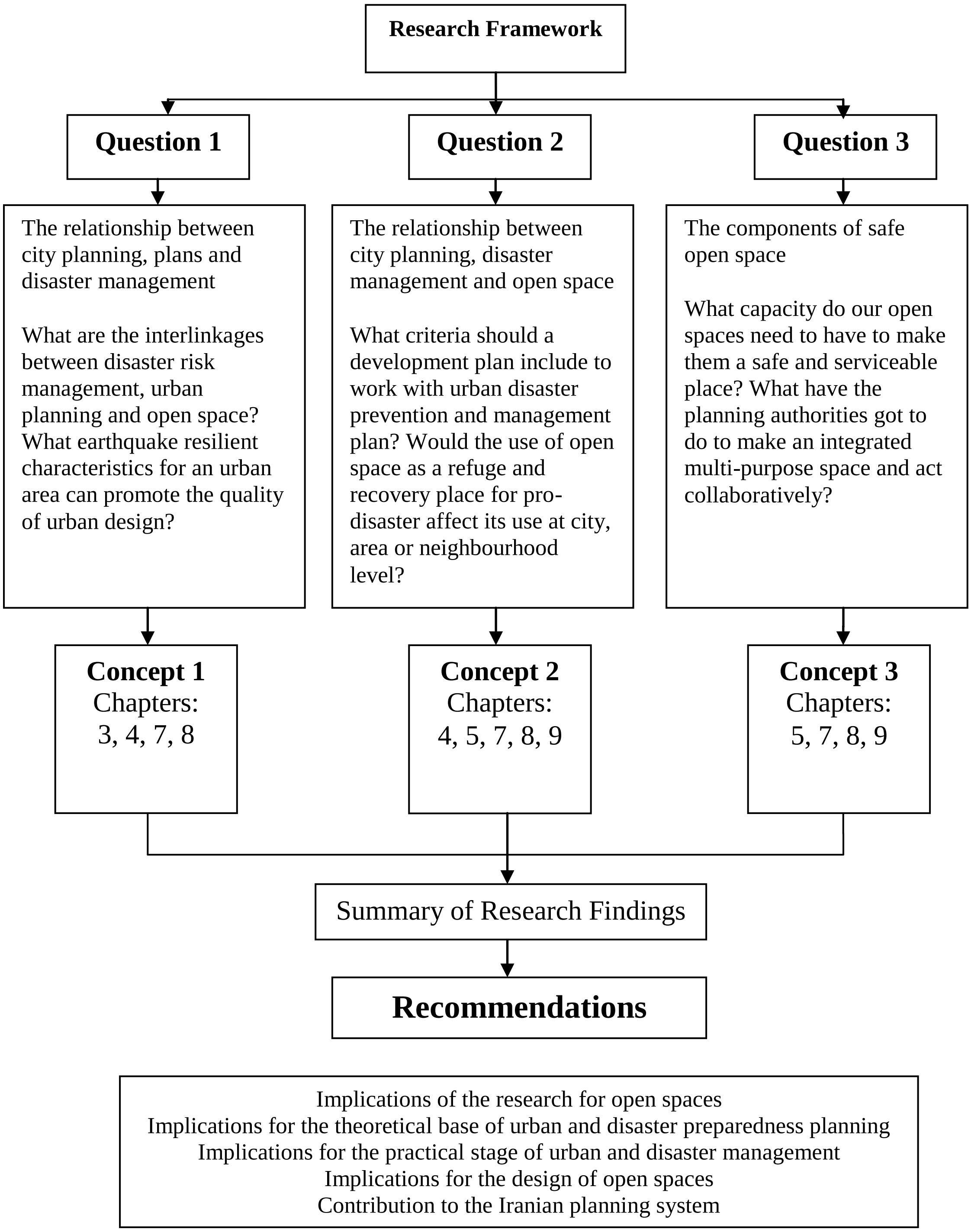


Figure 10.1: The concluding chapter's framework

10.3 Conceptualisation of the Research Aims

The aim of the research, to develop the understanding of the connections between planning and management in the city, disaster preparedness and functionality of the safe open space for vulnerable urban areas, required an analytical tool to help the evaluation and assessment of each element in a scientific and robust manner. In order to narrow the focus of the research, first a number of discourses in the field of disaster risk management were considered. The cycle of disaster, before and after the event, was briefly discussed. This highlighted pre-disaster risk mitigation planning as equally important, or even more important than, the post-disaster rescue and recovery plan. In many people's opinion, reorientation within the disaster management approach is the most effective tool in minimising disaster vulnerability. Thus, the four approaches of being proactive, reducing risk, being participatory and achieving integration have been encouraged as the most contemporary approach in this field. This primarily underpinned the research question's validity and discussion area more generally.

The VCA tool thus became the framework to measure the vulnerability of some urban elements, consisting of the social, physical and environmental aspects of disaster management, urban planning and open spaces as part of the wider urban context, followed by assessment of the capacity that exists within each context. The social and physical analysis includes a wide range of subjects, which can vary according to the main subject. In this research, as the research question clearly indicated, the aim was to analyse the use of open space at a neighbourhood and city level, as a means of safety in the event of an earthquake. Hence, the criteria of the assessment of the vulnerability and capacity of the city were limited to the buildings, roads, population and infrastructure elements.

Out of four vulnerability assessment models studied, the VCA model was chosen as the best tool for this research subject according to the research questions. The discussion regarding the present and most common features of urban development planning as well as disaster reduction planning was reviewed to consider how they work and communicate with each other in theory. This, with the help of the UNDP publication that recommended an integrated vision within the planning system, led the research to the main conceptual framework (Figure 10.2).

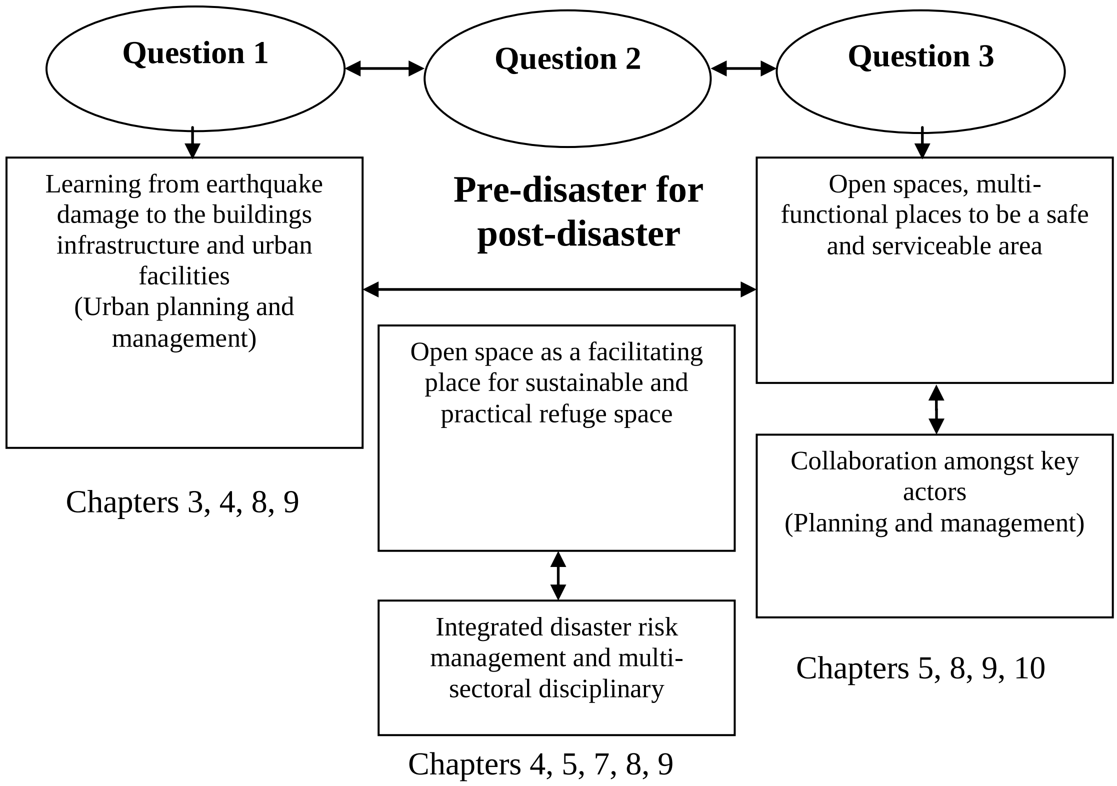


Figure 10.2: Research concepts and chapters

10.4 Conceptualising the Learning Process

The first aim of the research discussion was to identify the interlinkages between disaster management, land-use planning and open spaces. Hence the first conceptual tool was to learn from earthquake damage, management and planning, which consequently would include building, infrastructure and urban facilities. Chapter 3 had a special focus on the most common disaster cause and damage, earthquake intensity classification, building damage assessment methods and structural hazard calculation formulae. This was to fulfil the research aim of studying disaster damage techniques, and also the selection of the most appropriate method for damage estimation in the building and urban life of Tehran, and the case study area later in Chapters 8 and 9. It was learned that:

- Finding an appropriate estimation tool for the evaluation of damage before or after an earthquake (or another form of disaster) is as important as the rescue operation afterwards. There are still many shortcomings in each of the most popular building damage evaluation methods, which make their universal use difficult. Even within their own context, they do not fulfil every aspect of the urban structure.
- After every disaster, the specialist organisations try to learn from the past disaster, lessen their mistakes in post-disaster reactions, and be prepared for the next one. This enhances the process of disaster management. Looking at physical damage, along with other aspects of the society, may reduce the probability of risk. Therefore, failure to reconcile them with each other has reduced the effectiveness of past damage estimation studies.
- Urbanisation should not be the victim but should coexist with the disaster, by being prepared for it, rather than being reactive to its unforeseen consequences.
- The Iranian seismology sector, despite the long history of disaster strikes in the country, has not been able to classify and direct the scattered studies done by researchers and various organisations. That was the main reason, along the extent of the study area, that the researcher chose a simple analytical model for the damage estimation of buildings and other urban features of Tehran and the Khazaneh neighbourhood.

Learning from land-use planning and disaster management policy was the aim of the next chapter. The current structure of urban planning in every field is influenced by the international planning tradition adopted by planning organisations and research groups, adapted to the particular country’s regulations. The main findings of this chapter were:

- Within the field of urban development plans, there has been a longstanding tendency towards a more physical/social, and in some cases economic approach, from an urban planner’s point of view. The nature of cooperation amongst planning authorities is influenced by the bureaucratic system of each country.

- The complexity and individuality of the nature of urban issues has limited the development plan's decisions and impact as well as the diversity of people who have a say in this field.
- Disaster planning has also been considered to become an acceptable form of planning in many countries which have a higher frequency of disasters. The focus of experts in this field has moved from solely a building resistance policy to more of a management approach. Designated open spaces are one of the tools in reducing the impact of disaster.
- There is consensus on the multi-faceted nature of disaster impact on society, meaning greater emphasis on the encouragement of inclusive planning and integrated disaster management. Learning from past disaster plans has led the planning team to seek their place as highly important within the city planning and management process and diverted the frameworks in a plan to be more proactive rather than reactive.
- This chapter also highlights that integrated planning is an aspiration within the field of urban policy, but without the necessary theoretical and practical tools it cannot achieve its goal.

Having the first set of research questions in mind, Chapter 8 aimed to deliver an in-depth study in the assessment of the vulnerability and capacity of the study area in terms of planning documents, the physical environment and social conditions. The chapter revealed:

- How the present proposed development plan of the city and area work independently with no specific interlinkage with the disaster prevention plan and dedicated open spaces.
- That what affected the city's growth in the past was not inspired or influenced by overall disaster reduction requirements. These requirements are part of a greater disaster management and policy.
- That partial promotion of earthquake-resilient requirements, in terms of emergency routes, building standards, and public services cannot cope with the needs of today's city.

- The enforcement of many recent building control restrictions has not improved the quality of older buildings. For that reason, the densest areas are still the most vulnerable ones as they are built by lower-income people mainly before the 1990s.
- Building structures are categorised and inspected by a group of engineers that are not involved in any part of urban development, disaster management or urban planning. This makes the connections between the building industry, building control, city management and disaster policy very weak.
- The building characteristics (residential, commercial or public buildings) of Tehran (including District 17) are influenced by the non-compulsory decisions of some local authorities' recommendations. However, the enforcement of law or recommendations is inconsistent, as each organisation has its own regulations which are not respectful to or valid for others.
- The chapter also examined the public's knowledge regarding disaster planning issues and how they are informed and prepared. This, in line with damage estimation in the study area, showed the shortcomings of the first concept of the thesis, the vulnerability of the existing urban planning and management system to a disaster (illustrated by the lack of designated open urban spaces).

10.5 Pre-Disaster Preparation for the Post-Disaster Event Concept

The second series of questions raised under the research problem was being prepared before the disaster to give a fast and effective service after a disaster. This concept had two sets of criteria to be assessed: 1) The various aspects that preferably should be covered by disaster-related plans; and 2) the possibility of the use of open space as a safe area compromises its usual use. Chapters 4, 7, 8 and 9 attempted to answer the questions by reviewing literature, local documents and studies in the field. Some direct observation also helped to analyse what was not covered in local planning documents. Each chapter contributed by studying some aspects of these two parts from a certain point of view. Chapter 4 answered the questions by looking at policy documents in general terms, in other contexts, and the approaches to utilise the open space for more than one use. Open spaces, as part of city life, play an assortment of roles in creating balance within the urban structure:

- The traditional use of open spaces in different contexts, ranging from a place for social interaction to religious ceremonies.
- Their sustainability under the new urban planning literature was also cited. This gives various responsibilities to an open space in a city derived from its location, surrounding infrastructure, economic condition and available facilities.
- Using open spaces as an emergency safe place: they are/were occasionally used as a refuge area for those who were in danger from a natural disaster. This use has not been practised widely in the most vulnerable countries. Therefore, their design criteria do not include emergency requirements. However, for such countries as Japan, with emergency design consideration, open spaces are part of an integrated planning process which plays multiple roles in the urban fabric.

It was established as difficult (based on the literature of Chapter 4):

- To create a balance between all the functions for which an open space can be designed;
- To break through the tradition of architects' or urban designers' leadership of design teams;
- To give the same level of importance to disaster reduction and safety requirements as to aesthetic parameters of green open space;
- To make urban design an integrated task with disaster preparedness requirements.

The chapter's discussion was used exclusively later on in Chapters 7, 8 and 9, which analysed the case study's open spaces in terms of their use for emergency purposes.

Chapter 4 looked at the research concept question within the planning policy documents in terms of their context and level of engagement of open spaces. The review highlighted that:

- Although, in many advanced countries, an integrated approach to the design and management of urban neighbourhood is an advantage, emergency requirements and disaster mitigation planning is a separate task to be studied, proposed and put into practice by certain organisations which are not necessarily similar to the urban planning team.
- Open spaces (in the form of green space, parks or other urban fabrics) are not at the centre of attention and do not play a dominant role, but are for the fulfilment of certain goals in an urban context.
- The unfamiliarity of planners with disaster preparedness issues has made this subject independent and disconnected within the urban management disaster planning and open space design context.
- However, for many countries, open spaces are parts of a wider integrated disaster plan that works closely with city development plans. This approach has been used effectively to minimise a disaster's impact on urban life.

As the thesis progressed, the imperative to answer the second conceptual question directed the case study chapters. In the light of the main planning documents used for Tehran's development, Chapter 6 identified the urban spatial characteristics of the city from many other aspects. In terms of existing open spaces and disaster management, Chapter 7 discussed the following:

- Urban sprawl has been identified as the main cause of urban growth, whilst also compromising the consideration of adequate services and open space for each neighbourhood.
- Historically Tehran's remarkable natural features, mountains and waterways have been acknowledged. Having traditional gardens at the heart of residential areas is/was one of the local people's best memories.
- There is no record of them being used for giving refuge to people during past earthquakes. The interlinkage between open spaces and parks, as well as disaster planning, is vague, as open spaces' design criteria are simply derived from development plan frameworks.
- Building the city on several active faults did not have any impact on urban planning and open space design criteria. This was discussed exclusively in

Chapter 8 when the vulnerability and capacity of the city was studied. The vertical and horizontal axes of the city that define its skeleton can be studied and improved to work effectively in an emergency situation.

- These axes have formed the main transport routes of the city, facilitating the movement of millions of people every day. Their role in giving access to the people to reach public service locations, safe areas, and be able to get around the city, is important and can make integrated management theory close to a reality.

Chapter 8 discussed the second series of research questions by using the VCA tool. According to the categorisation of the analysis tool, open spaces come under the “physical” section and urban management under the “social” category. The following is the result of the review of local documents and fieldwork in Chapter 8:

- The differences between government agencies’ interpretations of Tehran’s problem have made their priorities different. Each development plan since 1968 has had its own targets and physical development regulations.
- There is consensus amongst all past development plans of the city that there is not enough space in the city to meet the population’s needs.
- The main purposes of open spaces are recreation, public gathering, relaxation, lessening of environmental pollution and the visual improvement of urban areas. None of the available plans, except Tehran’s disaster preparation and mitigation plan, has considered safety criteria for the design of the city’s open spaces. District 17 is a typical urban area of Tehran, trying to bring the physical development of the area under the municipality’s control. Open space design is also part of this process. The municipality, as outlined by the interviewees, has improved the quality of parks within the district over recent decades. There were many constraints in defining the standard of the quality of parks, based on their budget and development plan requirements. However, no one, as officials claimed, included parks under the disaster category.
- The impact of social vulnerability on the design of open space is only mentioned in the paper by the JICA report. This was further supported by the officials’ interviews. A majority of interviewees, in particular from the

municipality, appreciated the new approach towards disaster management in theory and mentioned the involvement of the general public in designated training courses, whilst some (like interviewees from the Seismic Centre of Iran) do not believe in expanding the network of people and organisations in disaster planning. This document does not have any influence on decisions taken by the development plan of District 17 or other master plans.

- Land-use planning is the main technique used by the planners to give direction and impose limitations on the city's growth. The criteria used in calculating the land area are purely population density-based, and density is subject to change when and where the municipality realises it is needed (density bonusing).

The context of Chapter 8 used an in-depth analysis which focused on open space use and damage to buildings. The chapter revealed that:

- The high vulnerability of building structures in many parts of the city makes the risk of building damage and human casualties high.
- There are districts, especially in the southern part of the city, which might face the worst damage. They are, equally, the most deprived areas in terms of building quality, open space quantity and capacity.
- The worst case scenario could happen in the selected study area (District 17). This is due to many conditions, including the number, accessibility to and from, and the size of available open spaces in the district.
- Integrated disaster management means including public services, such as hospitals, schools, fire stations, etc., within the disaster preparedness action plan and rescue operations. The chapter's study highlighted how improving public services may be important.
- The lack of adequate emergency services in the area, whether in terms of number or quality, has seriously undermined public safety. As a result, this chapter, along with the chapters mentioned above, revealed how, in an integrated risk management system, open space can play a role in giving services to vulnerable people after a disaster. This led the research towards answering the third conceptual question, which was to expand the functionality

of an open space beyond its physical traditional use and prepare it for multi-functionality, especially for disaster management.

10.6 Question 3: Open Spaces Multi-Functional Theme

The third series of questions is about the capacity of an open space to be made suitable for an emergency situation. The general categories of safe and serviceable areas are similar to the main themes used for the analysis of open spaces. Having the criteria of creating a safe and serviceable area in mind, the context of Chapters 4, 7, 8 and 9 contributed in expanding this concept from a different point of view and sources.

10.6.1 The Concept of Multi-Functionality in Literature

Chapter 4 explored relevant literature from other countries, known for their advance preparedness, to find out what elements needed to be taken into account, and what they hoped to bring to society. The findings were:

1) Adding new dimensions to the use of open spaces in some contexts requires a longstanding study and experiment in urban design theory and functionality. In disaster-prone zones, legal support and flexible legislation was required. This posed challenges to the research context and urban management governance.
2) The criteria for safe and serviceable areas vary, depending on the context (geographical, physical, environmental, economic, managerial, proximity to the centre of the area, etc.). They may need to be made safe in terms of building damage or from fire.

10.6.2 A Realistic Measurement

One of the points looked at in Chapter 7 was the extent of collaboration between Tehran's local authorities for the creation of a safe open space. The overall findings of the chapter were:

1) The municipality and its district sub-divisions is the main local authority in the urban management field that supplies the city with its road networks, building density, public transport and amenities, public services and green spaces.
2) There are other organisations that have an impact on the city's life.
3) Green spaces are an outcome of land-use planning, to target social, environmental and recreational requirements. They are located within the neighbourhood randomly, and entirely based on the availability of land.

10.6.3 Interpretation of Question 3

While Chapter 8 sought to outline the severity of the damage to the urban area of Tehran, it evaluated the parks' and open spaces' accessibility and quantity.

- The parks are small and distributed unevenly within the neighbourhood. They barely meet local residents' needs for play areas and relaxation.
- The municipality (via a private company) is the only authority maintaining and providing green spaces in the city.

Chapter 9 continued the insight into the multi-functionality of open spaces in the Khazaneh neighbourhood.

- Having the criteria for a safe and serviceable area in mind, the capacity and accessibility of the case study's selected open spaces were studied. They met some of the requirements and could be improved to a certain extent. Some suffered from major deficiencies in size, and there is a possibility of imposing relevant alterations to them to prepare them to become safe areas.
- The total size of open spaces in the neighbourhood is the first vulnerable point.
- This was coupled with narrow roads and an inadequate traffic management system.
- Local authorities in this area, as an example of the whole city, are subordinate to the municipality. In other words, the municipality is the sole authority responsible and has no desire to cooperate with other government departments.

- Acting independently is the general feature of the city's bureaucracy.

10.7 Summary of Research Findings

The research conceptual framework (Chapter 2) played a constructive role in accomplishing the structure of the study, the most relevant subjects for the study and the most appropriate method to analyse the research findings. Figure 10.3, inspired by the context of the chapters, summarises the outline of this section's discussion. Being reactive in disaster management is a longstanding tradition, whilst proactivity in disaster mitigation planning is a fairly new insight. Each chapter discussed part of the planning process.

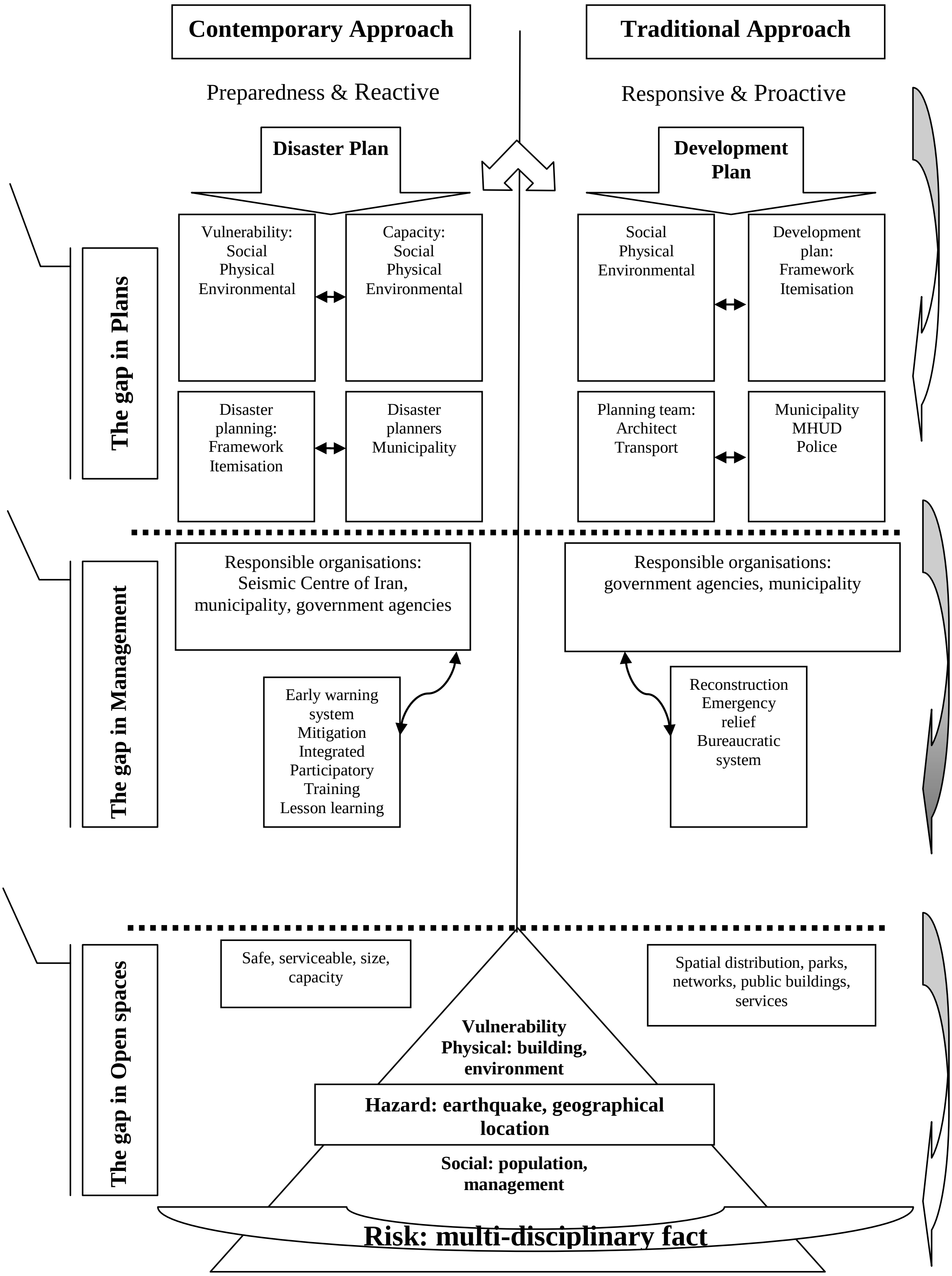


Figure 10.3: Approaches to the recommendation process

10.7.1 The Gap between a Responsive Approach and Proactiveness

The approach in disaster planning and management has developed via an experimental path and trial and error pattern. As many officials claimed, their knowledge has developed through years of confronting disaster. Development of this knowledge has mainly helped to come to the term with rescuing people and providing post-disaster services. Looking at the literature also revealed how scientists improved the techniques to strengthen the built environment quality. This has resulted in an introduction of building and planning disciplines over the years which is more reactive to the problem (in this study, disaster). This reaction (as the research disclosed in Chapters 2, 3, 4 and 8) has been translated into the scientific language in this field, especially the building industry and post-disaster rescue management and recovery (physical, social, economic and emotional). The context of interviews with some of the key players such as engineers supported this claim. The existing facilities and the approach towards disaster research are designed to:

- Respond to disaster quickly and adequately;
- Improve the quality of building construction;
- Rearrange the rescue operation.

But there was less about designing a resilient city to be proactive at different scales starting from the neighbourhood. The culture and knowledge of proactivity in disaster is limited to individual buildings' resilience according to the existing literature review.

Chapter 3, by looking at a wide range of literature, discovered that – despite all the past studies in building damage estimation, for instance before or after a disaster – each method results in many shortcomings in terms of the accuracy of its data, damage estimation and building performance. Obtaining various responses to a similar hazard in different situations makes the physical approach to risk evaluation a malfunctioning theory. This is where other urban features were gradually added to this field and led the approach to preparation for a disaster, not just in terms of physical or spatial capacity, but social, economic and urban planning elements (Chapter 4). This change of approach, which has been developed by international agencies' research and studies, is becoming a new approach to disaster as the literature review section proved, but having an integrated disaster management and plan was not a well-developed approach within the interviewees' bureaucratic culture.

1) In Chapter 4, one of the main findings was the difference between the frameworks of the development plan and disaster plan, and how, by using urban planning regulations, an area might be improved and reorganised to minimise disasters' impacts (land readjustment or landscape planning). The former is part of a plan working closely with the context, its criteria, priorities, the city's capacity and vulnerability; whilst the latter has focused on managing human resources and multi-agency cooperation. Looking at a couple of real examples within the literature, the experiences of Japan have successfully created and improved the open space use within the urban fabric with the purpose of safety and mitigating a disaster's impact. Development plans in general are a combination of proactive and reactive approaches towards urban affairs, as are disaster-related plans. Under the development plan, meeting the city's present or future needs, such as population increase, housing needs or fast networking connections, etc., creates a target for planners. Disaster plans, on the other hand, aim to increase the city's resilience and improve the disaster management mechanism. In other words, being prepared to react accordingly to disaster is part of a bigger picture in the field of disaster planning. But still there are debates (as the review of the literature in this chapter revealed) about what aspects of city life should become proactive to disaster and where urban development plans should stand on this subject; how decisions made for a city or neighbourhood by planning authorities have made, or are going to make, connections with the requirements of a disaster-resilient city. Indeed, it is not a well-developed mode of urban planning in many vulnerable urban contexts to be vigilant to the risk of disaster when development plans are proactively approved. The supportive statements of government officials who participated within the interviews are another witness to the lack of such active connections between these two main categories of planning and management. Officials from the municipality find it difficult to include safety issues and dedicated open spaces under the development plan criteria.

2) The other key issue highlighted in the research chapter was the management system in an urban context, which was analysed in Chapters 4, 8 and 9. Having a rather cooperative management team is a contemporary and proactive approach, as opposed to the leadership of a single authority in a small working team. Hence disaster planning is, to some extent, a new thing and needs a stronger background, and government support, to become a practical plan within a city. Management of the city requires a complex procedure with a strong regulatory requirement. According to interviews, the municipality limits its responsibility to the usual urban affairs and leaves the management of disaster with other organisations that are under the supervision of the province governor (Table 6.2). This network of working relations derives from the hierarchy of each organisation involved within the urban management system, as many participants in the interview believed. Therefore, changing their decision-making arrangements and planning systems requires a deep shake-up in the city's bureaucratic system. This idea also has to be supported by adequate research within both the academic and practical environments. The examples in Chapter 4 from a typical disaster management and mitigation plan showed that the commitment of the local government, with supportive legislation from the central government, is an effective tool in many contexts.

3) The third discussion of the research was around the role of open spaces in an urban context. It was found that the spatial distribution and capacity of green spaces are dictated by land-use plans. They are located in certain areas (especially in countries with unmanageable urban growth) based on their availability. Their use, furthermore, is decided by the municipality. Using them under their normal conditions was quite a familiar idea for the officials during the fieldwork and interviews, but as soon as it was suggested to redesign and reorganise the parks for a new function of safe and serviceable open space for disaster management, they deferred responsibility to a few organisations assigned to disaster-related issues. It was found that preparing an open space to be a safe and/or serviceable place for an emergency situation is a new idea in need of support from various local government agencies and increased public

awareness. The next few paragraphs will present more findings of the research in the three main categories of planning, management and open spaces.

10.7.2 The Gap between the Development Plan and Disaster Planning

The aim of both plans is to give certain services to society while imposing some rules and laws. They are both prepared by a group of planners, ranging from government to the private sector. However, it was learned from the research context that:

1) The main theme of urban development plans (despite their differences in different cities and contexts) is physical improvements, social cohesion and inclusiveness, balanced spatial distribution of services, economic development and prosperity, recreational benefits or decent infrastructure, or a combination of these. Some of these were directly referred to by the officials, whilst others are drawn principally from the literature and set by the research framework. They have to follow certain frameworks which are derived from the country's planning policies. Although the country's past disaster experiences may have a minor effect on the overall structure of urban development plans, there is no complete example of a development plan that has considered every aspect of the disaster mitigation criteria, as the review of California and Kanto's reconstruction plans (Chapter 4) demonstrated. Disaster preparedness and mitigation plans have recently gained attention from the government. The studies conducted by IIEES and the municipality as the most recent classified studies are the two main examples. This is due to the high frequency of disaster strikes and the extent of damage to urban life and the economy (Chapters 2 and 3). Assessing vulnerability and accepting risk as a multi-disciplinary fact has resulted in many studies by international organisations, aid groups and government agencies mainly to estimate the damage to the physical state, economy, population and infrastructure of the region after an earthquake. A large number of recommendations studied and suggested by aid agencies are usually reactive to disasters (Chapter 2).

2) Risk is not only the result of hazard severity. There are other elements that change the probability of the occurrence of the damage such as vulnerability. The physical condition of the given context is the main point of study in many disaster-related plans. However, recently there has been some suggestion to broaden the vulnerability criteria to a more socio-economic-oriented issue. Nevertheless, the emphasis is still on the urban built environment vulnerability and how the physical elements of the city are influenced by building engineering innovation in Iran, as claimed by the interviewees. The failure of the past disaster mitigation and rescue plans has been the foundation of this ideology, but the argument remains around the approaches used for the assessment of vulnerability, as well as capacity for a disaster plan, and the criteria for an integrated development plan. There is hardly any assessment index in common. Looking at the criteria in the social vulnerability assessment tool (Chapter 2) shows how lack of public knowledge about one's environment can put lives in danger or discredit any rescue plan, whilst the same element has a completely different interpretation in the development plan, which is about social exclusion and improvement of cultural confusion. Reviewing the local documents for the case study revealed that the planning documents, despite the influence of social vulnerability within the international and UN publications, have paid less attention to the local public knowledge and participation in disaster mitigation and planning management. This does not necessarily mean they have to see the world from the same point of view. However, creating such diversity from official plans is clearly problematic.

3) Given the differences in the nature of each plan, the teams responsible for the plans are also different. Chapters 4 and 7 contained a more dedicated discussion in this regard. Studying past urban development plans shows how the dominant role of architects within the planning process, after years of trial and error, was gradually replaced by urban planners from a more socially-oriented background. The other change was the involvement of the public sector (the municipality, government organisations) alongside the private sector (landlords, private development firms, cooperatives) and the community (voluntary groups, local residents) in the decision-making process and

sometimes investment in the projects. The diversity and extent of responsibility, and impact on decisions, vary from country to country; however, it has become a team-working activity and an accepted way of decision-making for the government. However, in the disaster planning team, the decision-makers are not the same (Chapter 2, 3 and 4). Examples of planning team members in disaster management, mentioned in the discussion in Chapter 3, clearly point out the key members. Government agencies who usually deal with post-disaster recovery and rescue operations are the main, and sometimes only, bodies which prepare plans. This kind of plan has two disadvantages. First, other organisations' opinions and recommendations make the plans richer in background and more practical. Second, cooperation and team-working increase the practicality of the plan. This has been recognised and supported by the Japanese government (Chapter 4) as the most effective tool so far. Years of master plan experience in Tehran (Chapters 6 and 7) have guided Tehran's development in the past; the presentation tools may have changed due to progress in computer technology. However, the outline of assessment is still around land-use planning. Past experiences have not really changed the master plans' approach, or the basis of decisions (population-based). The development plan framework is dictated by central government, and studied and developed by a private consultancy, under the strict supervision of the MHUD provincial offices and the municipality.

4) The Tehran city disaster mitigation plan is also a new document of its kind (Chapter 8) which has not been able to raise awareness so far. The review of its context also revealed that the lack of fundamental statistical data in the country on building structure, urban infrastructure, the network of roads and public transport, and public buildings, undermines the accuracy of the VCA. There is also no obligatory duty for any governmental or non-governmental organisation to follow the recommendations of the disaster plan. In other words, there is no supporting legislation in the country for such a report.

10.7.3 The Gap between Development Plan Management and Disaster Plan Management

The main purpose of preparing a plan (either development or disaster) is to put it into practice in a given context. For development plans which survive for decades, this is still a challenging issue, as many cities are still controlled and managed by a strong local government which their goal is to achieve their target.

1) For the Iranian municipalities, there are always controversial issues for many reasons (rapid population growth, social and cultural poverty, government organisations' priorities, etc.). These were discussed throughout the interviews and demand an integrated management team (Chapters 7 and 8). The municipality's power over the day to day issues of cities has also always been questioned by other urban authorities. The municipality is supposedly the most powerful body; however, there have always been debates about its involvement in the decision-making process of either of the plans. Having the municipality supported by the city council, as the city's manager for urban development plans, is an accepted mode of practice. The city council has controlling power over the municipality's activities but not necessarily over other local organisations. However, when it comes to disaster planning, the role of the municipality starts to fade away. The provincial governor's office and other organisations have been the responsible bodies who usually act after disasters. Consequently, their activities are focused around reconstruction and emergency relief operations. Even under the Municipality Act, there is no mention of disaster management in the section concerning the municipality's duties (see Chapters 4 and 7). Adding another complicated item to the municipality's duties was not encouraged by some of the interviewees. Furthermore, the idea was thought quite hard to achieve within the present planning and management system. However, the close connection between urban vulnerability and urban development undoubtedly requires an integrated management team with a more active involvement of the municipality.

2) This leads us to the next point made by the research, which is that the city's affairs are not managed in accordance with the disaster plan. Road networks, city infrastructure, distribution of emergency services and hospitals, building regulations and material quality control are all dealt with by various governmental and private organisations. They have hardly any targets in common and work at the local, regional, and national level independently. Bringing every urban activity under the management of a single organisation was not the point of this study. But the idea of a strong team-working and collective decision-making team has been examined by other countries and can be a solution for the new idea of inclusion of disaster planning and management into the municipality's management system. The short review of the case of the Bam reconstruction policy demonstrates how disconnection between the key city service providers puts the lives of people in danger and increases the number of casualties. It was also highlighted that there is no organisation clearly responsible for putting the disaster mitigation recommendations into practice in full. An early warning system, for instance, is a recognised system to prevent disaster damage, but has never been mentioned in any of the planning documents as a tool in the hands of city managers. If the council has to get involved in disaster management, then there should be a major change within the hierarchy of local, regional and national organisations, which is quite an ambitious idea, as almost all the interviewees believed. The role of the Seismic Centre of Iran in Tehran is limited to publishing research findings which have no impact on decisions made by the master plan or the municipality.

3) This all means that, despite it being proven by other countries (such as the Japanese and US national and local governments) that disaster management should be an integrated task, Tehran's disaster management system, alongside urban development planning, is solely a managed bureaucratic system.

10.7.4 The Gap between the Open Space Design Criteria in the Traditional and Contemporary Models

The design of open spaces has not been a controversial issue in urban planning. Creating a space which can fulfil the need for relaxation requirements of residents, e.g. parks, is the traditional goal of open spaces. Their contribution to the improvement of the urban environment is an accepted and well-developed fact. This means that, in general, their position is secondary to the buildings. However, the research, especially in Chapters 5, 8 and 9, discovered the following:

1) Open spaces are part of the structure of townscapes. They are used for a variety of purposes such as physical, symbolic, aesthetic, influencing social interaction, recreational opportunities, cultural manifestations, environmental quality and economic issues. Their interaction with society in the enhancement of urban quality has made them a synonym for parks and green spaces. This is more apparent in an urban context where solid buildings, roads and blocks of flats are the dominating features of a space. It is difficult to design and manage two or more uses in a limited open space without them affecting each other. It is even harder to design and manage the same space to provide adequate service for disaster alongside its usual use. In other words, prioritising these uses is a challenge to the municipality and other organisations. Turning them into a suitable place for safety is beyond development plans' criteria under the municipality's framework.

2) Their quality of presentation and maintenance can effectively change their general picture in the eyes of the public. There were spaces with market and mixed-use activities which brought livelihood and economic attraction to the area. They are not necessarily always green spaces, but also parts of buildings (public or private) that can serve a large number of people.

3) Having to add functions to them in a new design era gives them more responsibility to serve people. Being a safe place in the event of a disaster is a

complicated but necessary choice, which is added to the functions of green spaces in countries such as Japan.

4) Qualifying them as safe and serviceable places requires some complex procedures. They have to be (according to the context in which they are located) fireproof, easily accessible, safe for short- and long-term camping, adequate in size for the number of surrounding residents and other emergency requirements (see Chapters 4 and 9).

5) Adding these specifications to them requires an initial vulnerability analysis, data collection, capacity assessment, hazard identification, and a decision on whether a particular space will be a short-term refuge centre or long-term accommodation. These individual safety elements have to be developed. Working on each of the above elements requires changes within the relevant organisations' frameworks with regards to, for example, whether their building standard is limited to make them safer and less vulnerable to disaster. This can be exemplified by changes in the traffic management of those roads that play a crucial role in connectivity or improving the structure of the buildings which are located in strategic locations.

6) This point was challenged by the context of Chapter 9, when the capacity of selected green spaces was analysed and criticised. The current spatial condition of the surroundings of the selected open spaces in the case study area is in need of major changes in many ways. The roads' width and accessibility, for instance, are major issues which need to be addressed in order to raise the quality of these spaces. As explained, the suggested changes on many occasions are beyond the municipality's responsibility, need revision in the current development plans or building structure standards.

7) It was also learned that raising public awareness and seeking cooperation among government agencies is a key issue in using the spaces, by looking at Tokyo's fireproof safe spaces.

8) The fact that urban spatial obstacles can be removed by legal means (land readjustment) is a good example of imposing changes to the land-use system. It may have been used in other urban development processes, but it is a fairly new method in disaster preparedness. Therefore, using past urban development planning experiences for disaster management would be an advantage for planners. It would be more effective if those two categories of plans worked together as a comprehensive plan for the city. In this way, they would, firstly, reduce the vulnerability level of the urban context; secondly, maximise the current capacity; thirdly, bring planners together and avoid contradictions in plans and working practices.

9) Social involvement is a powerful tool in making this process familiar and in the challenges of preparing the spaces as well as guiding people to use them effectively. The highlights of certain points revealed by the research indicated that there are some sub-points that could expand the chapter's discussion. However, in brief, the research found that adding a new paradigm into the urban design tradition and urban management is a challenging issue, but a possible and necessary task. This leads us to the next section, which concerns recommendations.

10.8 Implications of the Research for Safe Open Spaces

The context of the thesis chapters gradually built upon the three angles of disaster, open space and planning (Figure 1.2). In each context, the approaches to planning with disaster recovery interests were studied. The multi-aspect nature of disaster planning was explored, not as a new paradigm, but as an underdeveloped ideology in need of improvement. The research question asked, "*How can urban open spaces influence urban resilience (the capacity of the city to absorb and adapt to disturbance) by providing safety and serviceability in a place where recovery happens?*"

Within the disconnected world of urban development and disaster planning, this research tried to make connections by looking at their frameworks, approaches and managerial aspects. This research tried to position these two categories of plans next to each other from a planner's point of view. Within the academic literature, this research developed a fairly new insight into the urban planning context, welcoming the engineering-dominated world of disaster planning and management whilst greeting the social pathology of disaster mitigation. In fact, open spaces were used as an instance of how urban elements can be improved to play their roles in increasing the capacity of city for a disaster. These are the recommendations made by the research:

Table 10.1: The simplified research findings of each chapter

Chapter	Conceptual Question series	Findings
1	**Questions 1, 2, 3**	–There are many elements in the field of disaster planning which are not developed enough –The risk of disaster occurring in Iranian cities should be considered by planning authorities
2	**Questions 1, 2, 3**	–The challenges facing governments in producing an integrated disaster preparedness plan –Being proactive instead of reactive to the problems –Lack of common ground for all kinds of natural and man-made risk –Risk is a combination of hazard, vulnerability and capacity
3	**Question 1**	–Physical approach to disaster –Improvement of seismologic knowledge, legislation and material –Building industry revolution –Damage estimation techniques –Hazard prediction tools
4	**Questions 1, 2, 3**	–Urban development plans: a social, physical, economic, and environmental task –Disaster planning, an independent study process conducted by certain actors, not in common with the urban planning team
5	**Main research questions**	–Summary of the research method in analysing the data, literature and other information obtained
6	**Question 2**	–Identifying the structure of Tehran –Natural and physical characteristics of the city –Historical development of the city
7	**Questions 1, 2, 3**	–The capacity and vulnerability of the city in terms of general public services and open spaces –The population density and demographic changes of different districts –Analysis of the city's social and physical vulnerability –The management of urban affairs in the study area is malfunctioning
8	**Questions 1, 2, 3**	–Building industry is not controlled and managed properly –Building damage is the main cause of human casualties –Urban services (roads and transportation, emergency teams, open spaces, etc.) have direct impact on the extent of damage to urban life
9	**Question 3**	–Open spaces' function is rather broad –Adding safety and serviceability to the open spaces is useful for the area –Making the open space a safe place is a multi-sectoral task

10.8.1 Implications for the Theoretical-Base of Urban Planning[36]

Although the ideas recommended in this section may not be original, the research (via the literature review and appraisal of local documents) re-examined the necessity and possibility of integrated planning from the early stages of data collection for an area vulnerable to hazards. This developed through restating the current structural framework of urban development plans and disaster mitigation plans. These are the underlying recommendations and possible objectives of a typical mixed development and disaster plan:

1) Urban development plans are a set of guided plans which are part of the cycle of urban adaptation to disaster. Therefore, in order to be connected, they have to be reflected in the development of the disaster preparedness plan.

2) The data collection stage needs to be expanded from a demographic and social assessment tool to a VCA stage which considers a detailed study of, for example, the population, which would consist of information regarding their ages, the condition of their health, disabilities, and general knowledge about the area. The building study should go further than the land occupancy percentage or density study. A detailed study of building types, structure, vulnerability and possible damage has to be added to the general framework of a typical development plan.

3) Risk reduction in buildings, road networking design, land-use planning, population density and distribution, hazardous building and industry location, and ecological and geographical vulnerability assessment are some of the new chapters that should be added on top of the traditional development planning or land-zoning plans in areas at risk.

4) It is also recommended that the culture of being proactive as opposed to reactive within the field of disaster mitigation planning is vital. It is a

[36] “Urban planning” in the following paragraphs means urban development plans and disaster plans.

proven fact by many scholars that human loss and economic damage is higher in a context with no prepared background.

5) Disaster resilience structure does not necessarily mean no damage or total immunity but less vulnerability and more flexibility. Building a solid structure with complete immunity in an urban context is an impossible idea for a city with a population of millions. However, improving the physical resilience of the city through a strict building code, density proposals, road accessibility improvements and physical capacity improvement are key as part of any new development plan.

6) Reducing man-made vulnerability, whether it is physical, social, economic or environmental, has to become the basis of a new design approach in the hands of decision-makers. It has three general stages, which are: adaptive strategies, good practice and a relief/recovery mechanism.

7) The progressive planning system is a lesson-learning mechanism that requires the courage to learn from the past, others' experiences, failed research, etc. Therefore, the process of selecting an appropriate framework for a development and disaster plan is as follows: identifying the right framework for the socio-physical conditions of the context, carrying out a diverse and comprehensive analysis of vulnerability and capacity in every aspect, identifying the main participative stakeholders, planning for complex situations, and being descriptive and analytical in a flexible and multi-approach design which is reliable and adaptive enough for future alterations.

8) Urban development plans have evolved, from originally being a single approach to urban problems, to integrated and multi-approach planning. A similar scenario is present within the field of disaster preparation planning. Creating the link between these two categories of planning, and considering them simultaneously, is what this research strongly recommends.

10.8.2 Implications for the Practical Stages of Urban Management

In the field of planning, arriving at a decent, considered plan is as important as putting it into practice effectively. Planning management has, or in other words must have, three sets of people, preferably independent but connected; first, the early stage decision-makers who are responsible for setting and preparing the plan; second, those who put the plan into practice in a real context; and third, those who observe the process in general and review its failures and achievements. It is recommended that:

1) Although there are differences between the requirements of every planning context, creating a sense of cooperation and exchange of knowledge between town planners, architects, economists, emergency personnel, civil and structure engineers, etc., has a positive impact on the plan to be more realistic, practical and integrated. Having in mind the priorities of each group of people who play a part in this process, it is necessary to produce a plan that can be beneficial to society in every aspect and be cost-effective.

2) Urban governance should mean more than just regeneration or development planning and practice processes. It has to include planners and engineers from a disaster management team. The urban society starts from the past and looks at the future, which might be a period of disaster. Thus, emergency planning and management should become part of its routine. As has been repeated throughout the research chapters, disaster planning is a multi-aspect activity and so is its management. Changing the attitude of the government from being reactive to disasters and focusing on emergency relief and recovery to being proactive and prepared for the emergency situations should produce changes in the nature of urban management.

3) In theory, risk is an equation of vulnerability, hazard, and capacity. In the managerial phase capacity is not only government’s preparedness but society’s, including that of individual citizens. Residents of each area are the prime target of every rescue effort. For that reason, it is essential to have them involved in the decision-making process, informed of available services, trained to be

responsible and active, and enthusiastically involved in the preparation and hazard mitigation process.

4) Various government organisations need to set their goals in urban and disaster planning using common ground, avoiding contradictions, and maximising their supporting actions in this field. Public health organisations, the police, the fire brigade, schools, road and public transport companies, etc., are some of the main governmental and non-governmental organisations that can increase or reduce the impact of any natural or man-made disaster. Their cooperation and exchange of opinion is highly recommended. The municipality leads urban development planning and should conduct disaster planning and practice also. This has to be strengthened internally and externally. The municipality's staff knowledge and capacity has to be improved, as well as their team-working capability.

5) An in-depth and constructive review of each government organisation's bureaucratic system is a step forward in improving the quality of urban management in general.

10.8.3 Implication for the Design of Open Spaces

Open space design has not been of importance in comparison to many other urban features, such as roads, fire stations or even hazardous industries. This thesis looked at the most common pattern of open spaces in the field of urban design. For many years, open spaces have been places for relaxation, leisure, play, events, social interaction, economic activities or monuments. However, in a new era with a new approach, open spaces are recommended to serve society in various ways:

1) Open spaces are good places to be safe and serviceable. They have to offer safety to people in the event of a disaster. There are recommended to be no physical obstacles or major building structures located in them which might be dangerous to the refugees. They should also prevent fire spreading by not containing objects that could catch fire quickly. Surrounding the space with

waterways is another way of preventing the spread of fire. Emergency supplies such as first aid equipment, drinking water, temporary shelter, and other short- or long-term equipment are some of the items that should be placed in an appointed open space.

2) One of the points that should be considered in the design of safe open spaces is accessibility to and from them. The width, length and quality of accessible routes, and consideration of traffic congestion and signposting, are as important as having less vulnerable buildings or other objects that will not block access on nearby roads. Helicopter and air access is also important for the distribution of medicine, food and other necessary items. Therefore, the selected open spaces need to have emergency landing facilities or availability.

3) The capacity of the appointed open spaces for post-disaster events has to be calculated to serve local residents. Land readjustment has been proven to be an effective tool in the hands of planning authorities to increase open spaces' capacity, to straighten roads and relocate hazardous facilities. There are similar regulations in every country's planning system, but not for disaster planning purposes. It is recommended that adapting such efficient legal support may be necessary if an open space is to become a safe place.

4) The open space design position should be promoted, from a green space which is only for the fulfilment of common social and traditional needs, to the city infrastructure category, which is more integrated with other urban elements and is based on every given context.

10.9 Contribution to the Iranian Planning System

As the literature review and analysis of local documents in the case study chapters revealed, the Iranian urban planning system is not even at an international standard level. Definitions, such as integrated planning, multi-sectoral planning, team-working, and even disaster preparedness planning, are, to some extent, new and premature definitions and experiences. Having all of the above discussions in mind, the following are highlights of the researcher's recommendations:

1) The Iranian planning system should change from a single-focus to a multi-approach plan. Land-use planning is no longer an effective way of dealing with urban issues, as society consists of different people, economic activities, natural features, cultural backgrounds and disaster possibilities.

2) In order to break through this longstanding tradition, it is recommended that the government (central and local) impose some changes on the planning frameworks, the bureaucratic system and management conventions.

3) With an urban planning and disaster management team in place, the city should be controlled, managed and run by a team of governmental organisations, local residents' representatives and voluntary groups who have expertise in this field.

4) Improvement of government authorities', private consultants' and citizens' awareness and knowledge about urban affairs and disaster risks is also important. This in turn can lead to better planning recommendations and lower disaster damage.

5) The criteria for the design of an open space have to change. The change needs to be in accordance with neighbourhood, district, regional and national requirements. Open spaces should be considered as multi-functional places.

6) The future of the city has to be in the hands of those who have knowledge and expertise about urban planning, disaster planning objectives, and society in general.

Many of the recommendations proposed in this section are similar to those stated in previous sections (general recommendations).

10.10 Evaluation of the Research

The research used a variety of methods to enrich its context and validate the debate. There were elements in academic literature and practical experience of disaster planning that were hard to obtain – for example, due to lack of a version in English,[37] or only published in the form of a final report.[38] This gap was fulfilled by my own observations and interviews. Having this in mind, adding some mathematical calculation to the evaluation of roads, open spaces and damage to certain selected buildings could enrich the technical aspects of the research. This is a time-consuming method which requires working with specialised software. However, I learned lessons from every piece of the literature I went through from the moment the research started to every single interview I did with local residents. The learning process was built upon academic literature, continued through fieldwork and direct observation and still continued through to the analytical stage. Specifically, I learned that the disaster mitigation process is a multi-sectoral issue which requires multi-agency cooperation within the social capacity of a given context.

10.11 Future Research

As a fairly new approach within the planning field, which has only been used by a number of countries, the integration of disaster planning with urban design has a debatable but bright future. This research only focused on the use of open spaces as safe and serviceable places in the event of a disaster. There were many aspects, such as elderly and disabled access, or the replacement of emergency services in the selected sites, that the research did not focus on. There are also facets of planning criteria and theory which can be added to the traditional/semi-contemporary planning system that the thesis omitted. These points, and many other ideas, can be used for further study by other researchers in urban design.

[37] Many articles were in Japanese, as Japan has extensive research in disaster planning issues.
[38] Only the final version of the JICA (2000) report, without the background data, was available to me.

Appendix 1

Questionnaire for Government Officers

What is your position?

How long have you been working in this position?

What is your main duty?

Do you attend decision-making meetings inter-organisation or external meetings?

What do you know about disaster-related policies in your organisation?

Is your organisation involved in any disaster-related issues?

Have you heard of the "Tehran Disaster Mitigation and Management Plan"?

Do you consider Tehran to be a safe place for any kind of disaster?

Which aspects of city's management/planning/spatial features should be improved to make city resilient to disaster?

What do you think about using open spaces as safe and serviceable places for port-disaster events?

Which organisations should improve their capacity and in which areas?

You may add any comment regarding disaster management and the role of open spaces at the end.

Appendix 2

Questionnaire for General Public

Group 1: General Demographic Information

How old are you? 1-18☐ 19-25 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☐ 56-65 ☐ 65-over ☐

Your sex? Male ☐ Female ☐

How many people do you have in your household? 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 and over ☐

Do you have disabled or elderly people living with you? Yes ☐ No ☐

Are you? Home owner ☐ Tenant ☐ Homeless☐

Living with parents or family member☐ Social housing ☐ Temporary☐

Is your home? A flat ☐ A house ☐

How old is your house? (approximate) 0-5 ☐ 5-10 ☐ 11-20 ☐ 20-30☐ Over 30 ☐

How long have you lived in the area? 0-2 years☐ 2-5 years☐ 5-10 years☐

10-25 years☐ over 25 years ☐

Group 2: Main Economic Activities

What is your employment status? Work ☐ Student ☐ Unemployed ☐

What is your qualification? Writing & reading☐ Did not finish school☐

Diploma ☐ College☐ Bachelor ☐ Master or over ☐

If you work, do you work locally or travel to work?

Work locally ☐ Go to work ☐ Travel to here to work ☐ None ☐

Group 3: General Knowledge about the Area You Live and Work in

What is your house structure? Brick ☐ Steel &Brick ☐ Concrete ☐
A combination of the above ☐

Do you use your local: Hospital ☐ Schools ☐ Municipality ☐

Library ☐ Community Centre ☐ Shops ☐ Parks ☐ Sport facilities ☐

Do you use the park near your home? Yes ☐ No ☐

How often do you go to the park? Daily ☐ Weekly ☐ Not often ☐
Never ☐ Fortnightly ☐ Monthly ☐

Do you know your area very well, for example how to get to the doctor's clinic?
Yes ☐ No ☐ Park Yes ☐ No ☐ Motorway Yes ☐ No ☐

Where do you park your car? No car ☐ On-street ☐ In the garage ☐

How wide is the street that you live in? 4m or under ☐ 4-6m ☐
6-10m ☐ 10-16m ☐ 16-24m ☐ 24m or over ☐

How do you travel to work? Bus ☐ Metro ☐ Train ☐ Car ☐
Taxi ☐ Walk ☐ Bike ☐

Is your local road busy with traffic? Yes ☐ No ☐ Only in rush hour ☐

How far do you travel to get to work, school, shops, socialising or using the public facilities? 0-0.5km ☐ 0.5-1.5km ☐ 1.5-5km ☐ 5-20km ☐ over 20km ☐

What park do you go to for relaxation purposes?

Do you know where the main high schools, police stations or fire station are?

What do you think about the park's facilities?

Do you know how to get to your nearest open space?

How many of the parks in your area do you know and where they are?

Group 4: Community Rescue

Have you ever experienced a natural disaster? Yes ☐ No ☐

If yes, what was that? Earthquake ☐ Flood ☐ Hurricane ☐ Famine ☐ Tsunami ☐ Drought ☐

Do you know if your building would survive the earthquake shake? Yes ☐ No ☐

Do you or anyone in your household know what to do in the event of an earthquake? Yes ☐ No ☐

Have you had any of this training? First Aid ☐ Rescue operations ☐ Safety procedures ☐

Have you heard about any disaster mitigation and management study and plan by the municipality or any other organisations?

Who do you think is responsible body in a disaster situation? (You may mark more than one) Municipality ☐ Council ☐ Provincial governor ☐ Red Crescent ☐ Police ☐ Fire brigade ☐ Hospitals ☐

What do you think is the relation between earthquake and parks?

What do you think about parks being used for rescue operations?

Have you ever been approached by local government for disaster management or training?

Has anyone visited your building to assess its earthquake vulnerability?

Do you attend training sessions to learn how to cope in the event of an earthquake?

What are the most vulnerable elements of your area? House ☐ Road ☐
Public buildings☐ Roads ☐ Government management☐

Will you contribute financially if you are asked to improve your building's structural resistance? Yes☐ No☐ Don't know ☐

With the help of government ☐

Did you use engineers to build your house? Yes ☐ No ☐

If yes at what stage?

Do you think it is a good idea to equip parks for emergency situations?

Yes☐ No ☐

If yes, with what equipment?

How do you contribute towards mitigating disaster impact? (add any idea)

By taking lessons and training ☐ By financial involvement☐ By improving my house's structural resistance ☐ It is not my duty ☐

How would you like to be involved in disaster management?

Have you heard of the "Tehran Disaster Mitigation and Management Plan"?

Yes☐ No ☐

Have you heard of the "District 17 Development Plan"? Yes ☐ No☐

Do you know any of the following objects' locations in your neighbourhood?

Gas main ☐ Public telephone☐ Fire hydrant ☐

Do you expect to experience an earthquake in Tehran in the near future?

If yes, what do you have to do before the earthquake?

If yes, what do you have to do during the earthquake?

If yes, what do you have to do after the earthquake?

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