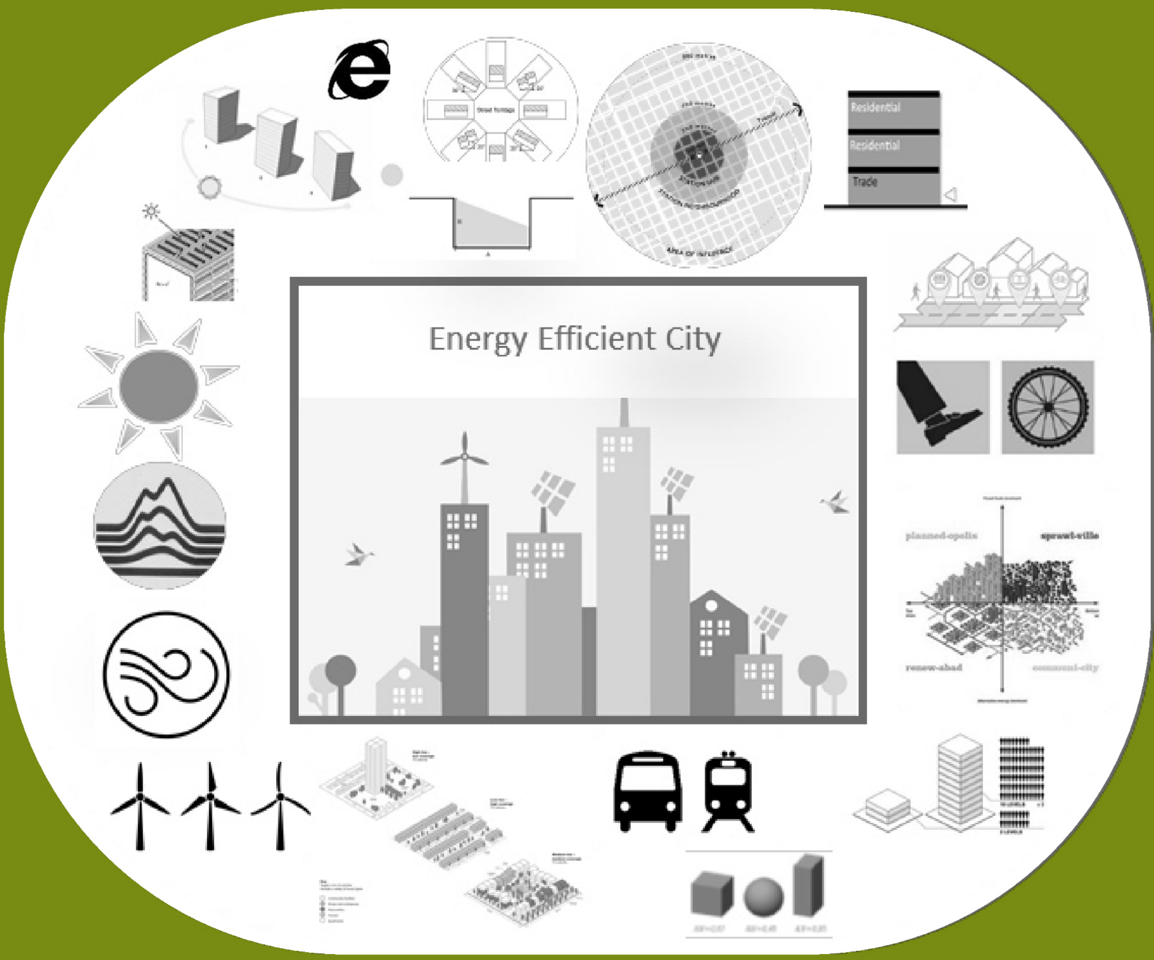
Energy Efficiency and Design Measures in Social Infrastructure Planning (the Case of Tehran)



A Ph.D research by Peyman Khodabakhsh
Technical University of Berlin – TU BERLIN

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Energy Efficiency and Design Measures in Social Infrastructure Planning
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vorgelegt von
M.Sc.
Peyman Khodabakhsh
geb. in Teheran

von der Fakultät VI Planen Bauen Umwelt
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Promotionsausschuss:

Vorsitzender: Prof. Dr. phil. Gabi Dolff-Bonekämper
Gutachterin: Prof. Elke Pahl-Weber
Gutachter: Prof. Dr.-Ing. Wolfgang Dickhaut

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Abstract

Given the robust trends towards global urbanization propensity, the energy and sustainability challenges cannot be addressed without explicit consideration of urban energy systems and their specific challenges and opportunities. A considerable amount of energy waste in the building and transport sector comes about due to inefficient development patterns as well as consumption habits. Towards steering an energy efficiency transformation in cities, it is thus crucial to develop policies, strategies and measures to improve efficiency in these sectors. Hence, not only physical but also climatic as well as socio-economic characteristics should be taken into account in development of energy efficient urban areas. The respective urban development factors - besides technological applications and organizational readiness - can support better energy performance of cities.

In this respect, the present research emphasizes on identifying energy efficiency and design measures together with their integration in local urban development practices. As the focus of this study is oriented towards Social Infrastructure (SI), the findings are concentrated on and modified for planning and provision of SIs. Furthermore, besides spatial dimensions, the research briefly illustrates the recent technological transformation by analysing the possibilities and fundamental dimensions to enhance the electronic service delivery of SIs.

In terms of methodology, the research investigates relevant theoretical knowledge in urban sustainability and energy efficiency and develops a comprehensive set of spatial planning and design measures to be analysed in the case study (District 22 of Tehran-Iran). The methods used to examine the local context are diverse and include: via desk research, field observations and interviews with local actors. Qualitative and quantitative analysis are utilized in the case study aiming at generating strategies and deriving recommendations for the integration of the spatial energy efficiency and design measures in planning for SIs. This is accompanied by the provision of a checklist of energy efficiency and design measures and their application in the urban planning process.

Key words: Urban energy efficiency, social infrastructure, e-services, spatial planning & design measures, smart cities

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CHAPTER 1

Problem statement and research methodology

Chapter 1 demonstrates an introductory overview on the general field of interest as well as the focus areas within this research. It provides a background of the problem and identifies the main gaps in the knowledge and the need for the study. To this background, research aim, primary research questions, research added value as well as research methodology and design are presented in detail.

Chapter 1. Problem statement and research methodology

1.1 Introduction

Given the robust trends toward a convergence of much of the developing world to levels of urbanization already found in the developed world, the energy and sustainability challenges cannot be addressed without explicit consideration of urban energy systems and their specific sustainability challenges and opportunities. Energy sources are largely consumed by the population in urban areas with a considerable amount of energy waste in the building and transport sector comes about due to inefficient development patterns as well as consumption habits. These two sectors are the ones with the greatest share of energy consumption in Iran and worldwide. From an urban development perspective and towards steering an energy efficiency transformation, it is thus crucial to develop policies, strategies and measures to improve efficiency in these two sectors. A bulk of measures have different impacts on sustainability and energy consumption of cities. Hence, not only physical but also socio-economic as well as local climate characteristics should be taken into account in development of urban areas. The spatial urban development factors - besides appropriate technological applications as well as organizational readiness - can support better energy performance of cities. Here, the triangle of planning & design measures, together with regulation and organizational factors, if being appropriately integrated, can multiply the impact. In other words, most energy efficiency and environmental targets in urban areas will not be achieved, unless an appropriate and integrated ecosystem is in place to evenly develop the abovementioned factors.

Many urban development and planning systems such as the Iranian one are considerably affected by centralized, comprehensive and traditional planning mechanisms, which put no priority on environmental and energy considerations. While new strategic planning approaches have been tested recently, an integrated planning system is still missing; one which systematically integrates environmental and energy criteria, actors and instruments together. In this respect, the present research emphasizes on integrating energy efficiency considerations in local urban development practices. Specifically, it aims at identifying current gaps in planning & design measures and analysing the possibility of delivering recommendations to amend the process in urban development plans (i.e. comprehensive and detailed plans). As the main focus of this study is oriented towards Social Infrastructure (SI), the findings are concentrated on and modified for planning and provision of SIs. From another perspective, technological advances have become an integrated part of all types of developments. The emersion of ICT and its application in urban area are not an independent issue from urban planning any longer. The current research targets this technological transformation besides spatial dimensions, and briefly analyzes the possibilities and fundamental dimensions to enhance the electronic service delivery of SIs.

In terms of methodology, the research investigates relevant theoretical knowledge in urban sustainability and energy efficiency and develops a comprehensive set of spatial planning and design measures to be analysed in the case study (District 22 of Tehran-Iran). The local energy related figures are surveyed in line with current practical procedures & bottlenecks in the local planning context. The methods used to examine the local context are diverse and include: via desk research, field observations and interviews with local actors. The information and data so obtained are analysed and conceptualized for the generation of thematic and abstract categories as a means to explain the phenomenon under study. Qualitative and quantitative analysis are utilized in the case study aiming at generating strategies and deriving recommendations for the integration of the spatial energy efficiency and design measures in planning for social infrastructures. This is accompanied by the provision of a checklist of energy efficiency planning and design measures and their application in the urban planning process. Besides planning and design measures, a crucial factor is deep knowledge about the organizational and regulatory dimensions of local urban development (i.e. including the structure of actors as well as the relevant planning and legal instruments). The research elucidates illustrative cases (District 22 of Tehran metropolitan area) on the current status and potential impact of the new planning & design measures on energy performance in the local context. Strategic measures and recommendations will be proposed with the potential of transferability and application in similar contexts.

1.2 Research focus area

Energy is essential for human development and urban energy systems are a crucial entry point for addressing the most pressing global challenges of the twenty-first century. These challenges include sustainable economic and social development, poverty eradication, adequate food production and food security, universal health provision, climate protection, conservation of ecosystems, peace and security. Yet, more than a decade into the twenty-first century, current energy systems do not meet most of these global challenges. A major transformation is therefore required in many dimensions of human life to address these challenges and to avoid potentially catastrophic future consequences for human and planetary systems (GEA, 2012).

With cities accounting for half of the world's population today, and two-thirds of global energy demand, urbanization is exacting a serious pressure on the environment. If rapid urban growth continues, energy use in cities and associated levels of greenhouse gas (GHG) emissions are projected to continue unabated. Current projections indicate that approximately 70 percent of the world's population will live in cities by 2050, producing around 80 percent of the world's GHG emissions. Most of this urban growth will take place in developing countries, where the vast majority of people remain underserved by basic infrastructure services and where city authorities are under-resourced to shift current trajectories (GEA, 2012).

The developing regions of Africa and Asia are where the most rapid urbanization is taking place, and they are least able to cope with the uncertainties and extremities of climate impacts. The development and mainstreaming of energy-efficient and low-carbon urban pathways, which curtail climate impacts without hampering the urban development agenda, are thus essential to meeting such challenges (K. Bose, 2010). Within this complex system, knowing, analysing and integrating the energy drivers and efficiency measures is crucial towards controlling, mitigating and optimizing energy performance levels in the urban context. The impetus for transformative changes in the energy system, however, may not be internally generated. This is mostly due to institutional inertia, incumbency and lack of capacity of existing organizations to respond effectively to changing conditions. In such situations clear and consistent external policy signals may be required to initiate and sustain the transformative change needed (GEA, 2012).

Urban planning and design can improve the energy performance of the built environment to a considerable extent. It does that by configuring the form and functional features of cities. This include measures, which impact on reducing demand for energy both in building and transport sector (as the largest energy end-consuming sectors in cities). To this background, several research and pilot activities have been carried out with the focus on improving energy efficiency in residential sector. These endeavours provide solutions in terms of spatial planning, technological as well as behavioural improvement with the aim of reducing energy demand and optimizing energy consumption in the residential sector. However, less attention is paid to explore the interaction of social infrastructure planning and energy efficiency in cities.

Social and community infrastructure and services are provided in response to the needs of communities. They enhance the quality of life, equity, law and order, stability and social wellbeing. Infrastructure as well as social infrastructure is assumed to explicitly impact energy consumption levels, insofar as consumers, urban built spaces and urban mobility are directly involved. A considerable amount of energy is being consumed in different sectors, which directly and indirectly are connected to social infrastructure (namely; heating and cooling spaces, mobility and access to these services etc.). Although social infrastructures occupy less space and land in comparison to residential built areas, they still generate a considerable amount of energy demand in urban areas. Their impact on energy demand is twofold. From one hand, energy is consumed in public buildings for heating, cooling and lighting purposes during the operation of social infrastructure. On the other hand, they impact heavily on urban transport and mobility intensity. These aspects of social infrastructures and its impact on energy consumption level in cities is often being underestimated. Similar to other built structures in cities, several types of spatial planning & design measures can potentially optimize energy demand and the level of consumption generated by social infrastructures. However, no systematic analysis has been carried out so far to identify these measures, classify them systematically and explore their impact on energy efficiency.

In the local context, analysis of the traffic data from Tehran transportation and traffic co. in 2014 indicates that more than 60% of the generated motorized trips in district 22 (the location of research case study) belongs to educational, recreational and other not home-based targets. A large share of these motorized trips are generated with the aim of approaching social infrastructures. By translating these figures to the amount of energy consumed in transport sector in Tehran, one can easily understand the importance of social infrastructure in regards to urban energy consumption level (Tehran Comprehensive Transportation and Traffic Co, 2014).

In terms of energy consumption in buildings, social infrastructures have extremely high energy consumption level in Iran. Nevertheless, high cost effective saving potentials from 30-50% have been proven even with current low energy prices. For existing buildings, an average savings potential of 35% over the next 25 years have been assumed to be feasible by systematic upgrading of existing buildings. While saving of 35% and more seem to be easily achievable from technical point of view, according to the currently very high consumption level, the crucial factor will be the possible speed of refurbishment. For new buildings, savings potentials of up to 80% compared to the current average are feasible. Implementing standards for new buildings and for building renovations together with applying controlling mechanisms for monitoring the building standards, are among the most important measures in reducing the energy consumption in social infrastructure buildings (Moshiri & Lechtenböhmer, 2015). Saving possibilities are even higher in urban growth areas, such as the District 22 of Tehran as the largest urban growth area in Tehran, where a great potential for implication of energy-oriented spatial planning and design measures in the planning and development of social infrastructures exists from the scratch.

Against this background, it is critical to seek out solutions targeting the minimization of energy consumption in social infrastructure by implanting sustainable urban planning and design measures (Shamsipour et al, 2014). Towards this end, the present study proceeds as follows:

It investigates relevant theoretical knowledge in urban sustainability and energy efficiency. The Iranian urban energy related facts and figures are surveyed in line with current practical procedures and bottlenecks in the local planning context. Both qualitative and quantitative analysis are put in place aiming at generating recommendations for integration of the energy efficiency and design measures in the statuary process of urban development plans. This will be accompanied by a checklist of urban energy efficiency measures and their application in the planning process. Herewith a crucial factor is the acquisition of deep knowledge about the organizational structures as well as the relevant planning and legal instruments in the Iranian planning context (the case of District 22 of Tehran). The research illustrates the local planning system as a show case and analyses the possibility of integrating energy efficiency and design measures in the local planning practices.

Besides spatial dimensions, the research briefly surveys the ICT applications and the smart city approach as a conversion wave in urban areas. In the case of social infrastructure new types of ICT-oriented service provision and delivery are expanding in a rapid pace (i.e. e-services). Application of these new technologies and further development of e-services not only will affect the needs of different social groups in accessing public services, but also change the way, quality and characteristics of service delivery by obtaining higher efficiency, quality and performance. The research identifies the fundamental dimensions of electronic services delivery and develops an analysis framework to be tested in the case study. It aims at identifying the systematic gaps and delivering responsive recommendations to improve the quality of electronic delivery of social infrastructures. The following figure gives an insight to the main influential elements in the research, both in terms of spatial measures and electronic service delivery and their impact on enhancing the level of energy efficiency in planning for social infrastructure (Figure 1).

Figure 1. The core concept of the research

Source. Khodabakhsh, 2017

The main target of the research is to introduce an integrated set of measures and recommendations, which support to achieve energy efficiency in the process of planning and provision of social infrastructure. This includes a comprehensive set of spatial planning and design measures accompanied by an assessment of the possibility to integrate ICT solutions and applications in the form of electronic services. All the surveyed and formulated qualitative and quantitative criteria are applied in the case study on District 22 of Tehran to assess the potential for change towards improvements in the local planning system.

Towards this end, a comprehensive survey and analysis is carried out on social infrastructure planning, urban energy efficiency and the concept of e-services. Principles, methods and respective planning criteria are extracted and the interface of integrated planning criteria have been developed for application in the case study.

Relevance to Iran and the case study (District 22 of Tehran)

The present research focuses on the Iranian urban planning context (the case of district 22 of Tehran) and analyses the possibilities to integrate energy efficiency and design measures in planning for social infrastructures. Generally speaking, Iran's urban planning system is considerably affected by a centralized system and comprehensive planning approach where environmental and energy aspects are of less or no importance at all. Although new strategic approaches have been tried in several planning practices in recent years, the dominant planning system is still oriented on physical and quantitative elements with a comprehensive planning approach. Any change in the general planning approach/system in Iran, will likely face tough resistance. This is so mostly due to the complexities in the steering modalities, accompanied with a lack of knowledge in new planning approaches and their benefits among local authorities. Some of These challenges are listed below:

- Existing rigid / non-flexible /"old fashioned" statutory urban planning system
- Inefficiencies in management structure and human resources
- Hierarchical and top-down steering modalities
- Lack of knowledge on new planning approaches and their benefits

On the operative level, the present study aims at identifying the possibilities for integrating new planning and design measures to improve energy efficiency level in planning for social infrastructure. It shall proceed by identifying and analysing existing gaps and developing corresponding recommendations to amend the existing process of social infrastructure[1] planning and provision in the local context.

[1] Researchers and practitioners around the world have suggested different classifications of these urban services. As the main focus of the present study is on the Iranian planning system, the following assets were chosen to be relevant in accordance with the Tehran urban development plans regulations: education, health care, social services (cultural and religious), and administration as well as recreation and sport facilities.

Local planning instruments & regulations

Urban development plans are key tools for designing the future physical and functional development of cities. Importantly, such plans can take a variety of shapes, with differing goals, emphases and scales. The present research aims at integrating energy efficiency and design measures in to the existing planning instruments namely urban comprehensive and urban detailed plans. It emphasizes on spatial planning & design criteria, policy/strategy measures and planning regulations, aiming at creating a modified energy-oriented planning & regulatory framework in planning and provision of social infrastructures.

Organizational structure

From the actors' perspective, complexities in the steering modalities in a multi-level hierarchical structure is crucial to be understood. As a component of any urban planning system, knowing the actors and steering modalities helps to find the gaps and propose proportionate solutions in integrating new measures in to current planning practice. Yet, there often exist contradictory policies, standards and regulations among higher and lower level ministries and administrations. The latter particularities in the Tehran case – i.e. actor constellation, procedures, norms – need to be taken well into account for any alteration in the current planning procedures to be successful.

1.3 Problem statement and research gap

Due to high energy demand in cities, urban areas contribute significantly to energy consumption and greenhouse gas emissions (GHG) such as carbon dioxide. This has led to an urgent need for the incorporation of energy efficiency issues in urban planning and design procedure. Diverse planning and design interventions provide great potentials to minimize the need for energy and utilize passive energy at very low or no extra costs. Implementing modifications in existing built environment and integrating climate responsive approaches in development of new urban areas can effectively optimize the energy performance of cities to a large extent. Several research activities and pilot practices have been implemented around energy efficiency topic in urban context.

However, a comprehensive and multi-dimensional approach is missed to bring together all influential planning and design measures from different scales and qualities. As a fundamental subset of urban infrastructure, social infrastructure[2] amounts to a considerable level of energy consumption in urban areas. The physical and functional shape of social infrastructure is mostly defined in urban development plans and through urban planning and design measures (e.g. development maps and development regulations and standards). This includes feature such as building densities, physical structure and allocations, transport networks as well as accessibility dimension. All these dimensions are influential in the level of generated energy consumption in and by social infrastructures. Research confirms that appropriate planning of Infrastructure as well as social infrastructure is likely to impact the reduction of energy consumption, as being involved with the wide range of citizens. However, a classified set of planning and design measures is missed in current research activities. The current research endeavour aims at filling in this gap by identifying energy related planning and design measures and developing a comprehensive energy efficiency and design checklist for planner and local authorities.

In the context of research case study, Tehran is the political and economic centre of the country and preferred place of residence of higher income groups. Its higher population, greater access to household facilities & equipment, and a higher percentage of residential area, render the effective energy demand of Tehran province highest in the whole country (Nourouzpour, 2010). In particular, the building sector has the highest energy consumption in Iran, followed by transportation services and the industry (IEA-WI, 2009). As a result of this great share of energy consumption and rapid environmental degradation, it is crucial to develop policies, strategies and measures for reducing the energy consumption level in Tehran. According to recent studies, social infrastructure represents an important subset of the infrastructure sector which, albeit its direct and indirect impact on energy consumption, is neglected by many authors. Specifically, energy consumption thereby originates from heating, cooling and lighting (building

[2] Social infrastructure is a general term referring to assets such as schools, universities, hospitals, cultural and sport services etc. Their main purpose is to improve social welfare and as such, form an important element of any type of urban settlement. Social infrastructure provision responds to basic needs of urban livelihood. Another indirect effect of social infrastructure provision lies in its capacity to enhance the quality of life, equity, law and order, stability and social well-being. Many framework conditions for the provision of urban infrastructure that have remained comparatively stable for decades are currently undergoing considerable change. The societal debate addresses not only how but also what, why, and how much infrastructure is to be provided in cities. There is a lack of research on the future development of both social and technical infrastructures and how this will affect and interact with forms of urban development. Urban development lacks guidance on dealing with these challenges. The increasing uncoupling of planning functions from utilities and service providers in many places makes the necessary systematic reflection on urban development, planning and infrastructures more difficult (Libbe et al, 2010- own translation).

energy sector) as well as from transport and mobility (transport energy sector). This is an area, where the current research emphasizes on.

A revision of planning practices with a focus on integrating EE (Energy Efficiency) and design measures in the local planning processes, can promote energy more efficient in urban development, specifically in urban growth areas (District 22 of Tehran). Thus, one of the most critical practical questions for the present research is how and where in the Iranian urban planning process, such energy efficiency measures can be integrated. Looking at the current Iranian urban/development planning system, only a few of the energy topics such as building densities and traffic spaces are addressed by regulations of mass and space on the plot (built-up area) and by defining the course and width of access areas. Many influential physical and functional measures, such as detailed physical configurations (i.e. by defining height, depth, type, and orientation of urban structures) are missing in the current planning practices. This indicates a wide room for improvement, concerning the integration of energy efficiency measures in spatial planning systems.

Other issue that needs to be discussed in this context revolves around the technological developments. Information and Communication Technology (ICT) is altering the evolution of cities. More specifically, the notion of "growing" cities, based on implementing conventional urban planning, is incrementally being replaced by the idea of making cities „smart". The Internet is changing the traditional urban planning model. Planners are compelled no longer consider solely the physical dimension of a city, but also the use of Information Technology in the sector of the economy, environment, mobility and governance.

Digitization and, associated therewith, the socio-economic transformation of society, pose challenges for governments and the future of social infrastructure. Therefore, a long-term vision for a modern and open public service delivery is required – i.e. how social infrastructure may be created and delivered seamlessly to any citizen and business at any moment of time. To this end, new and creative ways have to be found which improve quality and provide customized solutions while, at the same time, reducing costs and energy consumption. The planning and delivery of social infrastructure are affected by this rapid transformation resulted by advances in technologies and especially the ICT. Here, one application of ICT in social infrastructure and any other types of urban services can be defined under the concept of electronic services [3].

Limited number of research activities have focused on this dimension of social infrastructures especially in the Iranian context. Furthermore, the indirect impact of electronic service delivery on reducing the demand for urban movement and required built space for service delivery (back and front offices) are often neglected in urban studies. Against this background and besides exploring the spatial measures, the current status of e-services in selected social infrastructure (in accordance to the local context classifications) will be surveyed.

Looking at the local planning system, social infrastructure implicates a broad set of complexities which, in turn, necessitates a fundamental amendment in current planning procedures and the development of a new integrated approach. Therefore, applicable solutions/strategies to integrate new planning and design measures and dimensions in the local planning system towards more efficient and flexible planning and provision of social infrastructure is an important mission in this research.

1.3.1 Research questions

The main research question underlying my research endeavour reads:

How does integrating urban planning and design measures for social infrastructure affect energy performance levels? What are the implications thereof for the Iranian context? How can the Iranian urban planning process be improved accordingly?

In finding answers to these overarching questions, I shall proceed by tackling a set of subordinated questions. This subset of questions, which I have chosen to guide my research, is depicted in Table 1:

Table 1. Classified research questions

DIMENSIONS	QUESTIONS
Urban planning and design measures	What are the interrelation of social infrastructure planning and energy consumption in an urban growth area?
	Which energy efficiency and design measures are applicable for social infrastructure planning?
	How the energy efficiency and design measures can be integrated in the SI planning process?

[3] The research briefly focus on integrating e-services concept in planning and provision of social infrastructures.

	How this integration can support higher energy efficient performance in an urban area?
Organizational dimension (i.e. planning actors and stakeholder)	Who are the main influential actors in the process of planning for social infrastructure? Where and how can synergies be used to enhance energy performance of cities in the field of social infrastructure planning?
Regulatory dimension (i.e. planning instruments and enforcement)	Which planning instruments, tools and regulatory requirements can be modified for the integration of energy efficiency measures into spatial planning and design? What are limitations regarding the implementation of an adaptation agenda?

Source. Khodabakhsh, 2017

1.4 Research objectives

To recall, the present study's objective is to advance energy efficiency aspects in social infrastructure planning in the case of District 22 of Tehran. This will be done by developing and integrating a set of energy efficiency and design measures. A key facet of the research endeavour is the assessment of gaps, requirements and identification of priorities in the local planning system. This will be done, on the one hand, by exploring more energy efficient ways of planning social infrastructure and, on the other hand, by a brief survey on the impact of ICT on social infrastructure planning and provision (electronic delivery of services).

Objective

Enhancing energy saving by introducing efficiency considerations in social infrastructure planning through integrating a set of urban planning and design measures in local planning practices and incorporation of electronic services.

1.5 Research case study

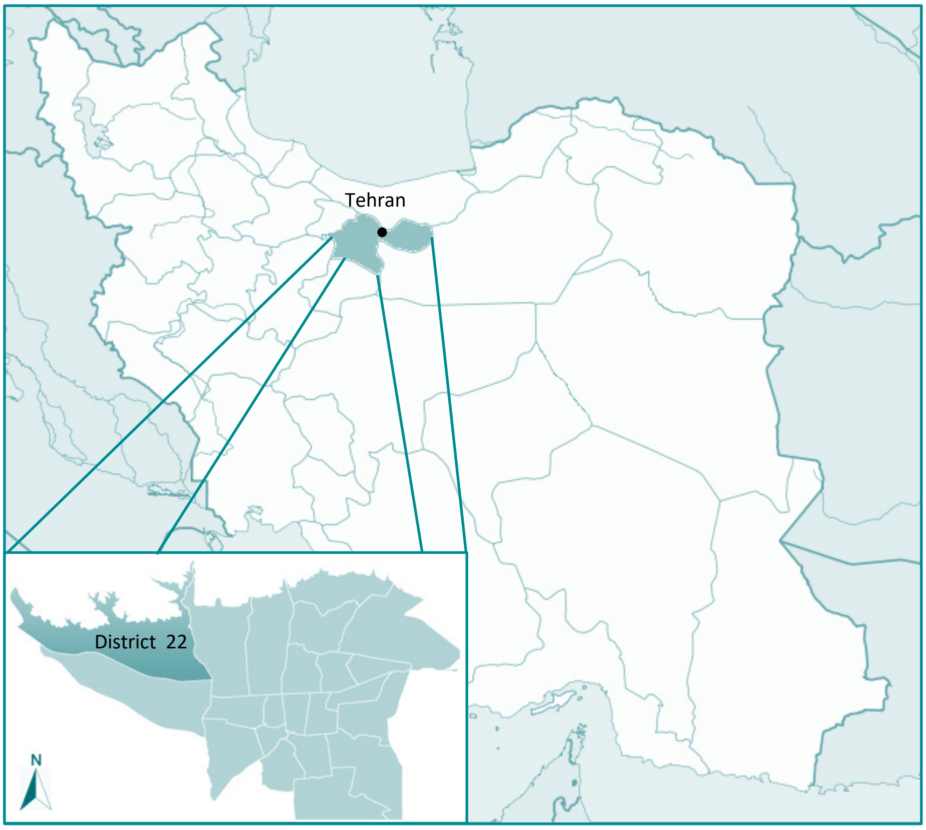
Focal point of the case study is an urban growth area located in the west end of the Tehran metropolitan region entitled Tehran District 22. The district suffers from insufficient social infrastructure, resulting from non-integrated planning practices in the past. Nevertheless, the district still bears room and potential for the implementation of appropriate planning measures and the integration of new ideas and concepts, particularly as large areas have not been physically developed yet.

Figure 2. Rapid physical development in district 22

Source. Khodabakhsh, 2017

Tehran District 22 moreover represents a very attractive urban area for the future population growth of Tehran city with high physical development potential. Considering the construction pace in in the recent past and the rapid physical development social infrastructure has become a challenging debate, which is intensified due to long travel distances to access the services affecting energy consumption levels especially in the transport sector.

Figure 3. Research case study



Source. Tehran District 22 portal, 2017

<u>The importance of energy topic</u>

In terms of energy demand and consumption, Iran's rapid population growth in the last three decades, with its subsequent urbanization rate, has resulted in an increased energy demand. Large fossil resources and increasing consumption thereof has put Iran among the world's top CO_2 emitting countries. The energy supply is largely based on fossil fuels and natural gas, especially in the building sector. The building sector (residential and commercial) is the largest energy consumer in the country, accounting for 35% of the national energy consumption in 2013. One of the main reasons for this high proportion of the overall energy consumption in the building sector is the highly subsidized energy price in Iran. However, due to policy changes in terms of gradual decrease of public subsidy on energy prices by the government since 2009 and the issue of energy efficiency has been high on the political agenda (Nasrollahi, 2011). The Tehran metropolitan region is, in many ways, the focus of the tremendous challenges posed by energy consumption in Iran. Tehran is the political, economic, financial, and cultural centre of Iran, accounting for 70% of Iran's economic and financial power. Despite the fact that Tehran only occupies 1.2% of Iran's total landmass, it contains more than 20% of the Population and about 35% of the country's industries (Atlas of Tehran Metropolis[4]).

The continues increase of energy demand and the impacts of built environment on energy consumption and increased emission of greenhouse gas (GHG) make the built environment a crucial factor in Tehran. This is accompanied by climate change effects and temperature increase of up to 4 degrees and an average 9% decrease in precipitation, which means longer cooling periods, and increased energy demand for cooling purposes (Atlas of Tehran Metropolis).

1.6 Researched added value and expected outcomes

The research will provide a better understanding on the role and impact of planning and design measures in achieving energy efficiency for social infrastructure, focusing on District 22 of Tehran and similar contexts (urban growth areas). The outcome will be an integrated recommendations and a "checklist" for local planning actors to enhance energy efficiency in spatial development of urban areas. Below follows a brief overview of some of the central outputs of this study:

- A comprehensive set of spatial energy efficiency and design measures in planning and development of urban areas (together with modifications for social infra-structures)

[4] Atlas of Tehran Metropolis. (n.d.). Retrieved January 10, 2018, from http://atlas.tehran.ir/Default.aspx?tabid=294

- Strategies on how to optimize the current planning process as well as recommendations on how to integrate the herein developed set of energy efficiency measures (focusing on technical, organizational as well as regulatory dimensions)
- Recommendations for stimulating the electronic delivery of social infrastructure
- Methodologies in the form of guidelines and checklists for energy efficient planning and design of social infrastructure resulting in adapted or new policies as well as recommendations for transfer into exiting planning practice.

1.7 Research methodology and design

The research investigates theoretical knowledge in urban sustainability and energy efficiency. To do so, influential energy efficiency planning and design measures are explored in line with their potential impacts on energy performance of the built environment. As the research methodology for this dissertation will be both qualitative and quantitative methods, the process of data collection and analysis will be based on a comparative exploratory approach. Library research, published fact sheets, good practices etc. will be used as the main data collection, accompanied by surveys and interviews with urban authorities and databases of the case study.

As defined, the first step of the research consists of a comprehensive literature review and document analysis around urban energy efficiency as well as social infrastructure planning. This includes transferrable qualitative and quantitative results from the existing studies on the impact of urban design measures on energy performance of the built environement. A modifet set of energy efficiency and design measures in social infrastructure planning together with an illustrated example (an educational center/school) are the main outcome of the literature studies.

All the explored planning and design measures of this part of research will be precisely examined in the case study (District 22 of Tehran). The findings of the local context are mainly derived from desk research, field observations and interviews with local actors. These data is analysed and conceptualized in order to explain how they help to explain the phenomenon under study. Both qualitative and quantitative analysis are utilized depending on the availability of loca statistics and aiming at exploring the gaps in the local context. This is followed by an integrated SWOT analysis to generate strategies and recommendations for integrating new energy related spatial planning criteria in the process of local statutory development plans (i.e. urban comprehensive plan, urban detailed plans etc.).

One main outcome of the research is an integrated energy efficiency and design checklist and its application in urban development. Hereby, a crucial factor is deep organizational as well as regulatory knowledge to ensure the enforcement of proposed measures in the Iranian planning context. The research illustrates a case study (District 22 of Tehran metropolitan area) on potential impact of the energy efficiency and design measures for social infrastructures in the local context (see Figure 4).

Below are some of the most important stages of the research:

A. Survey for energy efficiency and design measures accompanied by identification of the measures applicable in the process of social infrastructure planning.

B. An integrated checklist of energy efficiency and design measures in social infrastructure planning for application in the case study. Together with identification of which of them are already existence in the current planning practices and where the new measures and criteria can be placed.

C. Analysing the organizational structure, understanding the steering modalities, as well as analysing the local planning instruments and enforcement measures such as planning regulations and standards.

D. Assessment and analysis of the local condition in the statutory planning system – in the case study – and integration of new set of measures. Accompanied with an integrated assessment of electronic service delivery.

E. Recommendations for optimizing the local planning process and developing the integrated checklist. Together with strategies for the local context as well as transferrable strategies for similar context.

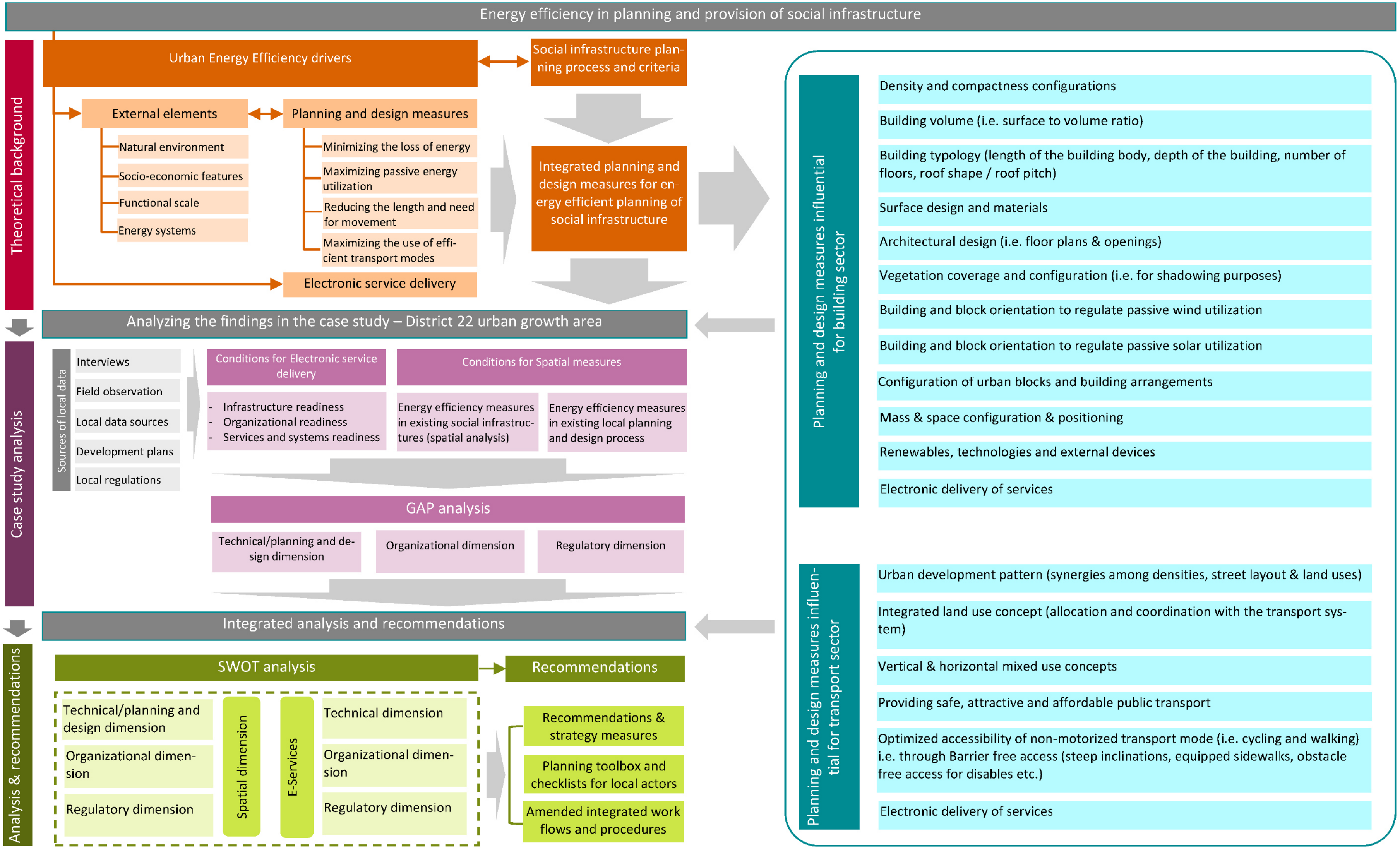
Moreover, as an exploratory research based on qualitative analysis methods, the focus of this research is on exploring/identifying possibilities, challenges, and implications of energy efficiency and design measures for planning social infrastructures in the in the local context of Iran. Therefore, the conclusions as well as the established checklist should be tested furthermore in other cases. Due to the limited availability of local data and statistics, the research combines both qualitative and quantitative analysis depending on the data availability. Furthermore, where possible and relevant, the quantitative results of the similar studies resulting from simulations, are mentioned in the literature review and with the aim of developing the energy efficiency checklist. In terms of research limitations, there exists a variety of challenges and barriers in different phases of the research especially in the local data provision. These are briefly listed in the following table:

Table 2. Existing challenges and limitations in the research

General categories	Challenges
Data availability	▪ Out-dated information sources and lack of adequate statistics and data in specific areas such as detailed energy statistics.
Communication barriers	▪ Time consuming process for communication with urban authorities in the district and beyond. ▪ Lack of clear area of expertise and interference among different urban authorities.
Urban governance and management	▪ Unstable and rapid changes in the management and organizations structure of city and therefore lack of a long term vision and strategies ahead. ▪ Application of the rigid comprehensive approach in current urban planning practices and difficulties to promote new approaches. ▪ Limited awareness among urban related authorities in regards to new approaches (i.e. energy and e-services) and the benefits that such approaches can bring in.

Source. Khodabakhsh, 2017

Figure 4. The detailed research process



Source. Khodabakhsh, 2017

CHAPTER 2

Literature review and theoretical framework

Chapter 2 provides a detailed and comprehensive theoretical review on the main research concepts namely; energy efficiency in the urban planning and design context as well as its contribution to planning for social infrastructure. Within the frame of second chapter the importance of energy efficiency as well as influential energy efficiency factors (in the form of urban planning and design measures) are explored and presented in the classified manner. The results provide a basis for analysing the implication of energy efficiency and design measures for planning social infrastructures. Explored planning and design measures from chapter 2 will be examined in the case study (presented in chapter 3).

Chapter 2. Literature review and theoretical framework

Introduction

Observations in policy making, research and development, demonstrate that much of the focus has been given to the technological dimensions of the energy efficiency. Advances in energy efficiency technologies provides great opportunities to choose among a wide range of options for energy saving technologies and the use of renewable energy. However, improving energy efficiency in cities is not only limited to technological solutions. A verity of issues influence enhancement of energy efficiency, which are, inter alia, the socio economic values, regional and local resources, demographic development of societies, individual lifestyles, economic practices and last but not least the physical and spatial structure of cities (Stoeglehner et al, 2014). This list can be further expanded and deepened by adding the awareness and educational backgrounds of stakeholders and end-users, which increases the complexity of energy debate in cities. Among the above mentioned factors, spatial structure of the built environment heavily influences both energy saving and the extended use of renewable energy sources. Despite great energy saving potentials brought by adapted configuration of built environment, this dimension of energy efficiency has been often neglected both in research and in practice.

Against this background, the present chapter carries out a comprehensive literature review on the concept of ''Urban Energy Efficiency''. My goal is to identify influential factors in obtaining efficiency in energy urban eco systems. Based on the analysis, a key practical objective is to derive a set of urban planning and design measures towards enhancing the energy efficiency in cities. Investigations in this chapter emphasizes on formal and functional dimensions of urban planning and design with the aim of reducing energy demand, enhancing the use of passive energy as well as minimizing the energy loss in urban built environment. The results so obtained shall also provide a basis for analysing the energy efficiency of social infrastructure which will be further surveyed in the case study.

2.1 Sustainability and energy efficiency discourse

2.1.1 The importance of energy and energy sources

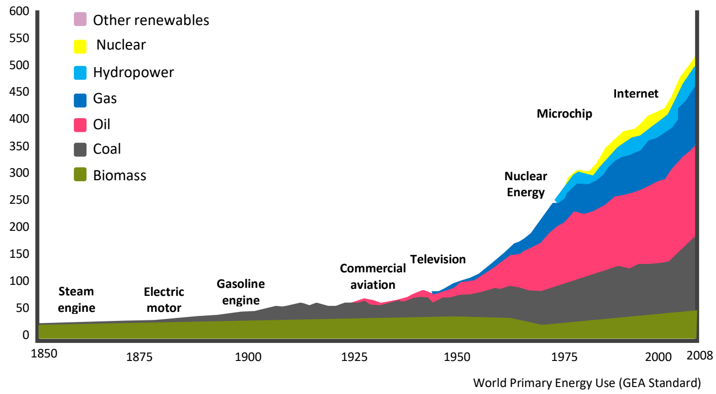
It goes without saying that energy is essential for human development. As such, energy systems are a crucial entry point for addressing the most pressing global challenges of the 21st century, including sustainable economic and social development, poverty eradication, adequate food production and food security, universal health care, climate protection, conservation of ecosystems, peace, and security. Yet, more than a decade into the 21st century, current energy systems do not meet these challenges. The traditional approach – in provision and consumption of energy sources - does not embrace the transformation needed to respond properly to the economic, environmental and social sustainability challenges of the 21st century. Therefore, a major shift is required to address these challenges and to avoid potentially catastrophic consequences for human and planetary systems (Grubler et al, 2012).

The industrial revolution threw humanity onto an explosive development path, whereby reliance on muscle power and traditional biomass as the main energy sources was replaced, for a large part, by fossil fuels. There have been major alterations in the share of global energy resources over the last two centuries (see Figure 5). The dominance of biomass in the 1800s was overtaken by coal in the first half of the 20th century, giving way to oil around 1970. Oil products still retains the largest share of global primary energy (Grubler et al, 2012). In 2005, approximately 78% of global energy was based on fossil energy sources that provided abundant and ever cheaper energy services to more than half the world's population.

At a more nuanced level, two marked phases of development can be discerned when looking at Figure 5 and the above described major alterations with regards to global energy resources. The19th and 20th centuries are mostly characterized by a shift from reliance on traditional energy sources to coal and subsequently oil and gas. Later on, hydropower, biomass, and nuclear energy have come to play an increased role, obtaining combined share of almost 12% in global energy consumption. By contrast, the use of renewable energy sources, such as solar and wind, remains at low levels in comparison[5] (Nakicenovic et al, 1998; Grubler, 2008).

[5] Overall, the share of renewable energy remains comparatively low, which is why its share is hardly discernible in the diagram.

Figure 5. Evolution of global primary energy soruces



Source. Nakicenovic et al, 1998; Grubler, 2008

Most fossil fuels are burned to turn into energy and gasses released in the process, in turn, cause air and water pollution. The resulting leads to over two million premature deaths per year, mostly suffered by women and children. At the same time, approximately 20% of the global population has no access to electricity, making it difficult for children to study after sunset and impossible, for example, to keep vaccines cold, provide mechanical energy for agriculture and irrigation, and power the most simple machines for manufacturing and commerce. This situation undermines economic development and energy security and causes indoor and outdoor air pollution and climate change (GEA, 2012).

Addressing these challenges is essential to averting a future with high economic and social costs and adverse environmental impacts on local, national and transnational scales. Energy-wise, a transformation is required to meet these challenges and bring prosperity and well-being to the nine billion people expected by 2050. The policy challenge is to accelerate, amplify, and help make the implementation of these changes possible, widespread, and affordable. Although they may be capital intensive and require high upfront investments. Potential short term costs are arguably offset by lower long-term costs and the overall expected benefits in the long run.

Importantly, however, the story does not end with costs. Agency is yet another key aspect for bringing about a “grand transformation”. So far, it appears, that by business-as-usual (BAU) thinking and behaviour obstructs the process. The change also seems to be blocked by locked-in decision-making processes, institutions, consumption patterns, capital vintages, interests, and investment patterns. Old development paths are, more often than not, “sticky” in that particular courses of action, once introduced, can be difficult to reverse (Pierson, 2000).

2.1.2 Energy efficiency: a brief genealogy and conceptual background

The concept of energy efficiency is rooted in the debate on sustainable development and sustainable cities. The term “sustainable development” can be traced back to the World Commission on Environment and Development Report (WCED, 1987[6]), which devotes a chapter to the so-called “urban challenge” in the “peripheral South”. The WCED concern was originally about the urban poor in rapidly growing large cities of the South. The term sustainable development is now used more frequently in the broader context of the need to protect the environment that underpins social and economic capital and development.

For this reason the term “sustainable cities” is more often associated with civic initiatives in cities of the North, addressing what is perceived as the unsustainable impact of their citizen’s lifestyles, especially in today’s times marked by large volumes of waste and GHG emissions. In this regard sustainability quite resembles the earlier idea of an “Eco city” with the focus on reducing the settlement’s “ecological footprint” (Anderson, 2006; Jabareen, 2006; Kenworthy, 2006; Pickett et al, 2008).

Attempts to achieve an optimal “sustainable urban system” in settlements invariably require some forms of spatial organization. This may be provided by a city authority, but it could equally be the covenants imposed by a land developer. “Sustainable” urban configurations are often expressed in terms of optimal building densities linked to low-profile transport networks. This metric is frequently employed in zoning regulations. The optimal configuration then seeks to avoid a very high density, which is conventionally associated with highly congested services and low-density automobile-dependent networks. An optimal density and compact configuration is expected to induce a stronger sense of community by providing some local retail and commercial space with local interaction, itself reducing the need for automobile travel. Energy implications of “sustainable cities” arise naturally from their move away from automobile dependency as well as attempts to exploit the use of natural energy sources. Given these well-documented environmental impacts, there is cause for concern about the future sustainability of the planet unless energy principles actively counteract these impacts. Energy policy, which provides a framework for regulatory activity, cannot be developed in isolation. It must incorporate the principles contained in the international framework for Ecologically Sustainable Development (ESD).

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[6] World Commission on Environment and Development Report (WCED). (n.d.). Retrieved January 10, 2018, from http://www.un-documents.net/our-common-future.pdf

The principles of ESD – intergenerational equity, the polluter pays principle, the precautionary principle and conservation of biological diversity – are now well known. They were clearly articulated in the documents which emanated from the 1992 United Nations Conference on Environment and Development (the Rio Conference). These include the Rio Declaration and Agenda 21. In addition, imperatives for reducing greenhouse gas emissions were formulated in the United Nations Framework Convention on Climate Change as well as the Kyoto Protocol. At the 2002 World Summit of Sustainable Development (WSSD), the links between sustainable development and the supply of energy were reiterated in the Plan of Implementation (Hemmersbach & Lebert, 2005).

The reasons to increase our attention to energy-related aspects in developmental issues worldwide are manifold. Economic, social, environmental and health impacts of energy consumption in line with energy sources scarcity are some examples. Since before the Industrial Revolution, societies have relied on increasing supplies of energy to meet their need for goods and services.

Major changes in current trends are required if future energy systems are to be affordable, safe, secure and environmentally sound. There is an urgent need for a sustained and comprehensive strategy to help resolve the following challenges:

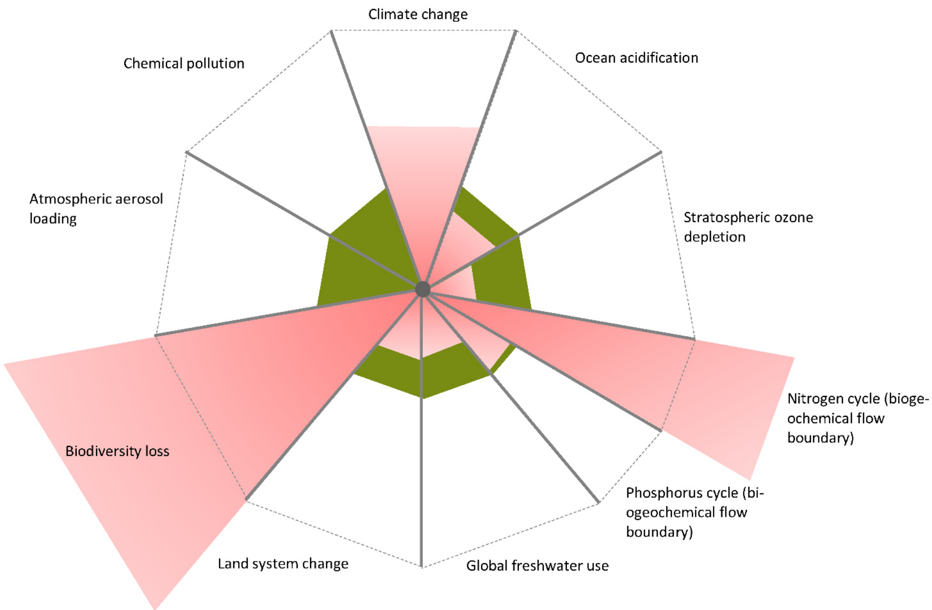
- providing affordable energy services for the well-being of the 7 billion people today and the 9 billion people projected by 2050;
- improving living conditions and enhancing economic opportunities, particularly for the 3 billion people who cook with solid fuels today and the 1.4 billion people without access to electricity;
- increasing energy security for all nations, regions, and communities;
- reducing global energy systems greenhouse gas emissions to limit global warming to less than 2°C above pre-industrial levels;
- reducing indoor and outdoor air pollution from fuel combustion and its impacts on human health; and
- reducing the adverse effects and ancillary risks associated with some energy systems and to increase prosperity;

Linkages between the energy system and the environment can be discerned on multiple levels and scales – from local to global. The risk is that systems on Earth may reach thresholds (i.e. in terms of scarcity of energy sources and the negative impacts on environment), resulting in non-linear, and potentially irreversible change, such as destabilization of the Greenland ice sheet or tropical rainforest systems.

Some of the most crucial challenges are illustrated in Figure 6, showing planetary boundaries for ten Earth system processes, which together define a safe operating space for humanity. Global estimations indicate that the safe levels are being approached or, in some cases, passed. The green area denotes a "safe operating space" for human development, and red indicates the current position for each boundary process (Emberson et al, 2012).

In 2005, energy supply and use contributed around 80% of CO_2 emissions and 30% of methane emissions, as well as large fractions of other substances, such as black carbon, organic carbon, and aerosols that can either warm or cool the atmosphere, depending on their composition. It is essential to reduce emissions of both long-lived GHGs, such as CO_2, and short-lived climate forcers, such as ozone precursors and black carbon (these emitted, for example, from the combustion of diesel fuel and household biomass fuel). Reducing short-lived climate forcers is critical to slow the rate of near-term climate change and provides a far greater likelihood of achieving the 2°C target in combination with decisive measures to bring down long-lived GHG emissions as well (Brunekreef and Holgate, 2002).

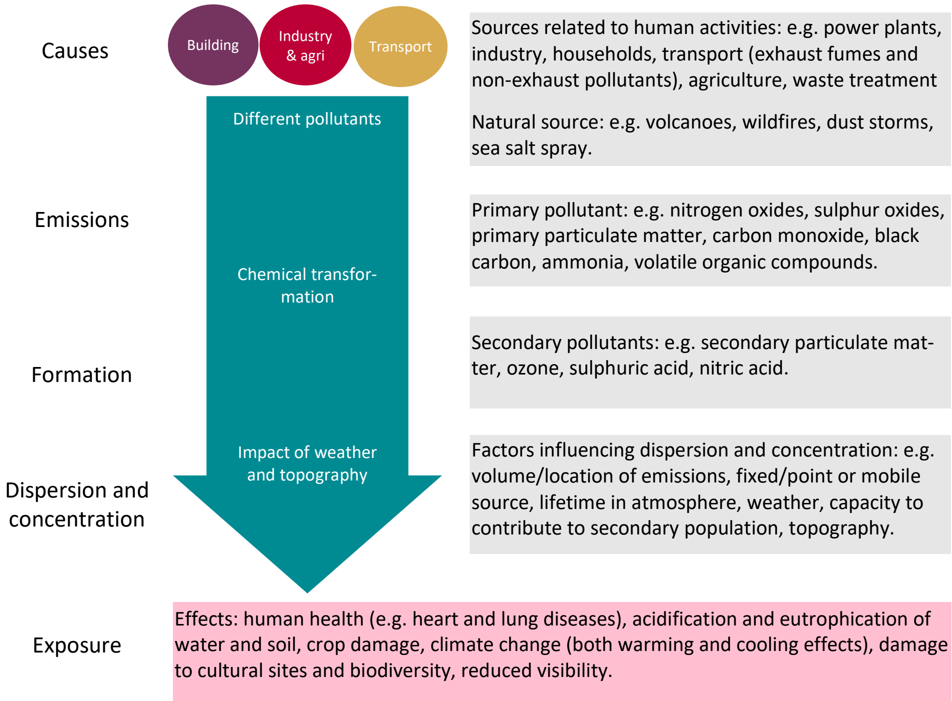
Figure 6. Current global state of the world for the 10 proposed planetary boundaries.



Source. Emberson et al, 2012

Mapping a pathway for air pollution (Figure 7), from sources to impacts, can be useful way to expose what is, in practice, a complex and multi-faceted issue. This process encompasses the initial source of emissions, how the emissions disperse in the air, any transformation that takes place, the extent to which the population/environment is exposed to the pollutants and the consequences arising therefrom (EEA, 2016).

Figure 7. Mapping air pollution from sources to impacts



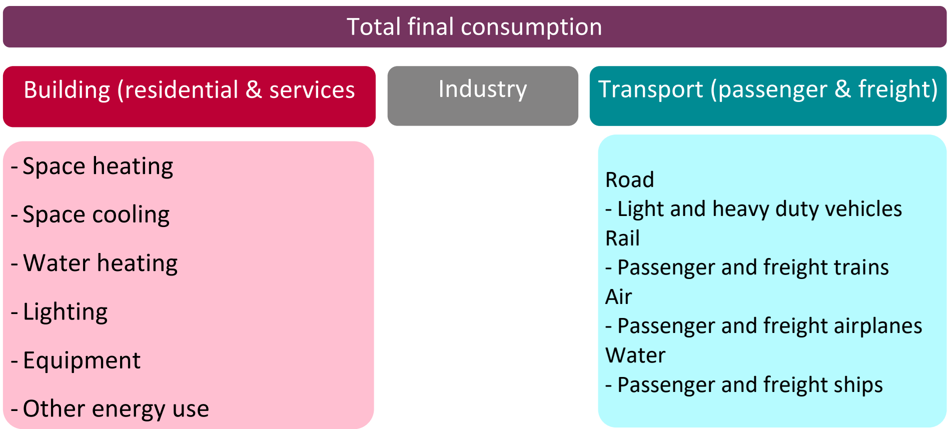
Source. EEA, 2016

2.2 Urban energy major end users

Global analysis indicates that over 60 per cent of global energy is consumed in cities, where roughly half of the world's population lives. Moreover, the urban population is expected to continue increasing rapidly due to growing urbanisation in emerging economies and developing countries. Such rapid growth puts cities at the centre of the global energy challenge. To this background, cities can play an important role in the application of efficiency solutions, especially if city planners learn to identify policy opportunities for reducing the consumption of energy and better exploiting the capacity to generate energy (IEA, 2012).

Worldwide, three sectors figure as the most prominent major energy end-users in urban areas: buildings (residential and public/commercial), transport and industry. The relative share of these sectors varies somewhat by region, with high-income countries exhibiting a greater share of residential, commercial, public, and transportation energy use, while residential and industrial sectors dominate the energy use in low-income countries (EEA, 2016). The focus of this research are the transport and building sector, as two areas were the potential effect of planning and design measures is most discernible. In terms of energy consumption and GHG emissions, the buildings and transportation sectors share not only similar levels of impact, but also notable efficiency interdependencies. Such interdependencies are evident in the energy consumption and GHG emission levels of different types of urban form. Urban form (the spatial arrangement of building types and transportation networks) influences transportation distances, transportation mode splits, building envelope heat transfer, and building material use, and each of these factors affect the energy consumption and GHG emissions of the built environment. Figure below lists the energy consuming sectors in urban areas. (EEA, 2016).

Figure 8. The main categories of energy consumer sectors[7]



Source. IEA, 2014

2.3 Energy efficient urban planning and design measures

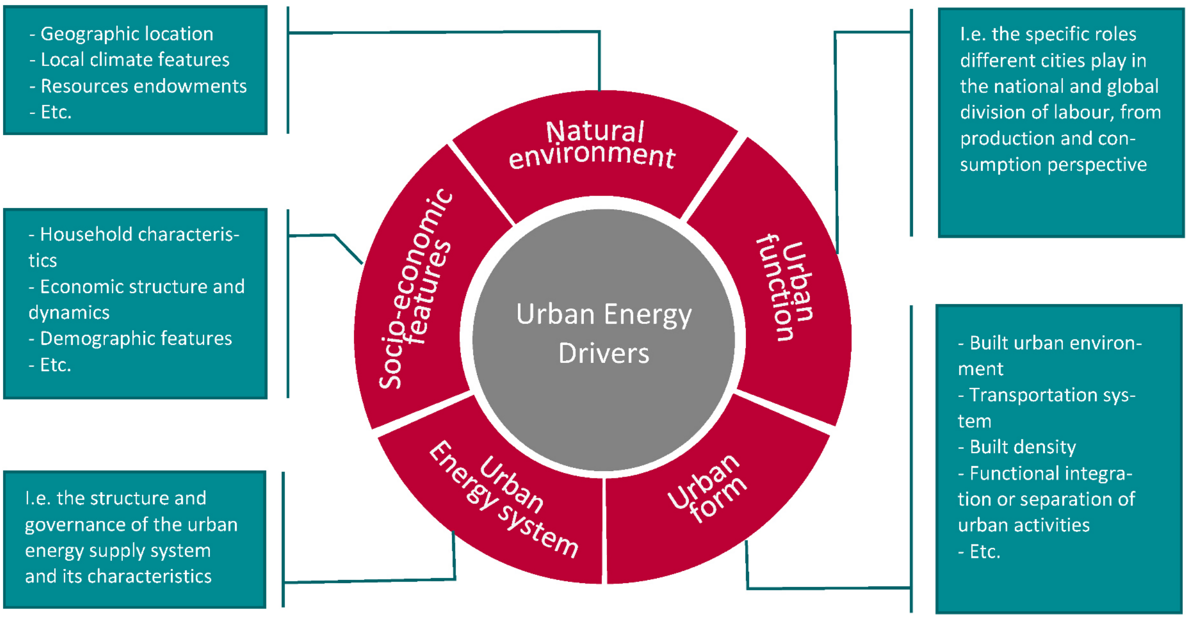
Introduction and focus area

The factors that determine urban energy use can be classified into a few major groups (see figure below). These factors do not work in isolation; rather, they are linked and exhibit feedback effects, which prohibits simple linear relations with aggregated energy use. The interaction between the driving factors may not only change from city to city. In addition many of the factors are dynamic and path dependent i.e., are contingent on historical development. There is, however, one factor that underpins all these determinants in a complex and nondeterministic way: the history of a city. The location

[7] Estimations of International energy outlook 2016 shows that in 2012 the share of total energy delivered to end users are for industrial sector 54%, transport sector 25% and building sector 20%.

of a city and the initial layout of its form emerge historically. The difference between sprawling North American cities that developed in the age of the automobile and older, compact European cities that developed their cores in the Middle Ages demonstrate this issue. Likewise, the economic activities of a city often stem from historical functions, whether as a major harbour, like Cape Town and Rotterdam, an industrial centre, like Beijing now and Manchester historically, or a market and exchange centre, like London, New York, and Singapore(GEA, 2012:1357).

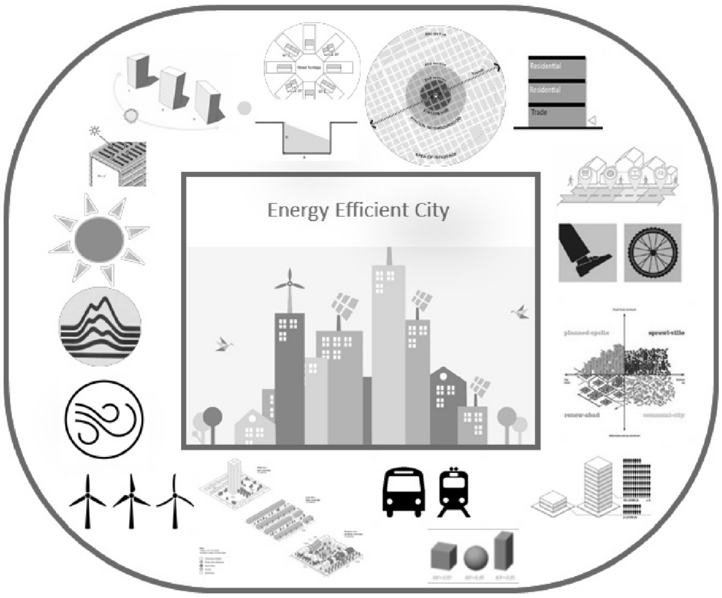
Figure 9. Urban energy key drivers



Source: GEA, 2012

In recent decades, the landscape of cities has changed significantly because of rapid urban population growth. A major feature of fast growing cities is urban sprawl, which drives the occupation of large areas of land and is usually accompanied by several many problems including inefficient land use configurations, high car dependency, low density and high segregation of uses. Cities of the future should build a different type of urban structure and space, where city life thrives and the most common problems of current urbanization such as energy efficiency are sufficiently addressed. Urban planning and design is one of the main tools to support achieving these objectives. Spatial characteristics of cities are generally similar or of higher importance than those of individual consumers or of pure technological solutions, when it comes to urban energy performance.

Figure 10. Influential dimensions of urban planning and design on the energy consumption



Source. Khodabakhsh, 2017

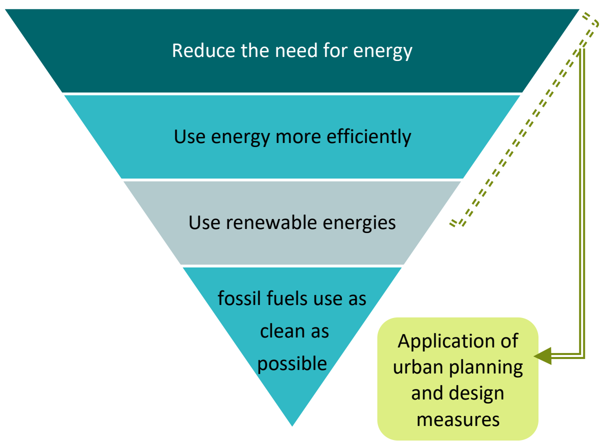
Energy efficiency is a “relevance” concept. That is to say, its meaning is situational in that primarily defined in comparison between two (or more) conditions with one another (i.e. condition A is more energy efficient than condition B etc.). Generally speaking, it is thus easier to state whether something is more (or less) energy efficient than to define energy efficiency itself. For instance, something is more energy efficient if it delivers more services for the same energy input, or the same services for less energy input. For example, when a compact fluorescent light bulb (CFL) uses less energy than an incandescent bulb to produce the same amount of light, the CFL is considered to be more energy efficient (IEA, 2014). Against this backdrop, what is provided by the Lawrence Berkeley National Laboratory seems to be an overall workable conceptualization: energy efficiency is “using less energy to provide the same service” (IEA, 2014).

A suitable comprehensive approach that is not focused on specific sectors or disciplines, but considers several energy related effects on the cities comes from the energy-related building research. I opt for the so-called Trias Energetica. This approach takes a more complex view of the built environment formulated under the headings "Prevention - Renewables - Efficiency" a target range for the sustainable use of energy (Entrop and Brouers 2010: 296). In the sustainability/energy efficiency debate very similar strategies are classified under the headings of efficiency, consistency and sufficiency, which - as the triad Energetica shows - also can be applied on the energy efficiency in the built environment (including Behrendt et al, 1998; Sachs, 2005; Hegger, 2007: 59). The Trias Energetica centres around three criteria:

- Efficiency: efficiency targets by a rational use of energy to minimize the use and conversion of materials and energy, thus increasing the energy and resource productivity (Behrendt et al, 1998: 261/262). Efficiency is a strategy with a high initial potential and lasting effect; these strategies can, however, find their limits when they can no longer neutralize an increasing demand (Sachs, 2005: 165; Entrop & Brouers, 2010: 296).
- Consistency (Renewables): Consistency refers to the provision of energy and raw materials consumption in closed energy systems, as indicated by the use of renewable energies i.e. solar, wind, hydrogen (Behrendt et al, 1998: 261/262; Entrop & Brouers, 2010: 296). In the wider context, the consistency strategy is aimed at closed material and energy flows within a spatial unit.
- Sufficiency (Prevention): Sufficiency targets consumption patterns of individual users, with the aim of limiting the consumption of energy (Sachs, 2005: 167; Hegger, 2007: 50, Entrop & Brouers, 2010: 296).

Based on the elaborations above, it is possible to derive a hierarchy of targets (see Figure 11). In line with the focus of the study at hand, the priorities in urban planning and design measures are rather focused on reducing the need for energy as well as to provide opportunities in maximizing the use of renewable as well as passive energies.[8]

Figure 11. Urban energy efficiency targets and the focus of this research



Source. Entrop and Brouwers, 2010

[8] The last aspect, use fossil fuels as clean as possible is not identified as a priority area of this research.

2.3.1 Spatial form and functional dimension

Thinking about sustainable/energy efficient urban structure begins with the urban region: the town or city and its rural and/or coastal hinterland. The town or city depends on its hinterland for food and water, clean air and open space and, looking for the future, perhaps on biomass or wind for energy. The hinterland is dependent on the town or city as a market for its products and for employment and services but is also affected by urban waste and pollution. Therefore, in larger scale, sustainable planning demands a more holistic and integrated approach to the urban region, which recognises the interdependencies and potential of both town and country (Ritchie & Thomas, 2013).

At the level of town or city, the walkable community provides a fundamental building-block in creating an energy efficient urban form. Many of the existing concepts emphasize on a polycentric urban structure in which a town or city comprises a network of distinct but overlapping communities, each focused (depending on the scale of the urban area) on a town, district or local centre, and within which people can access on foot most of the facilities and services needed for daily living. Each of these communities is defined by the walking catchment around the centre, which is generally taken to be c.800 m, equating to a 10-minute walk for neighbourhoods. Furthermore, shops and services tend to be focused along a main street running through the heart of the neighbourhood, at the convergence of movement routes and around key facilities such as public transport station (Ritchie & Thomas, 2013).

The degree to which shops and services spread outwards into surrounding streets is a function of the scale and role of a centre, the density of population (and spending power) within its catchment and the degree of consumption from neighbouring centres. Community scale social infrastructure such as schools, health centres and open spaces are distributed around the neighbourhood, reflecting more localised catchments and their greater requirements for space. Such neighbourhood structure provides a wide range of different types of housing opportunities. This provides the basis for a mixed community, representative of society with a large rather than having a narrow social focus. Housing densities are highest around the district centres, along the principal transport routes leading to neighbouring centres and overlooking parks, waterfront areas and other amenities. Densities reduce towards the edge of the walking catchment. Movement routes are shared by cars, buses (or trams), cyclists and pedestrians and go through the centre rather than around it as well as through residential neighbourhoods (Ritchie & Thomas, 2013).

In the literature of urban energy efficiency, there are trade-offs between urban density, dwelling type, block size, and the ecosystem services provided by vegetation. Both theoretically and empirically, it is by no means clear that there is an ideal urban form and morphology that can maximize energy performance and satisfy urban sustainability criteria (Owens, 1986). The dynamic interaction between energy systems and the spatial organization of built environment has been a subject of considerable interest since the energy crises of the 1970s (for example, see Ashworth, 1974; Beaumont and Keys, 1982; Burchell and Listokin, 1982; Hall, 1979; Odell, 1977; Owens, 1984a; 1984b).

Among different elements of spatial structure of settlements, land use affects energy consumption to a large extent. At all levels of spatial resolution, from local to regional scale, energy consumption parameters are influenced by spatial structure and land-use patterns. An important implication of this relationship is that land-use policies may have significant consequences for future energy consumption especially in the transport sector. Land-use planners should not only take these effects into considerations, but also devise appropriate policies to further energy conservation in the longer term (Owens, 1986).

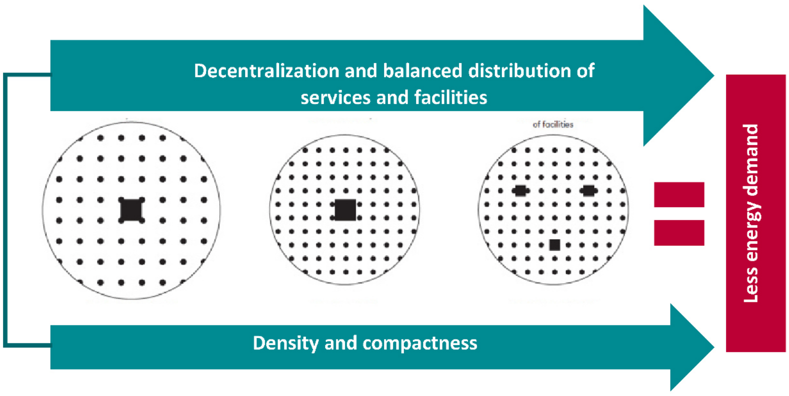
An important factor in planning an energy efficient urban settlement is the compactness of the built structures and balanced distribution of urban services and facilities. Doing so improves facilities' performance in relation to demand for urban mobility and movements and reduces energy consumption in the transport sector (Odell, 1975).

The creation of balanced distribution of facilities in relation to urban compactness and building configuration has been proved beneficial in many urban energy assessment models (Hemmens, 1967). The compact urban form is not equal to development of high rise buildings but rather signifies a balance of different types of buildings in accordance to citizen's needs and local conditions and the balanced allocation of urban services and facilities. Doing so creates shorter access networks and provides the possibility for a more efficient infrastructure development.

The decentralized urban structure is another influential criteria, while discussing urban energy efficiency. The adaptation of the compact city concept in polycentric spatial structures (decentralised concentration) appears to provide an answer to the trade-offs of a single compact city (e.g. disadvantages of high density) while keeping its advantages (Holden & Norland, 2005). Furthermore, polycentric spatial structures provide an alternative spatial principle for regions where compact city development is hardly feasible (e.g. sparsely populated regions) (Große et al, 2016).

Polycentric urban regions, however, favour shorter commuting distances (Grunfelder, Nielsen, & Groth, 2015). Reviewing existing empirical studies from the Nordic countries (Næss, 2012: 41) also indicates that "decentralized concentration provides considerable opportunities as one of the most energy-efficient settlement pattern at a wider regional scale". In addition, dense structures are considered to contribute in reducing travel needs by car (Næss, Sandberg & Røe, 1996). Newman and Kenworthy (1988) provide empirical evidence that locational factors have a greater impact on energy and the level of generated urban trips. Næss and Jensen (2004: 37) state that "urban structure influences facilitating some and discouraging other kinds of travel" (Næss, 2006). As a result, compact urban structures and decentralized development facilitate the efficient use of energy in cities (Fertner & Große, 2016).

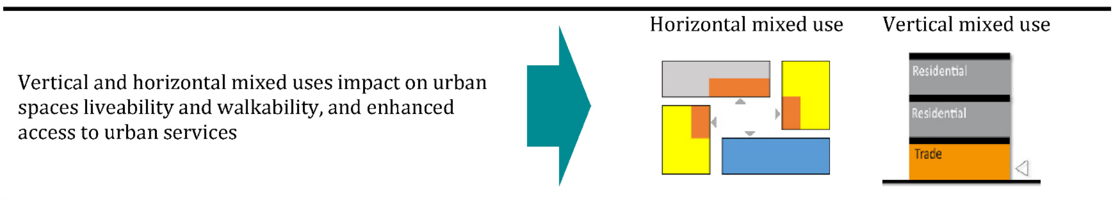
Figure 12. Synergies between urban compactness and configuration of urban services and facilities



Source. Owens, 1986

The pertinent energy literature recommends considering development patterns to optimize infrastructure accessibility conditions (all modes, especially walking, cycling and access to public transport). This influences the energy consumption level in transport sectors. It is therefore vital to ensure a balanced allocation of urban services and the integration of these services with the public transport system (creation of walking and cycling possibilities and creation of walkable distances) towards reducing transportation energy demand. To this end, concepts such as mixed use (vertical and horizontal) are highly recommended (Pahl-Weber et al, 2013).

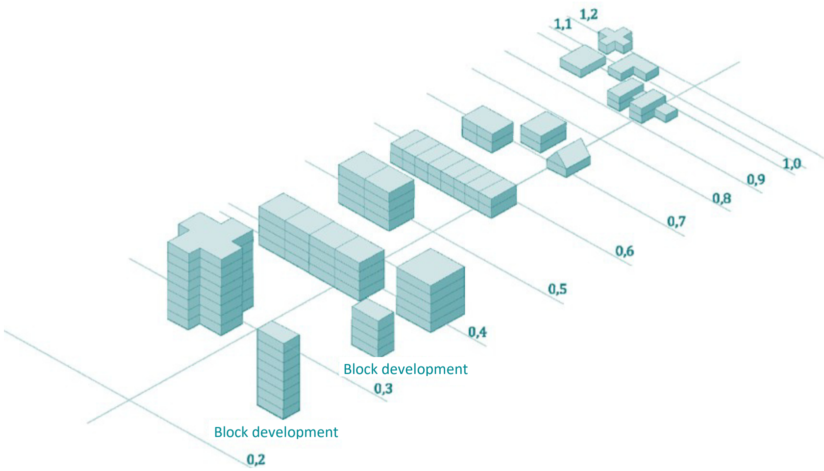
Figure 13. Vertical and horizontal mixed use concepts



Source. Pahl-Weber et al, 2013

In the urban energy literature, density has perhaps received more attention than any other single variable in the energy – urban form debate. The emphasis may well be responsible for the notion that energy efficiency requires "compact cities" – a notion which can be easily dispelled. Optimizing building volumes can, among other policies, stabilize a building's thermal behaviour through compactness and surface to volume ratios. This reduces thermal loss through building surfaces and efficiently regulates the interior climate against extreme outside temperatures and seasonal or daily temperature peaks. Depending on surface- design and material, the influence of outside climate on interior spaces can be greatly reduced. This strategy must be developed in tandem with architectural design (Peseke & Roscheck, 2010). Urban density is a major factor that influence on the urban ventilation conditions, as well as the urban temperature. Under given circumstances, an urban area with a high density of buildings can experience poor ventilation and strong heat island effect. In warm-humid regions, these features would lead to a high level of thermal stress of the inhabitants and to increased use of energy in air-conditioned buildings. However, high density urban areas with a mixture of high and low rises buildings, could provide better ventilation conditions than those with lower density but with buildings of the same height. Closely spaced or high-rise buildings are also affected by the use of natural lighting, natural ventilation and solar energy. If not properly planned, energy for electric lighting and mechanical cooling/ventilation may be increased and application of solar energy systems will be greatly limited (Khalil, 2015).

Figure 14. A/V relation of different building typologies[9]



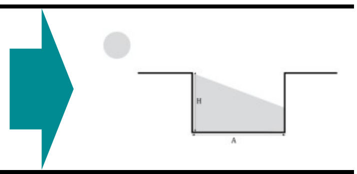
Source. Seelig, 2014

[9] Volume to surface ratio is an important criteria to plan for energy efficient buildings and urban blocks. (This should be observed in relation to local climate). e.g. In the local context of Iran, considering the local climate conditions, the optimum A/V ration should not exceed 0.65 for buildings with 3 external walls and 0.5 for buildings with 2 external walls.

Correspondingly, what is important is the height of the neighbouring building or physical structures – and in general the interrelation of the buildings in an urban structure considering the local climate conditions (i.e. sun light, wind exposure etc.)(Pahl-Weber et al, 2013).

Figure 15. Impact of building design on passive solar energy gain

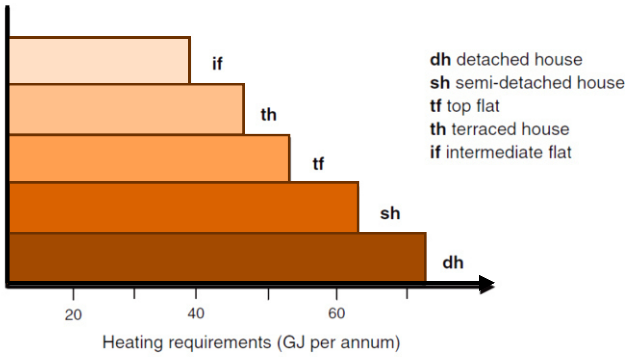
Identification of the maximum building and blocks height, considering the density factors, local climate and geographical conditions with the aim of enhancing the passive energy use of buildings and urban blocks.



Source. Pahl-Weber et al, 2013

Building types matter. Taking stock of different building typologies is conducive to understanding the overall trend in building energy consumption. In fact, analyses show quite unequivocally that built form exerts a systematic influence on energy requirements for space heating and cooling, holding other variables constant. Studying this relationship empirically is straightforward in that the heating requirements of a building can be calculated using basic parameters (size, shape, and structure, internal and external temperatures, and the ventilation rate). In a much quoted study, the British Building Research Establishment compared the heating requirements of hypothetical dwellings, which were of similar volume and insulation standards, but exhibited different forms (BRE, 1975). For example, single-family dwellings, where all walls and the roof are subject to exterior elements, usually require more energy to maintain the comfort level in the house than an apartment, where there may be only one wall facing the exterior (Figure 16).

Figure 16. Influence of built form on heating requirements



Source. BRE, 1975

This difference in the level of energy consumption is of similar magnitude to that between poorly insulated buildings and those with medium insulation standards, implying that any widespread trend in the built form of new housing could have a decisive influence on the consumption of energy (BRE, 1975). It is difficult to demonstrate a clear empirical relationship between built form and heating requirements because of the number of variables involved. Studies based on a large variety of sources (including published statistics, records of public utilities, household survey, and, in some cases, individual metering of dwellings) all show enormous variation in domestic energy requirements.

While relying to a greater or lesser degree on conventional energy sources, buildings and settlements can be planned in order to take maximum advantage of the energy cycles of the natural world. Implication of climate responsive design would serve as a principled strategy to minimize energy demand by improving for example thermal comfort in cities (Shamsipour et al, 2014). Sitting, layout, and orientation of buildings determine the extent to which they can be warmed by or shaded from the sun, and ventilated by or protected from the wind (Pahl-Weber et al, 2013). The orientation of buildings and blocks is directly related to their passive energy absorbance (sun light) as well as passive ventilation capacity.

Ensuring appropriate orientation therefore provides possibilities for cooling, heating as well as ventilation of the buildings without any external energy sources (Wehage et al, 2013). One of the most widely used models for analyzing the urban form on energy efficiency is the urban canyon, which, as its name would suggest, refers to a linear space such as street which is bounded on both sides by vertical elements such as the walls of adjacent buildings. As a model, the urban canyon may represent both a recurring module from which the textured urban surface is composed, and an individual space that is inhabited at ground level by people and urban activities.

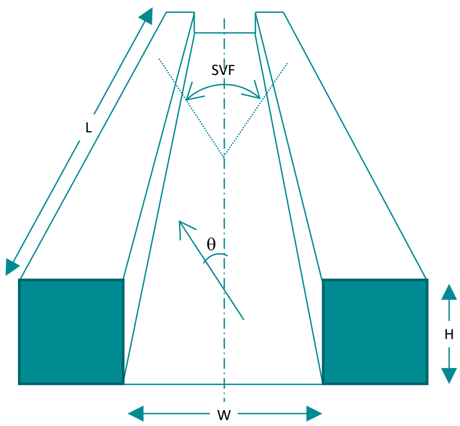
The geometry of the urban canyon may be described by three principal description (see Figure 17).

- The height-width (H/W) ratio, describes the sectional proportions of the urban canyon. It is defined as the ratio between the average height of adjacent vertical elements (such as building facades) and the average width of the space (i.e. the wall-to-wall distance across the street). While the aspect ratio applies most directly to symmetrical canyons whose adjacent buildings are of continues height and have a common setback, the averaging of both height and width allow for a general categorization of real-world streets which are almost always irregular to one degree to another. An additional measure, which is sometimes used together with H/W, is the canyon length (L).

- The canyon axis orientation (θ) represents the direction of the elongated space, measures (in degrees) as the angle between a line running north-south and the main axis running the length of the street or other linear space, measured in a clockwise direction. Often the canyon axis orientation is simply described by the closest cardinal directions (e.g. N-S, E-W) or diagonal (NW-SE, NE-SW).
- The sky view factor (SVF) of an urban canyon describes the cross-sectional proportions of the canyon. The SVF is the proportion of the sky dome that is "see" by a surface, either from a particular point on that surface or integrated over its entire area (Erell et al. 2012).

The geometric descriptions of urban canyons have been found to correlate in a useful way with a number of climatic effects. Both the aspect ratio and SVF of central-city street canyons have a direct relationship with the urban heat island effect, and the SVF is an essential parameter when quantifying the cooling of a space by long-wave radiation emitted from the ground to the sky or the exposure of diffuse solar radiation from the sky (ibid).

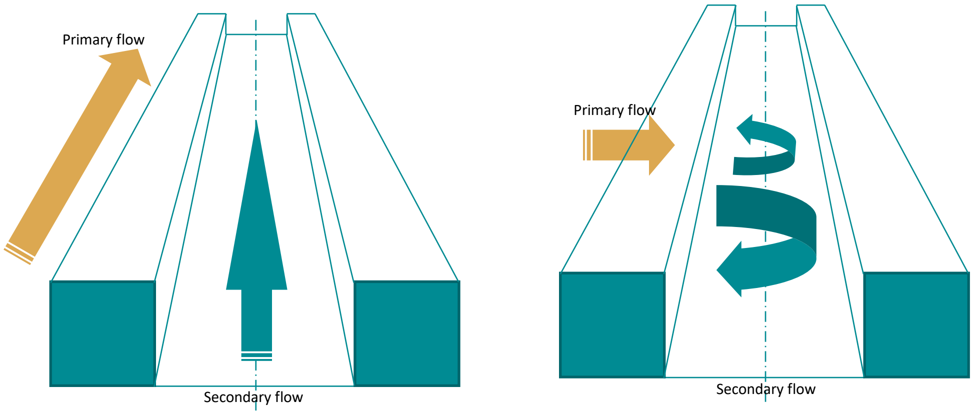
Figure 17. Schematic view of a symmetrical urban canyon and its geometric description



Source. Erell et al, 2012

Different threshold values of H/W have been shown to divide between different wind-regimes, or general patterns of air-flow over the urban surface, and the canyon proportions also play a role in direct solar shading and in the modification of urban albedo. The influence of building element on either air-flow or direct sunlight varies, however, not only with urban density but also with direction to the extent that canyon's axis orientation must also be considered with respect to the prevailing wind direction and sun angels (Erell et al. 2012).

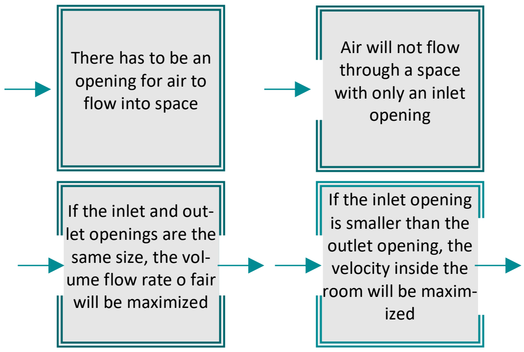
Figure 18. Idealized representation of wind flow in an urban street canyon



Source. Erell et al, 2012

Insulation of building envelopes, both opaque and transparent, is another influential measure for building energy conservation. Insulation of walls, roof, attic, basement walls and even foundations is considered an essential feature of energy-efficient buildings. In addition, as glass is a poor insulator, insulating transparent envelopes, windows and skylights, significantly reduces heat loss and gain during the winter and summer (Kim & Moon, 2009). Moreover, air flow requires inlet and outlet for passive ventilation of both in-door and out-door spaces (Bovill, 2015).

Figure 19. Inlets and outlets for air flow



Source. Bovill, 2015

Urban vegetation is credited with providing numerous benefits, such as mitigating the urban heat islands, reducing air-conditioning intensity in buildings, improving air quality and providing a psychologically superior setting for human activity. Landscaping, specifically the incorporation of planted areas in the urban fabric, may modify the microclimate of the areas in question, as well as the surrounding area. Typically, the availability of water and the resulting increase in evaporation result in lower surface temperatures. A recently irrigated lawn will therefore be cooler (during the daytime) than an otherwise similar lawn suffering a shortage of water. However, the effect of vegetation is quite complex, and varies with the type of plant, meteorological conditions and time of day. Under certain conditions, an urban park may even be slightly warmer than the surrounding built up areas (Erell et al. 2012).

Landscaping, such as the use of trees to provide shade in summer, has also significant impacts on energy demand. Traditional built form and micro location in different climatic regions that shows the benefits of built environment sitting in relation to microclimate have long been realized in practice. With energy conservation having become a significant issue in the recent past, interest in sitting in relation to microclimate has resurfaced. Table 3 provides building sitting prescriptions in relation to climatic features.

Table 3. Eco friendly design chart

Adaptation	**Cool regions: maximise warming effects of solar radiation, reduce impact of winter wind, avoid local climatic cold pockets**	**Temperate regions: maximise warming effects of sun in winter, maximise shade in summer, reduce impact of winter wind but allow air circulation in summer**	**Hot humid regions: maximise shade, maximise wind**	**Hot arid regions: maximise shade late morning and all afternoon, maximise humidity, maximise air movement in summer**
Position on slope	Low for wind shelter	Middle-upper for solar radiation exposure	High for wind	Low for cool air flow
Orientation on slope	South to south-east	South to south-east	South	East south-east for afternoon shade
Preferred winds	Sheltered from north and west	Avoid continental cold winds	Sheltered from north	Exposed to prevailing winds
Clustering	Around sun pocket	Around the common sunny terrace	Open to wind	Along east-west axis, for shade and wind
Building orientation	South-east	South to south-east	South towards prevailing wind	South
Tree forms	Deciduous trees near building, evergreens for windbreaks	Deciduous trees nearby on west. No evergreens near on south	High canopy trees. Deciduous trees near building	Trees overhanging roofs if possible
Road orientation	Crosswise to winter wind	Crosswise to winter wind	Broad channel	Narrow
Material coloration	Medium to dark	Medium	East-west axis, light, especially for roof	East-west axis, light on exposed surfaces,

Source. Keplinger, 1987

Among other factors, the average floor area per-capita is correlated with the general energy consumption in the building sector. Studies indicate that a positive correlations exist between the building floor area and energy consumption level. (Hamidi & Ewing, 2012). Policy-wise, steering-potential exists with master and detailed planning concepts for building developments especially in new development and urban growth areas.

Furthermore, domestic cultural and religious believes should also be considered in that and can affect development patterns (Pahl-Weber et al, 2013). Cultural backgrounds need to be taken into account in the planning and design of high density and compact structures. For instance, issues such as visibility from the neighbouring buildings are important factors to be integrated in urban development plans.

In terms of social norms and behavioural factors, a number of studies (Becker et al, 1981; Brandon and Lewis, 1999) indicate that environmental beliefs and/or socially responsible attitudes do not significantly influence energy consumption. Monetary savings, for instance, seem to be better motivators for energy saving. Elizabeth Shove (2003) finds that routine consumption is controlled to a large extent by social norms and is profoundly shaped by cultural and economic factors. She argues that current consumption patterns reflect that we generally remain unaware of routines and habits, particularly when it comes to energy and water consumption.

2.3.2 Spatial transport and mobility dimension

Urban areas offer significant opportunities for innovations in efficient transport technologies and services (Banister, 2008). Some of the main emerging trends include the alternative fuel vehicles market (e.g. electric vehicles, hybrids, and biofuels), co-operative vehicle infrastructure systems (e.g. automatic crash avoidance, fleet logistics management), real-time information and intelligent transport systems, and smarter mobility services such as car and bike-sharing.

While the innovations of the nineteenth and early twentieth centuries were driven primarily by the need to meet the mobility demands of people and freight on a large scale, in the previous years, transport technologies and policies have been driven increasingly by the need to provide efficient, clean, safe and sustainable mobility. Accordingly, there has been several policy directives and environmental legislation in recent years focusing on aggressive personal and industrial emission (Banister et al, 2000; Santos et al, 2010; Rodrigue et al, 2009).

Sustainable and energy efficient transport policy comprises a wide range of solutions and measures. As a background, the following table presents a sample of demand management policies, which ranges from charging and taxation to information and communication technologies (ICT) substitutions, such as e-commerce and telecommuting, to smart mobility measures encouraging lifestyle changes as increased walking or biking. Cairns et al. (2008) summarize the impacts of these measures from seven different studies, and demonstrate that soft policy measures may reduce traffic intensity by between 4 and 26 percent.

Table 4. Demand management policies and solutions for vehicle congestion

Demand management	Smart mobility	▪ Personal travel mitigation ▪ Walk/bike lifestyles ▪ Collaborative mobility
	Travel alternatives	▪ Alternative hours of travel ▪ Alternative work schedule ▪ Telecommuting/e-commerce ▪ Pedestrian/bicycle facilities ▪ Alternative fare strategies ▪ Public education campaigns
	Land use	▪ Smart growth policies ▪ Promotion of pedestrians/bicycle connections ▪ Transit stop/station design ▪ Transit oriented design ▪ Parking strategies
	Pricing	▪ High occupancy toll lanes ▪ Time of day pricing ▪ Activity centre pricing ▪ Parking pricing
	High-occupancy vehicles	▪ Rideshare matching/van-pools ▪ Priority parking for HOVs ▪ Parking cash-out ▪ Collaborative car sharing
	Transit	▪ Subsidized fares ▪ Transit oriented design ▪ Trip itinerary planning ▪ Transit security systems
	Freight	▪ Truck-only toll lanes ▪ Lane restrictions ▪ Delivery restrictions

Source. US FHWA, 2005

With regards to energy consumption in the transport sector, policy goals include the adoption of measures for increasing accessibility, the affordable provision of urban mobility services as well as promoting infrastructure that facilitates the widespread use of non-motorized options. Cities can be planned to be more compact with less urban sprawl and a greater mix of land uses and strategic sitting/placement of basic services to improve logistics and reduce the distances for passengers and goods. To this background, urban form and street design and layout can facilitate walking, cycling, and their integration within a network of public transport modes.

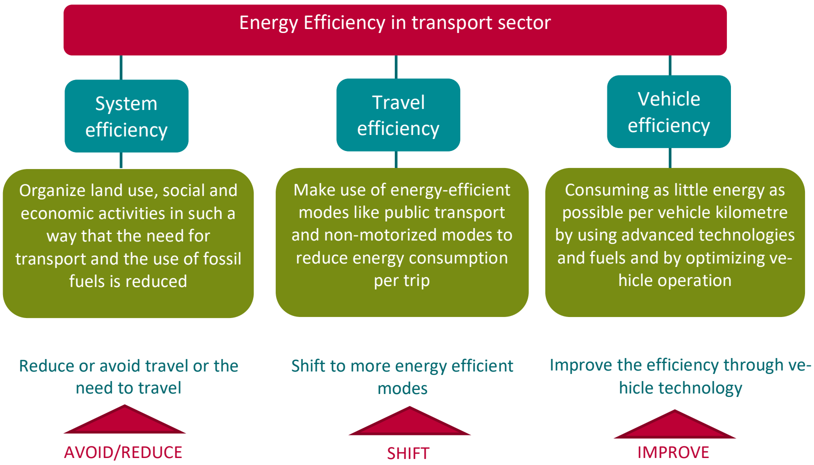
Studies on the interrelations between urban form and travel behaviour include a number of urban concepts ranging from the "compact city" stressing "the merits of urban containment" (Breheny, 1995: 82) to "decentralisation" referring "to all forms of population growth taking place away from existing urban centres" (Breheny, 1995:87). In other words, urban form not only shapes mobility, mobility also shapes urban form. Besides the impact of urban form on mobility, the competitive public transport systems and accompanying policies could induce reductions in energy use (induced by massive private vehicle use). Næss (2006) recognises the need for integrated transport related measures in urban planning accompanied by instruments to achieve significant changes. Likewise, public transport needs to be accompanied by land use and transport planning to restrict car use and direct development towards transit nodes (Anderson, Kanaroglou & Miller, 1996).

It is difficult to clearly verify the relationship between urban structure and travel behaviour. Some critics even consider it as 'weak' or 'uncertain', due to the importance of socio-economic factors and people's attitudes (Næss & Jensen, 2004). Breheny (1995), for instance, considers the present high mobility levels as a relevant obstacle to induce significant changes in travel patterns through changes in urban form. Certainly, socio-economic factors influence the effectiveness of energy efficient urban structures. But the consideration of socio-economic factors implies also the potential to carry out customised and, thereby, effective energy policies (Stead & Marshall, 2001; Stead, Williams & Titheridge, 2004).

Transport policy should emphasize on modes that are less energy-intensive, both for passenger and freight transport. In cities, change inducement works through a combination of push and pull measures, in particular, traffic-demand management can induce shifts from cars to public transit and cycling. Yet another mean is to promote non-motorized transportation, as there is wide agreement about its benefits to transportation and people's health. Parking policies, extensive carpooling and car sharing, combined with information technology, are key measures to reduce the use of cars. When transport choices are made, efficient road-capacity utilization, energy use and infrastructure costs for different modes should be juxtaposed (GEA, 2012).

Based on a holistic approach, energy-efficient transportation needs to be encouraged on three different levels: 1) individual vehicles (vehicle efficiency), 2) trips and commuting (travel efficiency) and the 3) transport system as a whole (system efficiency) (Böhler-Baedeker & Hüging, 2012). Two of the above mentioned dimensions are amenable to shifts through urban planning policies and are thus considered relevant to this research. These include "system efficiency" and "travel efficiency".

Figure 20. The energy efficiency targets in urban transport system



Source. Böhler-Baedeker & Hüging, 2012

A. System efficiency: strategies for reduction and avoidance

At the most general level, system efficiency relates to how and what kind of demand for transport (i.e. different modes of transport) is generated. Research has shown that infrastructure and city structures influence transport demand. Energy consumption per capita rises proportionally as city density drops (Newman and Kenworthy, 1989). The reduction in traffic volume is a crucial aspect of energy efficient transport. Land-use planning should therefore optimize the positioning of settlement and production structures to avoid traffic and reduce travel distances.

A dense urban structure with mixed uses is essential for a high system efficiency. It involves shorter travel distances and a model shift from road transport (high space consumption) to more efficient transport modes such as walking, cycling and public transport. The prerequisites for system efficiency do not only include a dense city system, but also proper management of the demand for transport and an adequate public transportation network (Böhler-Baedeker & Hüging, 2012). In order to reduce private motorized mobility, accessibility by walking, biking and public transport should be a priority. The location of residential and public facilities (e.g. schools and health facilities) together with supply qualities of public transport are the most important criteria in reducing the demand for car transport (Stoeglehner et al, 2016).

B. Travel efficiency: strategy for model shift

Travel efficiency relates to the energy consumption of different transportation modes. The main parameters of travel efficiency are the relative preponderance of the different transport modes (modal split) and the load factor of the vehicles. Energy consumption per passenger-kilometre varies between different modes of transport. An effective way of enhancing energy efficiency is to encourage travellers to use more efficient forms of transport, such as public transport and non-motorized vehicles. In general, private motorized modes of transport run on fuel and are much less energy-efficient than public transport. Travel using private motorized transport needs to be reduced, while the share of non-motorized and public transport must be increased. Increasing the share of public transport will lead to higher rates of occupancy in buses and trains, which will further increase the energy efficiency of public transportation (Böhler-Baedeker & Hüging, 2012). In general, mobility concepts that take the intermodal transport into account would provide a valuable input for integrated spatial and energy plans (Stoeglehner et al, 2016). Table 5 provides an overview of strategies for enhancing energy efficiency in urban transport.

Table 5. Strategies for enhancing energy efficiency in urban transport

Measures	Solutions
Expanding the role of public transport	▪ Improvements in the public transport system (increasing the attractively, accessibility and reliability) ▪ Enhancing the frequency of services and improving its operation
Enabling inter-modality	▪ Easy switch from private cars to public transport (i.e. providing park and ride facilities) ▪ High connectivity between public transport and non-motorized modes ▪ Adequate pedestrian and cycling infrastructure
Pedestrian and bicycle-friendly infrastructure	▪ Creation of continuous cycle network, possibly featuring separate bicycle lanes or even so-called cycle highways ▪ Shared bicycle services, which provide free or low-cost bicycles for public use ▪ Sufficient bicycle parking facilities ▪ Provision of safe sidewalks and pedestrians' crossings ▪ Restricted vehicle access to create pedestrian zones
System management	▪ Measures that reduce the speed or the quantity of motorized vehicles travelling in the city (i.e. license plate restriction concept) ▪ Creating environmental zones ▪ Speed restrictions ▪ Parking supply restrictions
Land use planning	▪ Smart land use policies could be designed to minimize the need for travel and reduce people's dependency on cars for transportation ▪ Mixed land use ▪ The density of built environment and functions ▪ Transit-oriented development (TOD) ▪ Reallocation of road space for the benefit of public transport or non-motorized modes of travel ▪ Maximum parking allowance

Source. GIZ, 2011

2.3.3 Communication technologies and urban energy efficiency

Introduction and focus area

As discussed previously, from the spatial perspective, two elements become fundamental while speaking around enhancing energy efficiency in planning for social infrastructure. These are energy efficiency in the building as well as energy efficiency in transport and mobility. In terms of buildings, due to the high energy consumption share in this sector there are considerable opportunities for enhancing energy saving. Discussions demonstrated that, there are three primary ways to enhance energy efficiency in the building sector, namely; through improved planning and design (utilization of passive energy gain as well as minimizing the loss of energy) to reduce heating, cooling, ventilating and lighting loads, through building upgrades and integration of new technologies (i.e. insulations, efficient thermodynamic systems) and the replacement of energy using equipment and by actively managing energy use (users habit).

Among the above mentioned measures, the focus of previous discussions were on the first dimension (spatial planning and design) and demonstration of measures to enhance energy efficiency in social infrastructure buildings. This includes planning and design measures for new buildings as well as design measures for retrofitting the existing buildings of social infrastructure[10]. In terms of transport and mobility, many urban growth areas (such as the District 22) are experiencing rapid growth of motorized transportation, especially when it comes to access to social infrastructures. This has been leading to severe congestion, which, in turn, is reducing the efficiency of the movements. Transport emissions have become a major contributor to air pollution and greenhouse gas emissions. The main cause of these problems has been the increasing preference for personal motor vehicles for commuting to work and access to urban services. Furthermore, urban development practices urban growth areas have worked in favour of such preference, leading to urban sprawl. Thus, remedial measures have to focus on reversing the preference for such modes of travel, shifting to public transport, cycling, or walking to minimize the need for private automobiles.

All the above mentioned measures both in terms of energy efficiency in building and transport sectors possess a spatial identity, with the potential of improvement through spatial planning and design. However, besides spatial dimensions of energy efficiency in planning for social infrastructures, another contemporary influential factor is the use of

[10] Both types of measures are relevant to district 22 as an urban growth area with a rapid pace of physical development.

Information and Communication Technologies (ICT). ICT has transformed how we live our lives and the way we interact in different contexts. Benefits of ICT and its upcoming efficiencies such as energy efficiency, are becoming the heart of many social infrastructures' reforms which have influenced the time, distance and space concepts. To this background, the main debate in this part of the research comprises of understanding the notion of electronic services, its planning and delivery process as well as analysis and recommendations for integration/improvement of electronic services for effective delivery of social infrastructures with the focus on District 22. This part of the study is built on a documentary analysis of literature concerning e-service, examined various web sites of government and cities including the research case study in order to have a broad understanding of contents and services available at the time of the study. These are accompanied by personal experiences (including the field observations), desk research and interviews with carefully selected individuals (presented in chapter 3[11]).

One of the main outcomes of this part is an integrated analysis around status quo of electronic service and further possibility of electronic provision of social infrastructure in the case study. To do so, a "three dimensional analysis approach" is chosen to assess the level of e-readiness in the case study. The e-readiness analysis method, comprises of infrastructure readiness dimension, organizational readiness dimension as well as services and systems readiness dimension.

2.3.3.1 Electronic services and their impact on energy consumption

The impact of ICT on the level of energy consumption can be discussed in two dimensions, namely the energy used by ICT equipment as well as the impact of ICT services on the energy use in different contexts. When it comes to the first dimension, ICT is usually thought of as computers and other electronic equipment. The infrastructure needed to use this end-use equipment is neglected most of the time. However, this hidden infrastructure (e.g. the servers that provide internet services and the radio antennas necessary to make mobile phone calls) is becoming an increasingly important component in ICT electricity requirements (Aebischer, 2008). Having discussed the energy demand of ICT the even more complex and relevant question regards the impact ICT might have on the overall energy demand. To do so, one has to consider:

[11] Where possible and in accordance to the availability of local data, both quantitative and qualitative analysis are applied, accompanied by demonstration of government's policies and initiatives in regard to electronic services planning and provision in the local context. The analysis will be used as a basis for gap analysis and delivery of recommendations in chapter 4.

- energy demand over the life cycle of different types of equipment, i.e. in addition to the direct energy demand discussed before, the energy for producing, distributing and refurbishing or recycling this equipment;
- efficiency improvements in technical and economic processes; of vehicles and mobility in general; and of buildings, appliances and other energy-consuming activities;
- structural changes of and within the economy, substitution between services, dematerialization of the economy;
- and acceleration of economic growth thanks to acceleration of labour productivity gains and rebound effects.

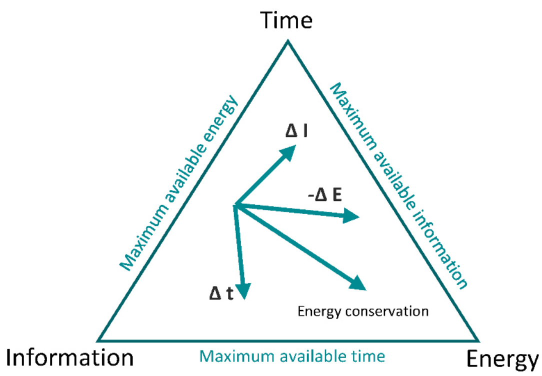
Most of the case studies investigate the impact of increased use of ICT in specific sectors of the economy. New organizational forms (i.e. e-work, e-commerce) and new products (i.e. e-paper, e-governance) are compared to traditional services and processes. Most of the studies do not question whether there is really a substitution between the traditional and the "intelligent" services and/or whether time and money saved by these new processes and services may lead to new energy consumption possibly balancing or even negating the original savings. Several authors discuss this topic and propose a framework "the three-order-effects of ICT" (Berkhout & Hertin, 2001; Fichter, 2002; Yi & Thomas, 2007: 845) for investigating these questions in a comprehensive way. These include:

- First-order impacts: direct environmental effects of the production and use of ICTs.
- Second-order impacts: indirect environmental impacts related to the effect of ICTs on the structure of the economy, production processes and distribution systems; the main types of positive environmental effects are dematerialization, virtualization and "demobilization".
- Third-order impacts: indirect effects on the environment, mainly through the stimulation of more consumption and higher economic growth by ICTs ("rebound effect"), and through impacts on lifestyles and value systems (Berkhout & Hertin, 2001: 2).

The third-order impacts are especially difficult to evaluate. Therefore, it is quite straightforward to try to evaluate the total impact of ICT by a top down macro approach, relating investments and/ or stocks of ICT to energy demand of an economic sector or of a national economy. Madlener (2008) for example, discusses some examples of macro evaluations. A rather comprehensive review of micro- and macro studies was also done by Yi/Thomas (2007). They conclude: “traditional assessment approaches are insufficient to accommodate the digital technology revolution and cannot accommodate the challenge of measuring the impacts of ICT on environmental sustainability and energy efficiency. New innovative methods need to be created to fill this gap”.

An alternative conceptual framework to examine the question of the impact of ICT is Spreng’s (1993) triangle. Spreng describes all economic activities in terms of time, energy and information. The precondition is that there is perfect substitutability between the three factors. Then information can be used to replace time, accelerating innovation cycles and increasing productivity without increasing energy demand; or just as easily information can substitute for energy (or natural resources) without increasing the time, labour or capital input. But in reality timesaving (or increase in productivity) by more information tends to increase energy demand, whereas more rational use of energy thanks to information may demand more time.

Figure 21. The time-energy-information triangle



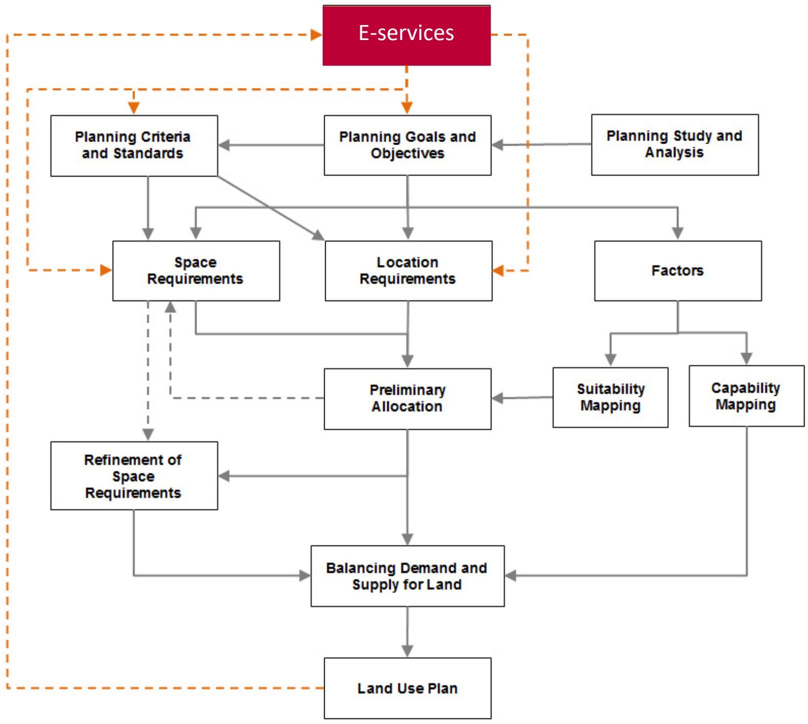
Source. Spreng, 1993

According to Spreng: “The importance of new information technology, in respect of future energy use can hardly be overstated. However, it can do two things. It can be used to substitute time by information or to substitute energy by information. In other words, it can be used to speed up the pace of life (work and leisure), thus promoting a society of harried mass consumers, or it can be used to conserve precious natural resources (energy and non-energy) by doing things more intelligently and improving the quality of life without adding stress to the environment. It is up to the society as a whole, politics of course included, to decide which of the two roads are taken” (Spreng, 1993).

A more subtle but nevertheless significant trend is the substitution of virtual activities for travel, such as teleworking, e-shopping, online banking and social networking. While some of these may substitute travel, the substitution patterns are generally far more complex. For instance, an online banking episode may clearly substitute a trip to the bank. But an online shopping episode might merely serve as a means of comparison shopping, followed by a trip to the store for the actual purchase; social networking activity online may serve as a scheduling tool for a meeting later in the evening at the theatre; time freed up due to teleworking may be spent in additional leisure travel and so on. While this trend of online activities is not directly related to the transport system, it is important to be aware of potential knock-on effects. Similarly, the role of mobile phones and smart phones in real-time scheduling, through the use of maps, text message and location-based applications, has very far reaching implications for how the transport system will be used. Location-based-applications, in particular, have the ability to produce completely unplanned, spur-of-the-moment activity driven by offers and discounts or online reviewes (Keirstead & Shah MD, 2013).

In the context of urban planning and according to the aforementioned illustrations regarding the role of ICT in social infrastructure and public services planning and provision, it is necessary to reconsider the spatial planning processes and to identify the areas in which ICT (in this context e-services) can be effectively integrated. One can illustrate the role of ICT in planning for social infrastructure as an integral part of a land use planning system. Land-use planning provides a balance between spaces and places in relation to the end user's demand and with the aim of enhancing service delivery quality. Stuart Chaplin and Kaiser (1979) have provided detailed discussion on the process of land-use planning. The following figure is based on their attempt and used here to present the influence area of e-services in planning for urban services. Two main contribution of e-services in this traditional planning system is on the allocation of services (impact on mobility) and physical space for services. The assumption in this research is that electronic services influence on allocation factors by reducing the need to move and therefore, reduced amount of energy consumed in transport sector. This happens due to demobilization, enhanced information flow and the improved online accessibility to services with less cost and time (Bawany, 2015). It also impact on the required physical space for service delivery (i.e. front and back offices) and therefore, less energy demand in heating, cooling and lighting.

Figure 22. The influence of E-Services on the traditional process of formulating land use plans



Source. Khodabakhsh, 2017 based on Chapin & Kaiser, 1979

2.3.3.2 Smart Cities and the concept of electronic services

The emergence of the “smart city” poses enormous challenges on cities and their planning. First, the city itself is being transformed from a place dominated by physical actions to one in which such actions are complemented by extensive use of information technologies. Second, many routine functions in cities are being replaced by computer controlled systems and various forms of automation are increasingly being blended with human actions. Third, the provision of data from these new electronic functions in the city offers the prospect of a world in which the implications of how the city is functioning is continuously available and such immediacy is compressing time scales in such a way that longer term planning itself faces the prospect of becoming continuous as data is updated in real time. One of the more widely used definitions defines smart cities as “cities that utilize information and communication technologies with the aim to increase the life quality of their inhabitants while providing sustainable development” (Bakici, Almirall & Wareham, 2013: 137).

Regardless of whether ICT takes center stage in the development of a smart city or not, it is clear that it acts as a key driver of smart city initiatives and thus needs attention from city planners and the various stakeholders interested in sustaining and improving quality of life in urban areas. Rapid development of ICT in line with application of new services has highly influenced urban life. In another word, the concepts of space and distance have lost their meaning and spatial elements of urban settlements are more and more integrated to the virtual (online and ICT based) ones. Undoubted, this is one of the dominant future urban transformations of most urban areas (Chourabi et al, 2012).

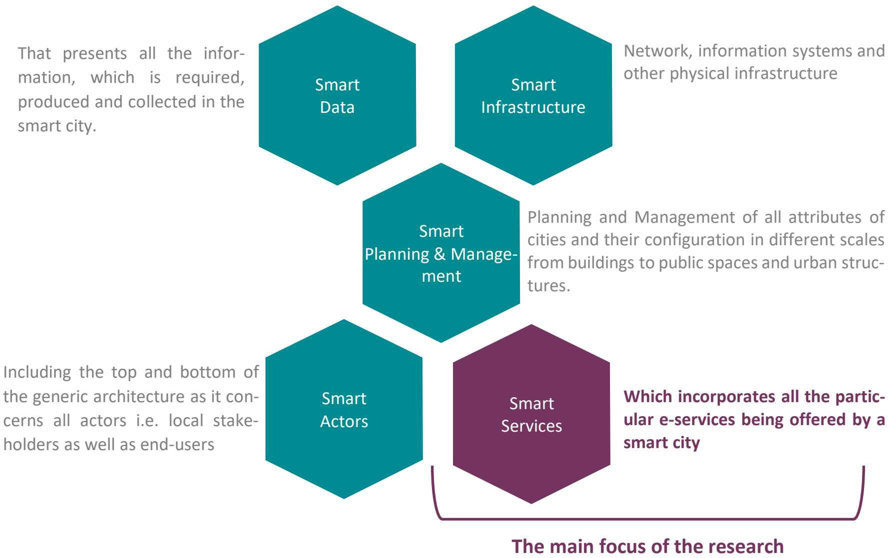
The Internet is changing the traditional urban planning and compelling planners to not only consider the physical dimension of cities but also to recognize the use of "Information Technology" in making the economy, environment, mobility and governance of a city more effective. Many current definitions of smart cities may not place such an emphasis on the central role played by ICT, nevertheless many definitions include some reference to the use of ICT for making modern cities more suited to the needs of citizens (Chourabi et al, 2012). To make an example, Caragliu, Bo, & Nijkamp (2009) view cities as smart when "investments in human and social capital and traditional and modern (ICT-based) infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory government". Harrison et al (2010) argue that a city is smart when it manages to connect the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city.

Since the eighties and nineties, the scientific literature has dedicated a lot of attention to the topic of the smart city, with a particular attention to the role of ICTs and their impacts on urban planning and on the structure of urban systems. For many visionaries in this field, new technologies and the overall information society contributed to the birth of a new economic era in the history of mankind and the concept of the information society has been successfully developed over the last 30 years by a number of distinguished proponents (Bell, 1974; Anthopoulos, 2011; Jones & Williams, 2005). In those academia years, international institutions and think tanks believed in a wired, ICT-driven form of city development. The focus was mainly oriented to the availability and quality of ICTs infrastructure within the urban system. In the contemporary debate, however, the concept of smart cities is much more related to the role of human capital, social and relational capital using ICTs.

In other words, we observe a growing attention to the role of the users and how they utilize communication infrastructures. The smart city seems to be an ideal solution to overcome existing and emerging urban population problems. Although, researchers have also identified challenges with reference to inequality, digital divide and changing cultural habits (Hofacker, 2007). Social adaption of such a system requires changing social habits of citizens in general and city management in specific (Jones & Williams, 2005).

In a more holistic approach, smart city consist of several dimensions. These dimensions form the backbone of all smart solutions in cities (Caragliu et al, 2009). These dimensions should be considered in an integrated system, meaning that if one element fails the whole smart system might collapse (Anthopoulos & Vakali, 2011). As illustrated in the figure, one important element in the frame of smart city notion is the wide spreading debate of electronic or digitally enabled services. ICT has caused a revolutionary transformation in urban service delivery and has made them smart, easy accessible, and available online. Since planning and provision of social infrastructure is the core task within this research, therefore, the focus in this part of the research is to understand and analyse the main factors and prerequisites in electronic delivery of social infrastructure. In general, an urban area can be considered as smart when city operations and services such as healthcare, education and transport are supported through ICT infrastructure in order to facilitate efficiency and ease of operation. Some valid examples of such services would be looking for a job, applying for a driver‘s license, buying of car and property, change of the address, request for a passport, start of a new business, reporting of a crime, declaration of income taxes, seeking health services, and so on. All such services require execution of several back and front office operations under an orchestrated coordination, designed by a citizen-centric approach (Bawany, 2015).

Figure 23. Dimensions of smart city and research focus area



Source. Khodabakhsh, 2017 based on Bakici et al. 2013

E-services are defined as those services that can be delivered electronically (Lovelock, 2004) and over electronic networks (Deakin, 2014). Boyer, Hallowell and Roth (2005) use the definition, "interactive services that are delivered on the Internet using advanced telecommunications, information, and multimedia technologies". Lovelock and Wirtz (2004) define service as "an act or performance offered by one party to another…an economic activity that creates value and provides benefits for customers…by bringing about a desired change in, or on behalf of, the recipient". This definition brings out both the process by which the service is produced and the outcome, in the form of benefits, that the customer receives. Both the service production processes and the outcomes are relevant when we consider e-services, as well. Regarding the service production process, an e-service is created and stored as an electronic code comprised of binary numbers, because it exists in a digital environment. Building on this, we observe that, by definition, the result of translating an act or performance into binary numbers is called an algorithm. Hahn and Kauffman (2002) have also identified e-services with algorithms. Using this idea, we could define e-service as: "an act or performance that creates value and provides benefits for customers through a process that is stored as an algorithm and typically implemented by networked software". Thus, our definition highlights the distinction between service production (a stored algorithm delivered by software) and service outcome (the desired benefit received by consumers).

By the entrance to the age of information the other side of information and communication technology with a tight linkage of citizens and government structures has appeared. Electronic government (e-government) as a major artery between the citizens and governments was developed (Allen et al., 2005; Kenny et al., 2001). With the arrival of the second decade of the 21st century, the view of governments has changed from the centralization of e-government policies toward the decentralization due to effective, integrated and personalized interactions of citizens and government. Nowadays, one application of this approach can be found in the concept of "electronic municipality (e-municipality)". E-municipality is one of the sub-categories of e-government which provides electronic services (e-services) to citizens in a smaller scale i.e. cities or even city districts (Scott, 2005; Gibbons, 2005; Moon and Norris, 2005; McMillan, 2004; Fletcher, 2004).

In a definition from Toots (2007), "e-municipality includes the use of information and communications technology (ICT) in order to facilitate the implementation of the governmental services, especially those parts, which are related to citizens' services.

Studies demonstrates that an appropriate implementation of the e-municipality concept is dependent to several many variables and factors such as:

- supply of financial resources in the local government in order to support the cost of the establishment, development and maintenance (Moon, 2002; Koh and Prybutok, 2002);
- attention to cultural, social, political and economic dimensions over the region as well as the existing end user's capacities (Gibbons, 2005; Kunstelj and De man, 2005);
- the capacity of the citizens to participate in developing and offering better services (Geiselhart, 2004; MacIntosh, 2003);
- political commitment and the pace of implementation/development of e-government activities in the country/region (Abdollahi, et al, 2009; Kunstelj et al, 2009; Esteves and Joseph, 2008), and
- Reducing central government interference in decision-making and handling it to cities and local governments (Gottschalk, 2009; Moon, 2002).

2.3.4 Organizational dimension of urban energy efficiency

Urban planning and design measures are necessary for achieving urban energy efficiency but not sufficient in and of themselves. What is required in addition are dedicated actors and a set of well-structured enforcement mechanisms. A number of authors (Alber and Kern 2008; Betsill and Bulkeley 2007; Collier 1997; Schreurs 2008; Bulkeley and Betsill 2005; Bulkeley and Kern 2006; Qi et al 2008) identified factors deemed crucial in shaping the local capacity to address climate change and urban energy efficiency issues. These factors are most prominently: leadership; municipal competencies; resources; and urban political economies.

Vertical and horizontal co-ordination (multi-level governance) is a key factor regarding capacities of local governance for energy efficiency (According to Betsill and Bulkeley, 2007; Alber and Kern, 2008). To date, evidence suggests that several many municipal climate change mitigation and energy efficiency policy remains concentrated in environmental departments, fragmented and often isolated from national and regional policy. This is due to dispersed nature of governing energy efficiency in cities which caused a highly fragmented strategies and actions. Therefore, a multi-level approach has increasingly been highlighted and demanded by different authors and expertise in the context of cross-cutting nature of governance (see Betsill and Bulkeley, 2007:448; DeAngelo and Harvey 1998; Bai 2007:24; Crass, 2008:7; Alber and Kern 2008:6).

Regardless of the constitutional form of government, multi-level governance calls for a narrowing or closing of the policy gaps among levels of government. It also provides a flexible framework to understand relationships between different actors horizontally across and vertically between different levels of government. On the one hand, the integration of energy efficiency policies with other policy sectors such as transport, planning, economic development and etc. call for a greater co-ordination between different agencies and policy division within municipalities (horizontal co-ordination). Furthermore, the vertical relation of different levels of government can enable or constrain municipal responses towards energy consumption mitigation. According to the pertinent literature, the co-ordination of competencies and resources, national level commitment and political will play important roles ensuring vertical co-ordination (Jasbi, 2012).

Table 6. Local governance capacity for urban energy efficiency

Key factors	Characteristics
Leadership (committed individuals)	In terms of the role of individuals as leaders within a municipality. The degree of institutionalization of energy efficiency agenda by policy entrepreneurs and political champions is critical to local governance capacity.
	Available opportunities for municipalities to perform leadership roles with respect to their peer communities.
Municipal government competencies and responsibilities	Competencies, power and duties of municipal government in the key sectors of energy, transport, planning and waste are critical in shaping the capacity for local energy efficiency policy and action. National policy and central-local relationship play very important roles. However, The capacity challenges facing municipalities with respect to their competencies and responsibilities are only partially derived from their relation with national government, but also dependent on their relation with other partners, and on the ability for local governments to create an enabling environment for local civil-society action. It demonstrates that municipalities have competencies both to shape their own emissions profiles, and through the use of different modes of governance can affect the emissions generated at the local level by a range of actors and activities. Research shows that when competencies for regulation, provision and enabling modes coincide, capacity to act on climate change and energy efficiency can be achieved at higher levels.
Resources	Local authorities' financial and human resources can support in addressing climate change and urban energy issues. Limited human resources can make a significant difference to the extent and efficiency of measures. While lack of finance for basic service provision is acute in many cities, this is also a key issue in relation to the mitigation of climate change and improving energy performance for investment in low carbon energy and transport infrastructures. Both, external and internal source of funding are critical. Significant difference in the local capacity can happen through secure funding from external sources like national governments. Presence and ability of individual political champions or policy entrepreneurs are the key factors for securing internal funding. Innovative financial mechanisms within municipalities such as energy performance contracting can overcome their inflexible budgetary structures.
Urban political	Climate protection and energy conservation are political issues, where different actors and groups have their own understanding of the problem and responding

economies	upon. A key aspect in this regard relates to the priority which is accepted locally. Often climate change and energy efficiency responses considered as a negative connotation that slow economic growth and hinder development of basic needs. However, reframing or linking energy efficiency and climate change problem to other pertinent local issue such as air quality can mobilize local action on climate change effectively.

Source. Bulkeley et al, 2009

2.3.5 Energy Efficiency and social infrastructure planning

Introduction and focus area

Social and community infrastructure and services are provided in response to the needs of communities. Infrastructure as well as social infrastructure is assumed to explicitly impact energy consumption levels, insofar as consumers, urban built spaces and urban mobility are directly involved. A considerable amount of energy is being consumed in different sectors, which directly and indirectly are connected to social infrastructure (namely; heating and cooling spaces, mobility and access to these services etc.). Although social infrastructures occupy less space and land in comparison to residential built areas, but they still generate a considerable amount of energy demand in cities. Their impact on energy demand is twofold. On the one hand, they consume energy in (often public) buildings for heating, cooling and lighting purposes. On the other hand, they impact heavily on urban transport and mobility intensity. These aspects of social infrastructures and its impact on energy consumption level in cities is often being underestimated. Several types of spatial planning measures can optimize energy demand and the level of consumption generated by social infrastructures. However, no systematic analysis has been carried out to identify and classify them systematically and to explore their impact on energy efficiency.

Analysis of the traffic data in different cities indicates that a considerable share of generated motorized trips belongs to social infrastructure (i.e. education, health, recreation, administration) and other not home-based targets. In terms of energy consumption in buildings, social infrastructures have extremely high energy consumption level in cities. Nevertheless, high cost effective saving potentials have been proven both for existing and new buildings. For existing buildings, the crucial factor will be the possible speed of refurbishment. Implementing standards for new buildings and for building renovations together with applying controlling mechanisms for monitoring the building standards, are among the most important measures in reducing the energy consumption in social infrastructure buildings (Moshiri & Lechtenböhmer, 2015).

Energy saving for social infrastructure doesn't only contribute to CO_2 reduction but also enhances public cost savings. Because of the large numbers of users, it is also a key to communicate more sustainable attitudes towards nature and energy as well as to develop greater understanding about new energy-saving technology. Against this background, it is critical to seek out solutions targeting the minimization of energy consumption in cities by implanting sustainable urban planning and design measures.

Having scoured the literature on energy efficiency, I shall now continue surveying the literature on social infrastructure planning with an emphasis on influential planning processes and criteria. Taking it from there, I will establish a link between energy efficiency and design measures and social infrastructure planning features. Having done so, I will provide an integrated and comprehensive checklist of energy efficiency and design measures in relation to social infrastructure planning that I shall apply to the case study (chapter 3).

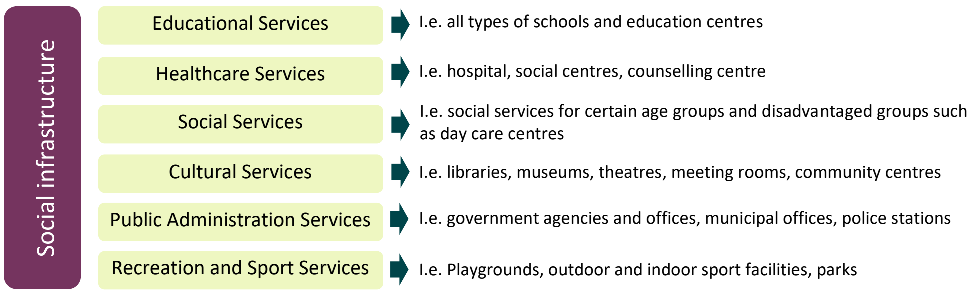
2.3.5.1 The contemporary concept of social infrastructure

As mentioned earlier, "Infrastructure" itself means ''the basic framework of a system or organization'', while the prefix ''infra'' itself, means ''below or beneath''. So infrastructure is what is below or beneath a structure. "social" is identified in terms of or pertaining to society and its organization (Funk, 1980 - own translation). Therefore ''social infrastructure'' can be seen as the basic framework of services relating to the organization of society, underlying any human settlement (CTBUH, 2001 - own translation). Social infrastructure is an imprecise term for very different types of facilities and services in local communities. A generally accepted definition of social infrastructure does not exist, as the interconnected topics vary across problem statements and perspectives. However, from a comprehensive point of view, the following categories can be said to include a wide array of social infrastructure:

- Education (all types of schools, pre-schools, community colleges),
- Health care (hospitals, social centres, counselling centres),
- Social services for certain age groups and for disadvantaged groups (kindergartens, day care centres, homes for the elderly, nursing homes, facilities for disabled, homeless, foreigners, counselling centres, and etc.),
- Cultural institutions (libraries, museums, theatres, meeting rooms, community centres, etc.),
- Institutions of public administration and safety (government agencies and offices, police stations, etc.),
- Recreational, sports and recreational facilities (playgrounds and sports surfaces, outdoor and indoor swimming pools, parks, etc.).

Even local shopping facilities for local businesses and local services can be attributed to certain aspects of the social infrastructure (ARL, 2005 - own translation). Social infrastructures are provided in response to the needs of communities. They enhance the quality of life, equity, law and order, stability and social wellbeing. Social infrastructures are often referred to as social services, public services, public facilities or public amenities as well as basic public services. Social services are services which are provided with the main aim of improving social welfare. These services include education, health care, police and fire protection, and a variety of cultural and recreational services. In accordance to the Handwörterbuch der Raumordnung, social infrastructure is an imprecise term for very different types of facilities and public services in communities. It can be seen as the basic framework of services pertaining to the organization of society, underlying any human settlement. Figure 24 depicts different categories of social infrastructure.

Figure 24. Main categories of social infrastructure



Source. Handwörterbuch der Raumordnung, 2005 (own translation)

In general, social infrastructure includes almost any infrastructural elements pertaining to people's socialization and the way they become an active and productive part of society including their social welfare, their emotional and physical well-being as well as their social life. It includes schools, childcare centres, libraries, and other places where children learn how to use skills they will need as adults. It also incorporates adult education facilities, literacy centres, multicultural and multilingual centres, services for people with disabilities, and places where adults engage in life long processes. Hospitals and health clinics, parks, playgrounds, sports and recreation centres – places that help keep people healthy – are vital components of social infrastructure. Social infrastructure also includes the theatres, art galleries, music halls, and movie houses that bring people together for arts and entertainment (Marcus and Sarkissian, 1986 - own translation).

Social infrastructure is often labelled in terms of "soft" services, as opposed to "hard" services, such as roads, water, sewers, electricity, and heating pipes underlying a settlement. While there are building codes which specify how much sewage capacity or electrical outlets must be provided in a given building, there are limited corresponding "social code" which would for instance stipulate minimum common meeting spaces in apartment buildings, or a certain amount of "affordable" grocery stores per hundred units of offices.

While there are certified engineers trained to create and inspect physical infrastructure, other relevant professionals such as planners or architects, rarely exhibit a solid background in terms of social infrastructure. Whereas, in advanced industrialized countries such as Australia and Canada moving into houses is uncommon before there are sewers, roads and water in place, moving in often takes place before the necessary schools, recreation centres and health care facilities are built. In fact, there are examples of entire districts of high rise office buildings where the thought that people might have to shop for groceries before, during, or immediately after their work day was not even considered, for instance, St. Kilda Road in Melbourne (Huxley, 1994).

Toronto has often been named one of the best cities in the world to live and work in by corporate analysts and business magazines (Fortune Magazine, 1996; Corporate Resourcess Group, 1995). This is because the city is considered safe, stable, clean and green and all of that despite horrendous traffic and relatively high taxes (compared to other cities in the United States). The upshot is that there are tremendous economic opportunities related to promoting social infrastructure, and terrible fiscal, as well as human, costs related to dismissing or downplaying it.

Many framework conditions for the provision of urban infrastructure, which have remained comparatively stable for decades, are currently undergoing considerable change. The societal debate addresses not only how but also what, why, and how much infrastructure is to be provided in cities. There is a lack of research into the development of both social and technical infrastructures over the decades to come and how this will affect and interact with forms of construction in urban development. As a consequence, urban development lacks guidance on dealing with these challenges. The increasing uncoupling of planning functions from utilities and service providers in many places renders necessary and likewise more difficult a systematic reflection on urban development, planning and infrastructures (Libbe et al, 2010 – own translation).

2.3.5.2 Energy efficient planning & design measures for social infrastructure

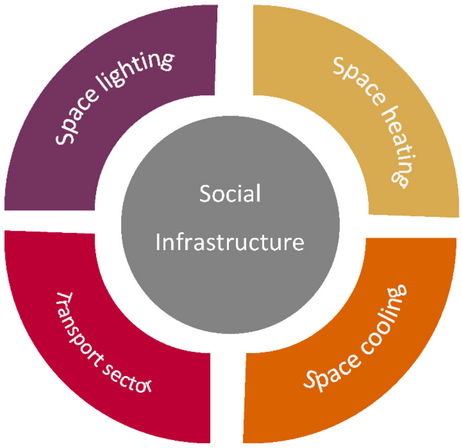
In the current debate on the reorientation and transformation of infrastructure, there exist some strong references on principles such as flexibility 'and' adaptability (e.g. Kluge & Libbe 2006 – own translation) taken as the subject of sustainability research (especially in climate research) (see, also, among other things Beckmann, 2006 - own translation). In terms of infrastructure, existing path dependencies should be overcome in view of increasing uncertainty in planning and to seek intelligent system solutions. For example innovative conceptual change through the flexible design of infrastructure. Regarding the technical infrastructure this mainly concerns the adaptation of existing networks and systems by supplementing (adaptation) the new technology lines (Koziol, 2006 - own translation).

With regards to social infrastructure, flexibility in planning implies susceptibility to possible influential factors, multiple uses of buildings as well as changes in the ownership as well as integration of new technologies in the process of service provision (In terms of involvement of private sector, non-profit institutions or rather official; See. Winkel, 2008 - own translation). With regards to energy efficient urban and infrastructure development, there is a debate that spatial models alone are not sufficient to fulfil the efficiency targets. They need to be accompanied by concrete planning and construction order as well as testing principles for dealing with planning for uncertainty. Furthermore, the ability to cope with technological development should be considered as one of the core components of future developments. In terms of planning for social infrastructure, efficiencies can be gained through a wide range of planning and design measures. This includes form and functional measures which influence energy consumption in the building and transport sector. Many urban energy related studies examined energy consumption in residential buildings focussing on architectural design and the application of new technological solutions. Energy statistics also confirm the importance of residential buildings in terms of furthering efficiency in the urban energy debate.

Despite the importance of residential buildings and their contribution on energy consumption and energy intensity in urban areas, energy consumption in public services and public buildings (the so called social infrastructures) is widely underestimated. The amount of social infrastructure energy use (i.e. for heating, cooling and lighting) might be less than the total energy use of housing and residential stocks in urban areas, however their relative energy use/demand is not limited to building sector. Social infrastructures are the main generators of urban movement and the energy consumption in the transport sector. This is an area where urban planning and design contribute by way of concepts such as balanced allocation of services aiming at minimizing travel distances, mixed uses, transit oriented development as well as push and pool strategies (Figure 25).

In additions, because of the large numbers of users, it is also a key to communicate more sustainable attitudes towards nature and energy as well as to develop greater understanding about new energy-saving technologies and planning approaches.

Figure 25. Impact of social infrastructure planning on energy sectors



Source. Khodabakhsh, 2017

Against this background and in accordance to the comprehensive set of energy efficiency planning and design measures addressed in this chapter, a modified checklist for energy efficiency measures for social infrastructure planning is introduced (Figure 26). The figure provides an insight of the main urban planning and design measures in relation to energy consumption generated by social infrastructure and comprises of three influential dimensions:

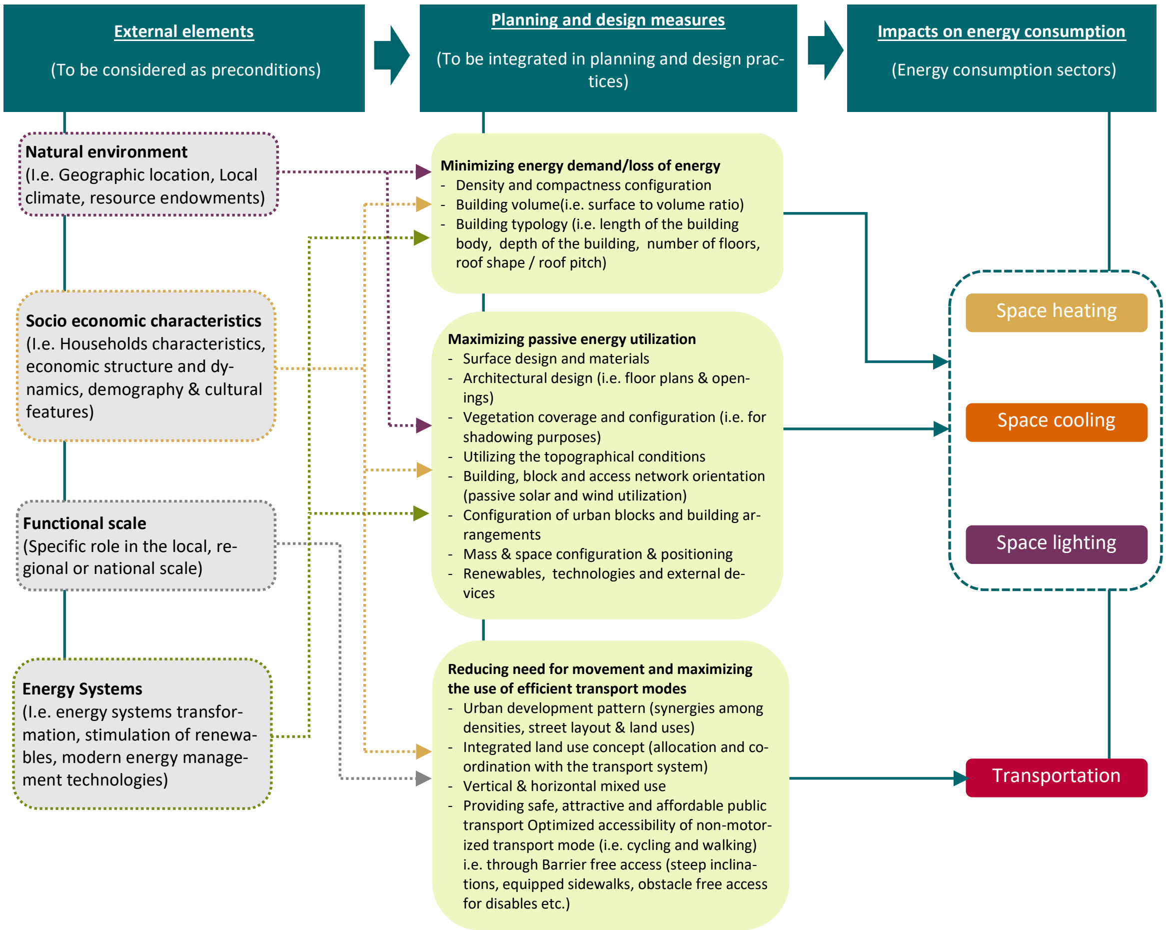
- External elements: to be considered as preconditions
- Planning and design measures: to be integrated in planning and design practices of social infrastructures
- Impacts on energy consumption: demonstrating the impact of each measure on each energy sector

In terms of planning and design measures, the figure classifies measures in to three main dimensions namely:

- Measures to minimize the energy demand and loss of energy
- Measures to maximize the passive energy utilization
- Measures to reduce the need for movement and to maximize the use of efficient transport modes

As one of the main outputs of this chapter, the figure provides a comprehensive set of measures for energy efficient planning and provision of social infrastructures, which will be further used as a basis for analysis in the case study.

Figure 26. Influential planning & design measures on building and transport energy use



Source. Khodabakhsh, 2017 adopted from GEA, 2012; Owens, 1984; Große et al, 2016; Pahl-Weber et al, 2013; Peseke & Roscheck, 2010; GIZ, 2011

Comparative literature studies (Chapter 2) indicates that planning for energy efficiency is a relatively new field of action with limited generalized knowledge either within the scientific literature or practice. Energy efficient planning and design of social infrastructure requires the integration of several disciplines such as urban and regional planning, ecology, economy, sociology and landscape architecture in order to create balance in terms of energy and planning/design qualities. Achieving such quality targets requires active participation of several stakeholders. One can divide stakeholders to those affected by the results (e.g. target groups, citizens and communities) and the stakeholders who play an active role in the process (e.g., planners, investors and responsible administration/local authorities). In terms of planning procedures, recent international developments indicate a shift from master planning to more process-oriented strategic planning approaches (UN-Habitat 2009: 47). Importantly, however, there are no pre-defined and optimal planning procedures to apply. At the very least, the basis for creating an energy-efficient urban form begins with an analysis of the local context taking into account the geographic and socio-cultural context as a means to develop criteria for different design scenarios.

Planning for energy efficient social infrastructure furthermore taps into a wide range of thematic fields including economic, social and environmental issues. Relevant indicators include land use and density, building configuration and design, movement and access regimes, open space design as well as energy supply. In the present context, two crucial dimensions are the form and functional dimension of social infrastructures and their specifications. The urban form and arrangement of built and open space of social infrastructure influences the microclimate by determining heat and light exposure (e.g. incidence and shading) as well as by affecting natural ventilation (e.g. wind and air exchange). It also allows for the use of renewable sources (i.e. PV pannel in social infrastructure buildings). The high level of solar radiation in the arid and semi-arid climate of Tehran, for instance, offers extensive passive energy potential which can be effectively utilized. At the same time, this effect needs to be put to work in a manner which avoids overheating. In terms of spatial planning, strategies for an energy-efficient social infrastructure form and function need to ensure the minimization of thermal loss in the buildings, the maximization of passive energy impact/passive energy use and the optimized allocations, which impacts on the access and mobility qualities of citizens to social infrastructure nodes.

The optimization of the social infrastructure building's volume can improve its thermal characteristics to a considerable extent. To this end, two conceivable strategies are: optimized compactness and surface-to-volume ratio. This configuration can reduce thermal loss through building surface and efficiently regulate the interior climate against outside temperatures. This can be achieved in different ways, through architectural design as well as urban planning and design strategies. Improving the surface-design and material is one such measure to reduce the influence of outside climate on interior spaces (i.e. openings configuration and colour of the surface).

Stimulating the use of passive energy helps to reduce active energy demand for cooling, heating and lighting in social infrastructure buildings. This includes optimized utilization of solar and wind energy for heating, cooling and lighting purposes. Solar energy has a great potential to be utilized more effectively in many regions in Iran. There already exist plenty of examples where smart (traditional) urban form patterns were applied in response to intensive sun and wind exposure. One example is the street layout and orientation (canyons) to maximize channelling the wind and providing shade (examples can be found in arid climates such as Yazd city in the centre of Iran). By contrast, in regions with cold winters sunlight on south-oriented surfaces helps to reduce the need for indoor heating. This pattern is observable in most cities in the northern geography of Iran. The combination of these measures considerably affect the level of energy demand in an urban environment.

Growing urban settlements require land available for housing as well as social infrastructure building purposes. This has resulted in a rapid physical expansion of cities and the creation of several urban growth areas (such as the District 22). To limit the impact on the natural resource cycle by such physical developments, the land intake should be reduced to a minimum. The compact and dense urban form, which is observable in many traditional Iranian cities, is a suitable approach for minimizing land consumption (i.e. low-rise, high density urban spatial structures).

The structure of the urban fabric can influence the cooling and heating demand of buildings e.g. the social infrastructure buildings in several ways. One key feature is built density. Higher densities allow for more efficient infrastructure systems, especially semi-central and decentralized systems, such as district heating. Urban texture can also influence energy consumption through morphology, e.g. through building typologies and configurations. The orientation and location of social unfrastructure buildings have a bearing on passive solar gain, as well as shading potential and the exposure of buildings to wind. Here social infrastructures have higher level of flexibility, as they often are located in larger parcels, which creates room for flexible configuration of mass and space as well as the orientation of the building. Another important factor is building compactness, which influences heat gain and loss and therewith reduces energy demand. Yet another factor is the orientation and dimension of access networks, which influence the solar gain of both the streets themselves, as well as the adjacent buildings, therewith impacting the ventilation of the entire urban area. Urban form and functional measures and their impact on mobility is another influential area in planning for energy efficiency. Mobility in the Iranian context and especially in the Tehran region primarily revolves around individual vehicles, thus consuming a considerable amount of energy resources and producing a large share of CO_2 emissions.

More energy efficient alternatives to individual vehicles ought to be found. An efficient public transport system needs to be developed and integrated within a city or region’s urban development concept together with efforts to minimize the necessity for long-distance daily travel. This requires a good balance of social infrastructure allocation. Mixed-use concepts (both vertical and horizontal mixed uses) can greatly reduce the need for motorized travel, especially when it comes to social infrastructures, which has the potential to generate a considerable amount of urban trips.

In short, urban form and function influence the level of energy consumption and GHG emissions to a considerable extent. Here, urban planning is a tool, which regulates densities, land use patterns, and infrastructure systems, as a result influencing the distribution of goods and users. Appropriate planning and design measures can affect the energy consumption level in cities as well as energy consumption patterns of individual energy consumers. Integrating these features, into the urban planning practices is a key requirement for achieving an urban fabric that is responsive to the local climate and, as a result, more energy-efficient. On the level of urban planning the above-mentioned features of the social infrastructures can be regulated in urban development plans through regulations and policies on building densities and built up areas, building configuration, such as height, depth, type, and orientation as well as planning for traffic areas.

Further elaborated on the figure above, a detailed demonstration of the planning and design measures on improving the energy performance of the social ingfrastructures is presented in the following table. Accoridng to the findings of energy efficiency literature, the impact of planning and design measures on energy efficiecny are multifold and comprises of the following typology of impacts:

❶ Minimization of the building energy demand
❷ Minimization of the building loss of energy
❸ Maximization of the building passive energy utilization
❹ Reduction of the need for motorized transport/movement
❺ Minimization of the VMT (Vehicle Miles Traveled)
❻ Maximization of the use of efficient transport modes

Table 7. Social infrastructure energy efficiency measures

Measures	Implication scale: Building	Implication scale: Urban structure	IMPACT
Density and compactness configurations of the social infrastructure and its surrounding built environment	×	×	❶❷
Building volume (i.e. surface to volume ratio) of the social infrastructure buildings	×	×	❶❷
Building typology of the social infrastructure (length of the building body, depth of the building, number of floors, roof shape / roof pitch)	×	×	❶❷❸
Surface design and materials of the social infrastructure	×	×	❶❷❸
Architectural design (i.e. floor plans & openings) of the social infrastructure	×		❶❷❸
Vegetation coverage and configuration impact on social infrastructure buildings thermal behaviour (i.e. for shadowing purposes)	×	×	❶❸
Utilizing the topographical conditions (i.e. south facing slopes) for passive eneryg utilization of the social infrastructure buildings	×	×	❶❸
Building and block orientation of social infrastructure to regulate passive wind utilization	×	×	❶❸
Building and block orientation of social infrastructure to regulate passive solar utilization	×	×	❶❸
Street network orientation and dimension to regulate passive solar and wind utilization for social infrastructures		×	❶❸
Configuration of urban blocks and social infrastructure building arrangements	×	×	❶❸
Mass & space configuration & positioning of the social infrastructures	×	×	❶❸
Renewables, technologies and external devices for social infrastructures	×	×	❶❷❸
Electronic delivery of the social infrastructure services	-	-	❶[12]❹❺
Urban development pattern (synergies among densities, street layout & land uses)		×	❹❺
Integrated social infrastructure concept (allocation and coordination with the transport system)		×	❹❺❻
Vertical & horizontal mixed use of social infrastructures	×	×	❹❺
Providing safe, attractive and affordable public transport to social infrastructures		×	❻
Optimized accessibility of non-motorized transport mode (i.e. cycling and walking) i.e. through barrier free access (steep inclinations, equipped sidewalks, obstacle free access for disables etc.)		×	❹❺

Source. Khodabakhsh, 2017 adopted from GEA, 2012; Owens, 1984; Große et al, 2016; Pahl-Weber et al, 2013; Peseke & Roscheck, 2010; GIZ, 2011

According to simulations carried out for sample builidngs in Tehran region in the frame of Young Cities project, a selected list of planning and design measures and their impact on energy efficiency in the buildings are proposed. Some of the main results of the analysis are presented in the following table. It presents the positive and negative effects of different architectural design features in reducing the energy demand in buildings in Tehran (Nasrollahi et al, 2013). A similar results can be concluded for the social infrastructure buildings.

[12] Through minimization of the need for built spaces (front and back offices) and delivery of the services via online means

Table 8. Effect of design features on the energy demand of a building in Tehran

Features			**Effect**
Orientation	south		++
	north		--
	east		--
	west		--
	south-east		+
	south-west		-
	north-east		--
	north-west		--
Elongation	east-west		++
	north-south		--
Increase of window area	south-facing windows		++
	north-facing windows	in buildings with a large area of south-facing windows	-
		in buildings with a small area of south-facing windows	--
	east-facing windows	in buildings with a large area of south-facing windows	-
		in buildings with a small area of south-facing windows	+
	west-facing windows	in buildings with a large area of south-facing windows	-
		in buildings with a small area of south-facing windows	+
	skylights	without shading device	-
		with internal shading device	-
		with external shading device	+-
Increase in thenumber of storeys			+
Shading devices	external	Fixed	+
		Adjustable	++
	internal	Adjustable	+-
Compactness	decrease in the external envelope		+
	increased length of south-facing façade		+
++very positive, + positive, --very negative, -negative			

Source. Nasrollahi et al, 2013

An example of school buildings

School buildings are important elements of social infrastructures, which considered to be one of the main consumers of energy. Considering the builindg typology, occupancy patterns as well as allocational features, school builidngs have a significant potentials for energy demand optimizations (Zomorodian & Nasrollahi, 2013). Statistics show that the average energy consumption in school buildings in Iran is more than 160 kWh/m^2 (Iranian Fuel Conservation Organization, 2009) which is two times more than the energy consumption level of schools in developed countries (Im & Habrel, 2006). Looking at the iranian context, there have been no particular regulation or guiding measure for improving energy performance of the schools buildings through climate responsive design. However, one of the most effective and ecological methods to improve energy savings is the reduction of energy demand throgh climate responsibve design, which is cost-neutral and reosurce efficient. Againts this background, some of the influential features of energy efficiency of schools are presented below in two categories, namely in the building, as well in transport/mobility. The aim is to present demonstrative quantitative and qualitative results from existings studies and simulations.

Since school buildings have specific occupancy patterns, certain regulations should be considered for the thermal insulation of these buildings. In Iran the ministry of energy has not developed specific regulations for the thermal insulation of school buildings and they are considered the same as other buildings such as restaurants and hospitals. According to the regulations only the roof and windows should be insulated. Simulations shows that by using thermal insulation in the roof and double glazed aluminium windows the primary energy demand of the school building decreases 6% in comparison to the existing case. This is due to the reduction in the heating energy demand (Zomorodian & Nasrollahi, 2013).

Infiltration is another important parameters that affects the energy demand in buildings and is determined by air change per hour. Air tightness of the building envelope relates to the window and door type, materials used and the quality of the construction process (Bankvall & Sikander, 2008). In Iran no regulations have been developed for the air tightness of buildings and due to the low construction quality of buildings, infiltration has been considered as one of the main routs of heat loss in buildings. Air tightening the building envelope will reduce the heat lost and improve the indoor air quality. The results of simulation shows that an infiltration rate more than 0.75 ach increases the primary energy demand in comparison to the existing case. Because of the high density in classrooms, decreasing the air change rate can affect the indoor air quality due to the lack of fresh air. The primary energy demand of the model with 0.75 ach infiltration shows a decrease of 11% in comparison to a case which has an infiltration rate of 2 ach (Zomorodian & Nasrollahi, 2013).

Configuration of the opening such as the window area in different orientations is one of the most important architectural factors affecting the building's energy demand. Windows provide solar heat gain, daylight and even natural ventilation for indoor spaces. Since windows are the weakest thermal link in the building envelope, their design has a direct impact on the thermal comfort and the energy demand in buildings. In school buildings due to the room size, the window-to-wall ratio is usually high. Therefore, by designing appropriate windows a balance between lighting, heating, cooling and ventilation would be obtained. In order to define an optimum window-to wall ratio in different sides of the building several simulation shall be done. Here, an important parameter considered in defining the optimum window-to wall ratio is the daylight factor (BHRC, 1992). As an example and in the viewpoint of energy efficiency a 20% window/wall ratio is optimum when only lighting is considered. Here the heating demand first increases by increasing the window/wall ration from 0% to 10% and then decreases with a high inclination due to the increasing amount of solar gain. This shows the high potential of using solar gains for heating purposes. Despite the high potential of solar gain for heating, the cooling energy demand highly increases by increasing the window/wall ration. Simulations show that the building with optimum window to wall ratio has 8% less primary energy demand (Zomorodian & Nasrollahi, 2013). Sun penetration in indoor spaces is the main reason for space overheating in warm seasons. Provide appropriate daylight level in classrooms with large windows requires shading provisions to prevent sun penetration in warm months. Sun shading is an effective strategy in decreasing cooling energy demand in hot and dry climates. Increasing the overhang projection size increases the heating and lighting energy demand and decreases the cooling energy demand.

The increase in heating energy demand is more than the decrease of cooling energy demand which is because of the high solar altitude in the Iranian context and the school occupied hours which is mostly in the morning. A balance between the lighting, heating and cooling energy demand can be obtained by considering appropriate shadings which can allow sun penetration in cold months and prevent it in warm months. Simulations show that the primary energy demand of a building with an optimum shading device decreases up to 5% (Zomorodian & Nasrollahi, 2013). Building orientation is an important design factor in the building energy consumption. By optimizing the school building orientation the sun radiation and daylight can increase in summer and winter and the energy demand for lighting, heating and cooling can decrease. The school building's orientation and the energy demand are directly linked due to the window orientations. The dominant wind direction is also considered in defining the optimum orientation (Zomorodian & Nasrollahi, 2013).

The energy demand of buildings specifically depends on the shape and typology of the building. Form and shape are critical factors in absorbing and radiating heat during the day and night and thus a critical parameter in the building's heating and cooling energy demand. Various formal factors including elongation and compactness, number of stories, plan shape, roof form, wall slope and the ground adjacency level are investigated in order to find the optimum value for each parameter. The compactness of the building which is the result of omitting the side projection of the building can reduce the primary energy demand up to 3% (Zomorodian & Nasrollahi, 2013). Besides building morphology of the school buildings, urban planning factors influence on the level of energy consumption in urban areas. Optimization of the allocational measures, effectiveness of public transport system as well as catschment areas can postiviely influence the level of energy demand specially in the transport sector. Among other planning measures, standard catchment areas play an important role in minimzation of the VMT. As an example, a 800 meter catschment area is an optimum distance for primary schools primary schools in the neighbourhoods to be accessible by foot.

CHAPTER 3

Case study analysis: District 22 - Tehran

Chapter 3 focuses on examining the identified energy efficiency and design measures from the previous chapter in the research case study (district 22 of Tehran). The aim within this chapter is to investigate how and to which extent the existing social infrastructures in district 22 are developed in accordance to energy efficiency and design measures and how these measures are integrated/enforced in the current spatial development frameworks and regulations. This includes spatial analysis on measures for minimizing the loss of energy, maximizing the use of passive energy (climate responsive planning and design) as well as measures for more efficient transport and mobility (comprises of measures for reducing the need for travel as well as measures to minimize the VMT). Besides spatial planning and design measures, new forms of urban services planning and provision are briefly introduced. This include demonstrations on electronic service delivery and analysis of its substantial elements in the local context. To achieve the expected results and depending on the data availability both qualitative and quantities methods are applied in analysing the local status in the case study. This includes desk research, field observations as well as interviews with local authorities and experts.

Chapter 3. Case Study analysis - District 22 of Tehran

Introduction

This chapter applies the derived energy efficiency measures from chapter 2 on the case of District 22 of Tehran. A central objective is to investigate how and to which extent the existing spatial features (i.e. physical and functional) of social infrastructures in District 22 are in accordance with energy efficiency planning and design measures. To do so, besides an overview on the main urban energy fact and figures in the local context, first, a spatial analysis on pertinent measures (i.e. building compactness, orientation, height, physical structures and impacts on neighbouring buildings, vegetation, passive solar energy absorbance etc.) will be conducted. Second, current urban development regulations and procedures are examined with the aim of identifying the gaps regarding energy efficiency measures in the existing local planning and design process. Third, new forms of urban service planning and provision are briefly introduced. This includes demonstrations on electronic service delivery and analysis of its substantial elements in the local context. Against this background, both qualitative and quantities methods are applied in analyzing the local status quo. This includes desk research, field observations as well as interviews with local authorities and experts.[13]

Desk research activities are based on assessing local academic articles, online data sources, urban development regulations as well as local development strategies. These are accompanied by a survey on urban development practices – with the main focus on District 22 – in relation to energy efficiency. It is thereby intended to evaluate the importance of energy efficiency in the contemporary urban planning and design practices in the local context. In the course of field observations, several meetings were organized and interviews carried out with local government officials, experts from consulting agencies, municipality organizations and governmental bodies. The aggregation of findings from interviews as well as field observation promote a better understading around existing practical gaps over integration of energy efficiency measures in planning and provision of social infrastructure. [14]

[13] In terms of access to local data, the quality of analysis depends on the availability of data. This should be considered as the main challenge in access to data sources for elaborating the findings.

[14] In doing the interviews, influential stakeholders have been identified. These include a wide range of actors from local authorities (several departments in District 22 municipality i.e. department of ICT, urban design and environment commission, deputy department of the mayor, urban planning and development department and geo-spatial information department, Tehran Municipality Research and Planning Canter (TMRPC), Tehran Municipality Information and Communication Technology Organization (TMICTO), Tehran City Technology Company (on behalf of Tehran Municipality), Tehran Municipality Urban Planing and Architecture Department), local consulting companies (i.e. Armanshahr Consulting Engineers responsible for preparation of several urban

Against this background, the analysis of the case study centers on the following dimensions:

- Energy efficiency and design measures in the local planning system as well as existing built environment
- Organizational dimension such as institutional capacity as well as influential actors and stakeholders
- Urban development regulation, consisting of the relevant energy efficiency regulations, instruments as well as enforcement measures

This chapter's findings will later be used for the purpose of a gap analysis as well as the derivation of recommendations further on in chapter 4.

3.1 An overview on urban planning system in Iran

Nowadays, due to rapid urban population growth and complexity of contemporary urban challenges and problems, it is impossible or almost preposterous, to leave cities 'forming' upon on economic, environmental, social and political factors without coordinated supervision. In fact, 'shaping' urban settlements in the framework of urban development laws, regulations and plans – in other words, an 'urban planning system' – is irremissible. Consequently, planning system and urban settlement development are indeed co-responded within transformation processes of cities. Therefore, a proper perception of the urban planning system (here Iran), enables urban planners and researchers to align their strategies more precisely with the political and cultural context.

To this background, knowing the statutory planning framework is crucial for steering future developments in urban areas. In the case of Iran, the urban planning system is characterized by a centralized top-down approach, which follows traditional comprehensive planning modalities. In some recent practices in larger urban areas (e.g. in Tehran), the typical master planning model was replaced by strategic planning approaches. However, many previous routines were kept in place.

The inertia implicated therein suggests that full-fledged transformations may not occur in the short term. Nevertheless, the strategic planning framework has potential to become the main planning approach in mid and long term. Although several actions have been taken toward realization of strategic planning, enforcement still faces several

development plans of District 22 , Engareh Consulting Engineers, Omra-Zaveh Consulting Engineers, Academia (i.e. Shahid Beheshti University- Department of Urban and Regional Planning, Iran University of Science and Technology – Department of urban and Regional Planning) as well as local experts active in different urban development planning in the Iranian context.

institutional, legal, and contextual challenges which do not allow for a complete application of a strategic planning approach in Iran. In practice, this has resulted in a mixture of traditional comprehensive and strategic planning approaches, which is known as “transition period”.

3.1.1 A comprehensive centralized planning system

Iran has faced massive alterations during the previous decades regarding its urbanization process, and correspondingly, it’s planning system. Historically, the urbanization process of Iran can be described in three time periods: 1. familiarity with urbanization (Qajar dynasty), 2. renovation of urbanization and urban development (1920-1960, the First Pahlavi era) 3. predomination of urbanization and new urban development (1961 up to now, Second Pahlavi era and after Islamic revolution) (Pirzadeh, 2008).

In the first period, the “primitive” signs of industrial civilization like factories, telegraph, railway, automobile, hospital etc. found their way into Iranian cities and brought about changes in physical and spatial structures (Mashadizadeh, 1995). In the second period, the renovation process of cities was intensified under novelty seeking policy of the government and the first urban development plans were prepared.

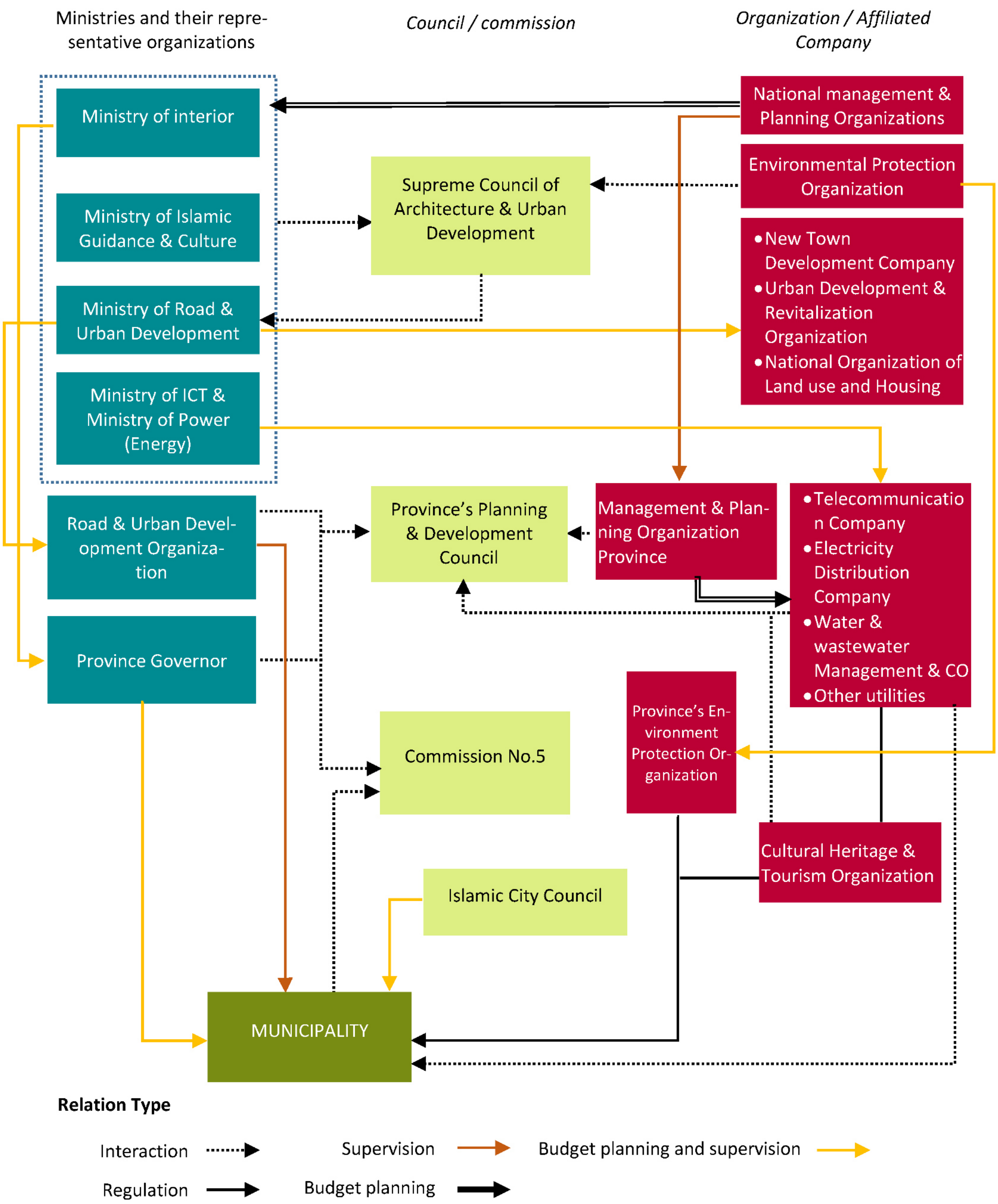
As a consequence, partial modernization had occurred and the transformation of Iranian cities from traditional to modern— particularly Tehran—had begun (Ziari, 2006). The third period is known as the rapid urbanization period. Among its hallmark events can be named: the land reform (1962), the implementation of 5-year development plans, fast increase in oil export revenues, rural to urban migration and legalization of different urban planning laws and development plans (Master Planning), establishment of Ministry of Housing and Urban Development were the most significant influential elements of this period (Pirzadeh, 2008; Ziari, 2006). It can be stated that, urban planning authorities in Iran have been established and modified gradually, according to the specific era and its requirements. The current urban planning system of Iran can be described as a sectoral-centralized model, where organizations and agencies in different planning levels are vertically linked. The responsive institutions at local level are thus considered as mere “representatives” of the overarching ministry or organization at national level (Hejazi, 2003; Saeednia, 2013).

The urban planning bodies in Iran are structured in three spatial levels: national, regional (province –“Ostan” and county-“Shahrestan”) and local (city-“Shahr”). Specifically, the ministries and their affiliated organizations at national level are engaged in the planning process through policy-making, supervision, preparation of development plans and budgeting. Their representative organization(s) at regional and local level are responsible for implementing the top-down planning orders and policies. Within this network consisting of multiple agents and organizations, the following actors play a more significant role. The Ministry of Road and Urban Development (MRUD) and its affiliated organizations and companies are responsible for the preparation of the majority of all urban development plans at different spatial levels. These include, most importantly, master (comprehensive) plans and detailed plans (Zebardast, 2005). The Supreme Council of Architecture and Urban Development, oversees the plans prepared by MRUD, and grants final approval (MRUD, 2012). It also sets up implementation guidelines. Commission No. 5 is the responsible actor for revision, modification and approval of detailed plans, as long as such alterations have no decisive contradiction with the Master (comprehensive) plan (Saeednia, 2013). The Management and Planning Organization (MPO) is the main actor regarding budget planning in Iran and is also responsible for preparing the national spatial plans. Furthermore, it grades and ranks urban planning consultants, both firms and individuals.

The municipalities and the Islamic city councils are the main enforcing bodies involved in the local-level of urban planning system in Iran. However, both organizations lack sufficient legal power to influence the urban development and planning process of cities – with the exception of Tehran[15]. The Municipality is a public body and mostly financially independent[16] overseen by the Ministry of Interior, and recently by the Islamic city council. Therefore, the municipality is more of an executive rather than legislative authority with its responsibilities being limited to the implementation of master plans, detailed plans and other urban management activities (i.e. sanitation and street naming) (Zamani & Arefi, 2013). Finally, the Islamic city council, has to elect the Mayor and oversees the municipality budgets. Additionally, it finances a part of the budget for the preparation of detailed plans (Saeednia, 2013).

[15] This is due to financial independencies of the Tehran Municipality
[16] Municipalities of small cities still receive financial support from the province governor

Figure 27. Planning process in Iran



Source. Pahl-Weber & Schwartze, 2014

3.1.2 Typology of development plans

Similar to the planning structure and bodies, there is also a hierarchical classification of development plans in Iran. All development plans in Iran are categorized into three levels: national, regional and sub-regional and local level. Each plan should be devised based on the defined framework of the affiliated higher-level plan. This structure very much resembles requirements of planning bodies as described above. Therefore, a top-down system is observable in this instance as well. Among different kind of plans, the most influential on local level are master and detailed plans. The figure below illustrates different levels of development plans in Iran.

Figure 28. Different levels of development plans

National	- Socio-economic and cultural five-year plan - National physical plan, land development plan - Specific master plan (agriculture, airports, & port master plans)		1:1000000 1:250000	- National Policy measures
Regional	- Regional master plans - Provincial & regional master plans - Sub-regional master plans - Urban complex plans for megacities		1:250000 1:50000	- Regional strategies and roadmaps
Local	- **Comprehensive (master) plans** - **Detailed plans ("Tarh-e-Tafsili")** - Urban guidance plans for small cities - New city plans - Site-development plans for cities ("Amade sazi") - Upgrading and renewal plans		1:10000 1:2000	- Concrete Strategies - Spatial and regulatory measures - Allocation and per capita standards - Development regulations - etc.

Source. Pahl-Weber & Schwartze, 2014

3.1.2.1 Master and detailed plans

The detailed plan is a local-level development plan, in which urban services and spaces are mapped and detailed in terms of form and content. Detailed plans provide specific guidelines for different urban sectors which, based on their priorities, will be reflected as implementation plans in the municipalities'[17] enforcement thereof. The detailed plan is situated within the context of the overarching master (comprehensive) plan, includes general regulations and criteria and clarifies the exact land-use for specified areas in urban districts at local level. Among other important functional items outlined in the detailed plan are: detailed access network, population and building densities in local urban units, the regeneration, renovation and other urban shortage priorities, the exact location of urban development elements, land ownership and the specifications based on the official registration (MRUD, 2012). The content of the detailed plan and Master (comprehensive) plan mostly differ in their level of detail. Whereas the urban master (comprehensive) plan presents a general framework, the detailed plan elaborates further details and operational aspects such as: land-use map, access network map, per-capita area, implementation criteria and physical regulations. These maps and regulations are part of the detailed plan and require approval by the legal administrations. In fact, the detailed plan contains all necessary details and definitions on the level of urban quarters (Shieh, 1990:96).

[17] As the local implementation body in Iran

The whole detailed plan approval process is consisting of five main steps (see figure below) It starts with the budget appropriation by the MRUD and municipality, which should be enacted by MPO and the Islamic City Council, respectively. The next step is the plan preparation process, which is assumed by qualified urban planning consulting engineers under the procedural and functional supervision of the Road & Urban Development Organization and the functional supervision of the municipality. Within a specific time frame the finalized detailed plan should be submitted to Commission No.5 for the enactment process. Its accuracy and quality in form and content in accordance to the master/comprehensive plan is assessed by the Technical Committee of Commission No.5. If there are no functional conflicts and contradictions, the plan is notified for the implementation phase to the Municipality and the Islamic City Council (MRUD, 2012).

Figure 29. Detailed plan administrative process

	STEP	ACTION	ACTOR (ORGANIZATION)
Budget phase	Budget allocation	▪ Allocation of needed budget for preparation of detailed plan	Management and planning organization Islamic City Council
Preparation phase	Contract	▪ Signing a contract with a qualified consulting engineering company	Organization of Road and Urban Development
	Plan preparation	▪ Preparation of detailed plan by selected consultant engineering company	Urban Planning Consultant Engineering Company
Approval phase	Evaluation of plan	▪ Evaluation of detailed plan through different meetings by experts from different disciplines	Technical Committee of Commission No. 5
	Approval and notification	▪ Final evaluation of detailed plan through approval meeting by member of commission 5 and final approval. ▪ Notification of the approved plan for implementation phase	Commission No. 5
Implementation phase	Implementation	▪ Implementation of detailed plan with cooperation of public and private developers	Municipality Islamic City Council
Revision phase	Plan Revision	▪ Checking and evaluating revisions (or changes) in detailed plan, requested by municipality, and approving applied changes. ▪ In case of major conflicts with master plan (comprehensive plan), checking and final approval of the changes.	Commission No. 5 Supreme Council of Architecture and Urban Development

Source. Pahl-Weber & Schwartze, 2014

If, during the implementation phase, the need for revision occurs, Commission No.5 can request additional reviews. In case of basic conflicts with the master plan, the Supreme Council of Architecture and Urban Development, as the legitimated body for final decision, takes care of the procedure (MRUD, 2012).

3.1.2.2 Detailed and strategic planning in Iran

One of the most central elements in Iranian urban development planning, as described above, is the detailed plan. Detailed plans are the main reference document for municipalities for future urban development and implementation in all physical and functional areas. This include buildings and their configuration to urban services and functional aspects of an urban system. The Ministry of Road and Urban Development is the main responsible body for the preparation of the detailed plans. However, an exception is the capital of Iran, Tehran, where the municipality is basically the respective responsible authority. Furthermore, the municipalities are the responsible authorities for the implementation of the plan. The existing rigid urban detailed planning system has been slightly evolved through more strategic and flexible approaches. In fact criticism of comprehensive urban planning was first voiced in the early 1960s. It stated that planners must pay less attention to unpredictable details and issues, and should rather concentrate on visible and critical problems. In order to overcome the existing flaws of comprehensive planning, the utilization of strategic planning is necessary because strategic planning can provide a stable base to understanding critical issues. Also, strategic planning takes place step by step. It considers both the relationship between different levels of planning and its stages. It also attends to the central problems, avoids paying too much attention to unpredictable masses of detail and grants a greater participatory role to local institutions (Faludi, 1973; Farhoodi et al, 2009).

In the opinion of Peter Hall, urban development plans, instead of engaging with unnecessary details, should concentrate on fundamental issues as well as a periodic evaluation of whether the plan is achieving its goals. In this view, planning should be a goal-oriented, step-by-step process (MRUD, 2006). Thus, strategic planning creates an answer to the basic weaknesses of comprehensive planning in providing for the city’s needs and guiding its growth and future development. In comparison with the comprehensive plan, which emphasizes a physical framework model called a land-use map, strategic planning focuses on the fact that planning is a process involving relationships between different parts and local participation (Wu, 2007).

This kind of planning deals more with operational and implementation-related factors than does comprehensive planning and has a more reciprocal relationship in that process (Saeednia, 2003). During the 1960s and 1970s, at the same time as criticism rose against at the comprehensive urban planning model, strategic planning became commonly practiced in the field of urban development throughout the world because of its flexible, constantly reassessed and step-by-step character.

In the last two decades it has been receiving more and more attention in planning practices. A lot of major cities around the world have since developed strategic plans (Halla, 2007; Moradi Masihi, 2005; Pincetl, 2006; Steinberg, 2005). Strategic urban planning has resolved many of defects and flaws perpetrated by comprehensive planning both in the theoretical domain and in the development and implementation of urban planning strategies. Nowadays, it is accepted by many management and planning institutions around the world. The following table displays a comparative analysis of the different processes of developing plans, including their often divergent kinds of goals, the planning processes, differences in the degree of participation of stakeholder groups and the implementation capabilities that both models – comprehensive and strategic planning – incorporate.

Table 9. Comprehensive and strategic planning attributes

Field	Comprehensive planning	Strategic planning
Conceptual framework	1. Emphasis on knowing the details of problems in the city 2. Hard and inflexible planning 3. lack of attention to the economic goals of the city 4. Comprehensive in the studies 5. The land-use map considered the final document	1. Knowing the city's strategic problem or problems while avoiding becoming entangled in details 2. Flexible planning approach and keeping abreast urban changes 3. Efforts to promote the city's economy 4. Selective and targeted studies 5. Preference for plans that are functional and practical
Goals and planning process	1. The goal of preparing the physical output (land-use map) 2. Process of preparation and implementation simply top-down and unilateral 3. Fixed forecasting and making decision for the future 4. Goals and procedures are not clear and transparent 5. Separation of the decision-making process	1. Integrating the physical goals with the social and economic ones 2. Top-down and bottom-up consultative process of planning and implementation 3. Ongoing process of systematic decision-making with respect to the future 4. Clarity of the final vision and the goals for reaching it 5. Reciprocal links in the decision-making process
Preparation of stakeholder groups	1. No consideration of the participation of the people and social institutions 2. Planning and designing is imposed from above 3. Relies on a technocratic approach with little faith in creativity and innovation	1. Effective participation of the people and stakeholder organizations 2. Designing and planning based on the viewpoints of stakeholders 3. Believes that participation creates innovative approaches

	4. No consideration of social policies and needs	4. Consideration of change in political and social demands
Implementation capabilities	1. Weaknesses and strengths of the organizations charged with implementation aren't considered 2. Local authorities marginalized from the preparation and approval of plans 3. Lack of supervision of implementation. 4. Based on an idealistic scenario	1. Assessment of weaknesses and strengths of implementing organizations taken into account 2. Local authorities given wide powers to select strategic approach and managers 3. Ongoing supervision and oversight 4. Based recognition of the real capabilities of the city

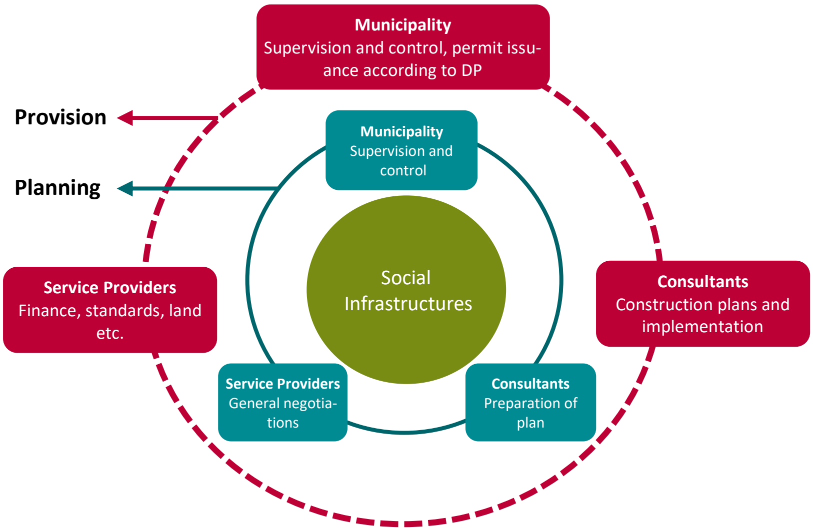
Source. Andersen, 2000; Clark, 1996; Halla, 2007; Johnson, 1994; Moradi Masihi, 2005; Saeednia, 2003a & 2003b; Steinberg, 2005; Sridharana et al, 2007; Wu, 2007

Since 2001, Iranian policy-makers have made some efforts to introduce this approach to urban planning. The Tehran municipality enacted its first strategic plan in 2001 as an attempt to resolve many problems of its metropolitan area and to obviate the implementation and participation shortfalls of its 1968 comprehensive plan. This plan analyses the main development problems of the city, which include failures in the implementation of the comprehensive plan, inconsistency between the various existing plans and problems arising from fast population growth (Atash, 2007). Since then, several strategic oriented approaches have been applied in provision of urban development plans with different scales. One explicit example is the preparation of City Development Strategy (CDS) plan in district 22 in 2006 as the case study of this research.

3.1.3 Planning and provision of social infrastructure in Iran

According to the central planning system in Iran, planning & development of social infrastructure is carried out based on a comprehensive approach in the context of urban development plans and under the direct supervision of municipalities as the main steering authority at the local level. These types of services are normally presented in the form of land uses and activities (e.g. land use maps). Required land is typically calculated according to the per capita standards and allocated in the frame of comprehensive and detailed plans. From the provision/implementation perspective, this is the task of each relevant service provider (including relevant governmental authorities & ministries in national, regional and local level) to physically provide social infrastructures according to urban comprehensive/detailed plans and regulations. In this context, municipalities are responsible for assuring an integrated planning in accordance to the legally binding urban development plan. Their task is also to offer service providers and developers the required building permits and allowances according to rules and regulations including subsequent supervision and approval requirements in different physical development phases.

Figure 30. A schematic view of social infrastructure planning in the Iranian planning system



Source. Khodabakhsh, 2017 (based on energy efficient social infrastructure planning and provision interviews – Annex 1, and reviewing local development plans and regulations[18])

From a social infrastructure planning perspective, several actors are influential in the planning and provision process. These include governmental and non-governmental organizations as service providers (i.e. ministries and their relevant regional organizations), municipalities as controlling bodies for permit issuance, supervision and approval as well as private consultancies and investors. While, involved ministries are mostly responsible for developing general sectoral policies, strategies and budgeting, municipalities are more integrated in the spatial planning and implementation process thereof. Put differently, municipalities supervise the integrated planning, management and development of all urban services in their territory through their permits issuance mechanisms in accordance with development plans and physical development regulations. Each service provider is required to operate under this framework of municipalities. During the process, several consulting engineers, both public and private companies, are hired to support municipalities and service providers for appropriate planning and provision of services (i.e. the physical construction). From planning instruments perspective, as explained before, both comprehensive and detailed plans are considered as the main enforcement instruments, drawing the required physical and functional features of social infrastructure. The enforcement of comprehensive and detailed plans are guaranteed through a combination of measures, namely: regulations, maps and guidelines.

[18] See annex 1.

- Regulation: focusing on physical and functional features, such as: building codes, density and height limits, compatibility of adjacent services and activities.
- Maps: drawing the allocation of different services based on existing thresholds standards as well as catchment range analysis
- Guidelines and strategies: including short, mid and long term strategies and guidelines for future development of social infrastructure.

In addition, the municipality do not have direct impact in planning and provision of social infrastructure. Its role is limited to provision of land for each of the service providers and issuing building permits as well as control and supervision over the construction in accordance with statutory plans and issued urban development regulations. In exceptional cases, such as cultural, sport facilities and community centres, the municipality directly contributes in planning and implementation phase.

Looking at the existing municipal structure, there exist no department dedicated to planning, implementation and control of social infrastructure and most of these tasks are being delivered by different department with limited integration mechanisms. The following table gives an overall view of the roles and responsibilities in terms of social infrastructure planning and provision in Iran.

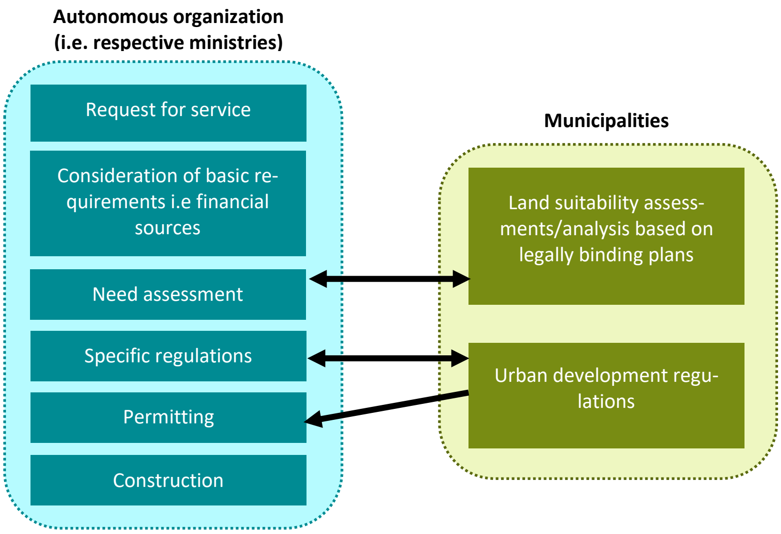
Table 10. Roles and responsibilities in local social infrastructure planning and provision

Who Plans:	Each service provider i.e. the ministries or organizations are responsible for sectoral planning and provision of social infrastructure. Their service development is mandated to fit within the existing frameworks designed by statutory development plans i.e. master and detailed plans. The overall supervision in physical development is the task of municipality.
Who gives the permit:	The municipality is the responsible body for issuing the building permissions in any types of physical development activities in the framework of statutory plans and development regulations.
Who construct:	Depending on the financial and business models, each of the service providers (ministries, organizations) are responsible for implementation of their services. Private sector contribution in different forms is also a common approach in development of urban services.

Source. Khodabakhsh, 2017 (based on energy efficient social infrastructure planning and provision interviews – Annex 1, and reviewing local development plans and regulations)

Figure below, provides an example of the main tasks and the responsible authorities in the process of social infrastructure planning and provision:

Figure 31. The role of municipalities in planning and provision of social infrastructures



Source. Khodabakhsh, 2017 (based on energy efficient social infrastructure planning and provision interviews – Annex 1, and reviewing local development plans and regulations)

Table below gives an insight of the influential authorities in planning and provision of social infrastructures in Iran.

Table 11. Local authorities and their contribution to social infrastructure planning and provision

Level	the main actors		Respective organization	field of intervention
National & regional	Ministries and national departments and organisations		Ministry of Health and Medical Education	PN, GNAR
			Ministry of Road and Urban Development	PN, GNAR
			Ministry of Education	PN, GNAR
			Ministry of Science, Research and Technology	PN, GNAR
			Ministry of Sport and Youth	PN, GNAR
			Iran Cultural Heritage and Tourism Organization	PN, GNAR
			Ministry of interior	PN, GNAR
			Urban Development and Architecture High Council	PN, GNAR
			Building and housing research centre	SPNR
	Regional Organizations		Health and Medical Education Organization in provinces	PR, GPAR
			Road and Urban Development Organization in provinces	PR, GPAR
			Education Organization in provinces	PR, GPAR
			Science, Research and Technology Organization in provinces	PR, GPAR
			Sport and Youth Organization in provinces	PR, GPAR
			Cultural Heritage and Tourism Organization in provinces	PR, GPAR
			Province governor	PR, GPAR
			Urban Development and Architecture High Council in provinces	PR, GPAR, EDP
			Commission No 5	EDP
Local	Local planning government		Municipalities	DU, CS, SPI, SM
			City or town councils	SM
	Local civic/public organizations		NGOS	VA, AR
			Construction engineering organization	CRS, SPI
			Neighbourhood councils	CLC
	Local for profit partners	Property owners	Private	PL
			Public (mainly the municipality)	PL
			Governmental	PL
		Constructor & planners	Private (i.e. consulting & construction companies)	PC
			Public (i.e. municipalities and their sub-companies)	PC
			Governmental (i.e. Ministries and governmental organizations)	PC
		Service providers	Private	SD
			Public	SD
			Governmental	SD

Policy making in National level (PN), Supporting Policy making in National level & Research (SPNR), General National Acts and Regulations (GNAR), Policy making in Rational level (PR), Support Policy making in Rational level (SPR), General Rational Acts and Regulations (GRAR), Enacting Urban Development (EDP), Urban development (Spatial Development) (DU), Control Services and facilities (CS), Supervision and Permit Issuance (SPI), Supervision on Municipalities (SM), Voluntary Activities (VA), Awareness Raising (AR), Construction Regulations and Standards (CRS), Provision of Land (PL), Planning and Construction (PC), Service Delivery (SD), Communication with Local authorities and Citizens (CLC)

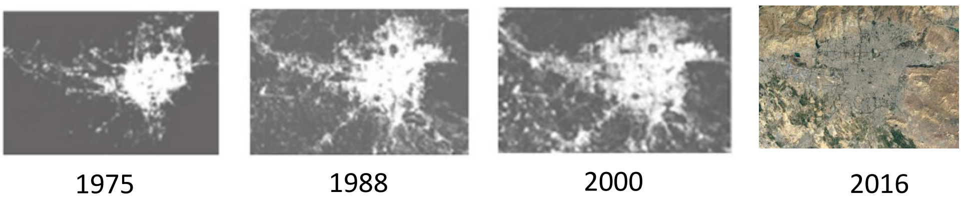
Source: Khodabakhsh, 2017 (based on energy efficient social infrastructure planning and provision interviews – Annex 1, and reviewing local development plans and regulations)

3.2 District 22 – An overview

3.2.1 A historical review on District 22

Tehran is a city with a population of seven million within a wider urban region comprising more than twelve million inhabitants. As the capital city of Iran, it functions as a center of gravity for the economic, political and cultural affairs of the country. Tehran is a modern city, with high-rise buildings and a network of motorways with all the associated problems of traffic congestion, environmental pollution and housing shortage. This urban landscape is primarily a result of the city's growth and development during the second half of the twentieth century. A brief investigation of the contemporary city shows that modernization of the urban space has continued after the revolution, more or less along the same lines that had been set before 1979. Although interrupted by war, revolutions and periods of economic slowdown, Tehran's urban form today is the result of five centuries of urban development, and more than 150 years of modernization marked by intense urban development and renewal. The rapid urban growth in the second half of the twentieth century (Figure 32), furthermore, was largely dependent on earlier stages modernization, which paved the way for subsequent development and expansion (Barati et al, 2010).

Figure 32. Tehran urban growth (1975-2016)

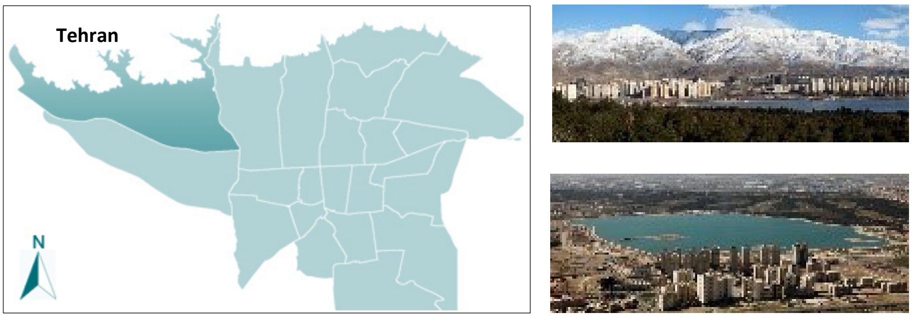


Source. Barati et al, 2010

In Terms of physical growth, due to the landform and geomorphological aspect of Tehran, the city tends to extend westwards. The northern and eastern part of the city is bounded by mountains, and the southern part is bounded by farms. Another major reason for the westward urban extension of the city is its air quality. The prevailing wind direction in Tehran is from west to east.

The western part of Tehran also forms the focal point of the present research (District 22) as a new and recently developed urban district for the future population and urban growth of Tehran. District 22 is the largest urban district of Tehran located in the northwestern part of the city, which is considered as the main remaining urban growth potential of the city (Barati et al, 2010).

Figure 33. Research case study



Source. Tehran District 22 official Portal, 2017 [19]

With an area of about 6,000 hectares, District 22 has special climate and geographic features. Its boundaries are the Kan floodway to the east, the Tehran-Karaj freeway to the south, the end of the Vardavard area to the west (Kilometer 30 of the Tehran-Karaj freeway) and the Alborz range to the north, which extends up to an elevation of 1,800 meters. Apart from the approved built townships, a large area of District contains unutilized and agricultural land in the form of large urban parcels. In 2006, District 22 had a population of about 108,674, and there were about 29,017 households scattered on 1,000 acres throughout the region (Table 12). District 22 is unique in terms of green area per capita (ca. 272 square meters), low population density and calm traffic movement. It is the green belt area of Tehran, known as the “clean air arena” of the city with many forest areas and recreational sites.

Table 12. The population of Tehran District 22

District No	1996-01-25	2006-10-25	District No	1996-01-25	2006-10-25
1	249,676	379,962	**12**	189,625	248,048
2	458,089	608,814	**13**	245,142	245,724
3	259,019	290,726	**14**	394,611	483,432
4	663,166	819,921	**15**	622,517	642,526
5	427,995	679,108	**16**	298,410	291,169
6	220,331	237,292	**17**	287,367	256,022
7	300,212	310,184	**18**	296,243	317,188
8	336,474	378,725	**19**	227,389	247,815
9	173,482	165,903	**20**	356,079	335,634
10	282,308	315,619	**21**	188,890	159,793
11	225,840	275,241	**22**	**56,020**	**108,674**

Source. Barati et al, 2010

Persistent population growth and extensive developments greatly influenced the physical appearance of Tehran. One of its results being the formation of District 22, which without any doubt, was the greatest and vastest urban development area in Tehran. With an area of approximately 6,000 hectares, this region has been created with the aim of improving the conjestion level of Tehran and creating living area for the rapid

[19] Tehran District 22 official Portal. (n.d.). Retrieved January 10, 2018, from http://region22.tehran.ir/

increasing population of Tehran. In the last 30 years, District 22 of Tehran went through special construction activities and since then, construction of this area came to Tehran practitioners and manufacturer's attention. The original owners of these lands were Farmanfarmayan and Firouzgar family. After approval of the comprehensive plan of Tehran from 1970, this area has been defined as a new city and named Kan New City, and its domain has been designed by Farmanfarmayan Consulting Engineers and Partners. From 1960 to 1979 approximately 20% of these territories has been parceled out and the rest of the lands were divided into large pieces (1,000 m^2). After the Islamic Revolution in 1979, Farmanfarmayan and Firouzgar lands were nationalized and some of them were assigned to the Urban Land Organization. In addition, 500 hectares land were endowed to Ayatollah Mola Ali Kani who used to be the owner of these lands since the Qajar era. During the war between Iran and Iraq (1980-1988), the military used 25% of these lands due to strategic prefrences. In other parts of the land, housing cooperatives began to build residential complexes.

In the latter half of the 20th century, Tehran was struggling to keep up with rapid population growth. Against this background, the Municipality of Tehran, following the directions of its comprehensive development plan, decided to add the North-West area of Tehran into the services area of the city (Barati et al, 2010). In 1990, in line with the recommendations of the High Council of Urban Development, the master plan of District 22 was put on the Bavand Company agenda. In 1993, studies conducted by Bavand Company were approved as the Master Plan of District 22. After its approval, the plan faced a variety of hurdles (especially in terms of realization). As a result, the Bavand and Armanshahr Company put the master plan under review once again. After several years of effort and study, the Section 5 Commission approved a revised master plan for District 22 and the municipality of District 22 was officialy activated (ibid).

In terms of land use, the revised master plan envisaged for a total of 6,200 hectares. Amongst the main land uses, 22% belongs to green areas and parks, 1% for educational space, 3% for higher education, 4% for services, 5% for sport space, 6% for a lake, and 3% for residential purposes [20] (ibid).

[20] Residential density divided in three categories, which are Low density (100 units per hectare), Medium density (135 units per hectare) and High density (200 units per hectare).

3.2.2 Development plans & social infrastructures in District 22

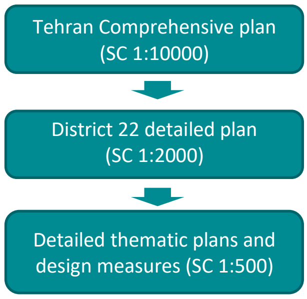
The continuous population growth and economic transformation have had a large impact on the physical development of Tehran city in recent years. A prime example of this process is the formation of District 22 as the largest urban growth area connected to Tehran. The main driving force in the development of District 22 was the need for fullfilling basic urban service shortages of Tehran and absorping its population surplus - especially from Tehran central declined and deteriorated urban areas. As a result, District 22 has been the subject to massive development and construction projects during the previous 30 years (Tehran District 22 official Portal, 2017).[21]

Figure 34. Physical development and construction in District 22

Source. Khodabakhsh, 2017

District 22 as one of the largest urban development areas of Tehran has been evolving both in physical and functional terms. It is the only remaining urban growth area of Tehran which provides the opportunity for implementing future proof planning and design concepts from scratch.

Figure 35. The main urban development plans in District 22



Source. Iran Ministry of Road and Urban Development

Similar to other urban settlements, the spatial development of the district is steered by a set of hierarchical statutory plans on different levels and with varying focus points. These include the comprehensive/master plan, detailed plan as well as urban design and a verity of thematic plans. As explained above, in 1992 a detailed plan for District 22 has been prepared by Bavand Consulting Engineers. Because of various organizational, land - ownership as well as financial challenges together with rapid physical and population growth of the district, the plan was not successful and additionally faced massive feasibility challenges. In response to these challenges, the plan was revised by cooperation of two consulting companies, namely Armanshahr and

[21] Tehran District 22 official Portal. (n.d.). Retrieved January 10, 2018, from http://region22.tehran.ir/

Bavand. After submission, the new plan has been approved eight years later by Commission Nr. 5 of the High Council of Architecture and Urban Development. The enacted plan has been transposed for implementation to the District Municipality in 2001, and the municipality has started its official development actitivies accordingly[22] (Tehran District 22 official Portal, 2017).[23] Akin to previously enacted development plans, the new plan faced similar feasibility issues endangering the achievement of set physical and functional development targets. As a responsive measure, the municipality changed its approach so that in 2013 another development plan was prepared, however this time with fundamental alterations in accordance with the City Development Strategic (CDS) approach[24]. The assessment done by CDS showed that all previously development plans were unsuccessful in terms of urban services provision after twelve years of implementation.

Several basic civic requirements pertaining to education, health, sports and recreation, cultural and administrative services were not provided. This resulted in a sever lack of social infrastructure within District 22. A quantitative analysis by CDS plan computing the feasibility rate of social infrastructure of previous development plans indicates a limited realization rate thereof. The following table gives an overview on the realization rate of the main urban services from 2001 to 2013 in District 22, in accordance with the proposed numbers by the previous urban development plan (Armanshahr, 2013).

Table 13. Realization rate of the main urban services proposed by pervious development plan of District 22

Land uses	Current area (2013)	Proposed area by previous detailed plan in 2001	difference	Feasibility rate
Education	188,968	4,478,013	4,289,045	4.2
Medical	18,654	494,057	475,403	3.8
Administration	112,493	695,920	583,427	16.2
Cultural- religious	74,277	432,798	358,521	17.2
Green spaces	494,166	12,675,781	12,181,615	3.9
Sport	62,531	4,039,663	3,977,132	1.5
Other infrastructures & facilities	273,987	2,230,201	1,956,214	12.3

Source. Armanshahr, 2013

Table below demonstrates the per capita availability rate of key social infrastructures in different spatial scales (neighbourhood, sub-district and district). This analysis indicates a considerable difference between the standard and realized per-capita availability across different types of social infrastructure.

[22] Based on the strategic vision of the new plan, district 22 was supposed to provide all urban services shortages from the west part of Tehran
[23] Tehran District 22 official Portal. (n.d.). Retrieved January 10, 2018, from http://region22.tehran.ir/
[24] Prepared by Armanshahr Consulting Engineers

Table 14. Per-capita status of social infrastructures in District 22 (year 2013)

Scale		Education	Sport	Medical	Cultural	Religious	Administration	Facilities and urban infrastructure	Open & green spaces
Neighborhood	Proposed per capita	1.5	0.4	0.2	0.2	0.5	0	0.35	2.7
	Current per capita	0.16	0.07	0.04	0.04	0.1	0.0	0.01	0.63
	Ratio (current/proposed)	**0.11**	**0.16**	**0.22**	**0.2**	**0.2**	**-**	**0.02**	**0.23**
Sub-district	Proposed per capita	1.5	0.40	0.5	0.25	0.0	0.2	0.15	2.8
	Current per capita	0.34	0.10	0.01	0.03	0.0	0.2	0.56	0.85
	Ratio (current/proposed)	**0.23**	**0.26**	**0.01**	**0.12**	**-**	**1**	**3.74**	**0.3**
District	Proposed per capita	3	1.2	0.8	0.3	0.25	0.8	1	4.5
	Current per capita	0.16	0.05	0.02	0.005	0.09	0.19	0.39	0.25
	Ratio (current/proposed)	**0.05**	**0.04**	**0.02**	**0.02**	**0.34**	**0.24**	**0.39**	**0.06**
Sum	Proposed per capita	6	2.00	1.5	0.75	0.75	1	1.5	10.0
	Current per capita	0.66	0.22	0.07	0.07	0.19	0.39	0.96	1.73
	Ratio (current/proposed)	**0.11**	**0.11**	**0.04**	**0.1**	**0.25**	**0.39**	**0.64**	**0.17**

Source. Armanshahr, 2013

In other words, the planning and provision of social infrastructure[25] in District 22 has not been able to keep up with rapid physical development and construction in recent years. The issue is exacerbated by long travel distances implicated in lacking infrastructures. Existing shortcomings further include weak accessibility and an uneven distribution of infrastructure services across the District – from neighbourhood to the whole district – large area of the district, spread development patterns as well as private car dependency due to inefficient public transport systems all contribute to an overall low quality of social infrastructure in District 22.

3.2.3 Population growth and density in District 22

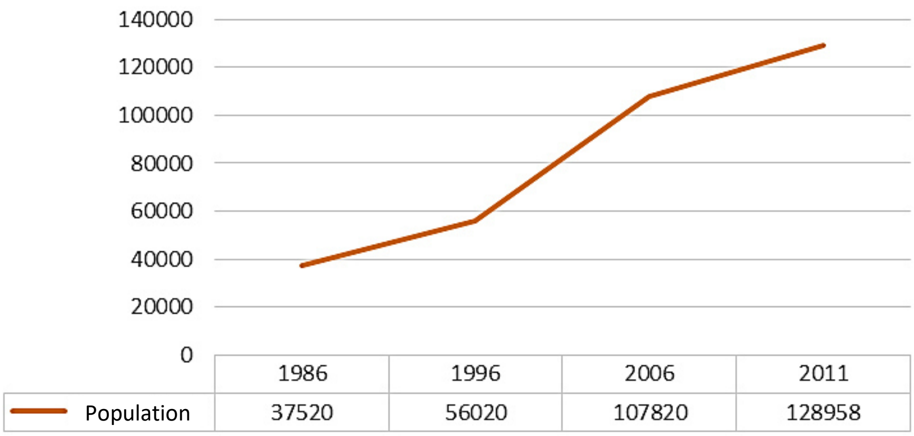
District 22 has the lowest population density among other urban districts in Tehran metropolitan area. Its low population density provides opportunities for future population gain and the best potential for Tehran metropolitan area to absorb population increase in the future. However, as a result of rapid physical development in recent years, the population of District 22 has been growing quite fast in comparison to average growth rates in other parts of Tehran and the country. The official statistic show a population growth from 37,520 to 107,820 inhabitants from 1986 to2006, the corresponding growth rates from 1986 to 1996 being 4.09% and from 1996 to 2006, 6.76%. As a point of comparison: population growth rates for Tehran and Iran as a whole from 1996 to 2006 were merely as high as 2.1% and 1.6%, respectively. In terms of population density, according to the national cencus data in 2011, District 22 has the

[25] In Tehran development plans, the so-called "basic urban services".

lowest population density among the twentytwo districts of Tehran. Although the gross population density of District 22 has been growing over time (ca. 24 Person/Hectare in 2006 and 29 Person/Hectare in 2011), the figures still reside much below the average population density rates for the whole Tehran metropolitan area (Ca. 130 Person/Hectare) (SCI (Statistical Centre of Iran), 2011).

Figure 36 shows the demographic change in District 22 between 1986 and 2011. The slope of the graph indicates a substantial population growth. Among the causes for the population increase can be named the inward migration of the Tehran population due to affordable housing as well as environmental advantages in comparison to other areas in the Tehran metropolitan area. Moreover, the fast growing construction pace in housing sector is another important factor for rapid demographic growth in District 22.

Figure 36. District 22 population growth from 1986 to 2011

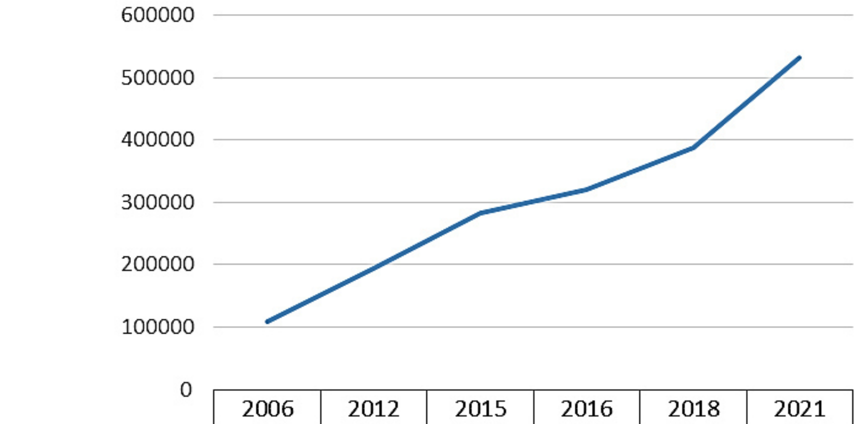


Source. Armanshahr, 2013

In terms of demographic structure, the largest share of District 22 inhabitants belongs to the age group 15-30 years[26]. One way to interpret this figure is that District 22 may be especially attractive for younger families as a result of availability of affordable housing in comparison to other urban areas in Tehran.[27] With regards to the future, demographic predictions indicate an uninterrupted population growth up until 2021. According to Armanshahr, this is the result of rapid physical development strategies in the district and its capacity to absorp incoming population (Armanshahr, 2013).

[26] Such a young demographic structure calls for potential capacity for active participation in development activities in the district (as experienced in the process of CDS plan preparation).
[27] Based on results from the CDS plan

Figure 37. District 22 future population growth (estimated)



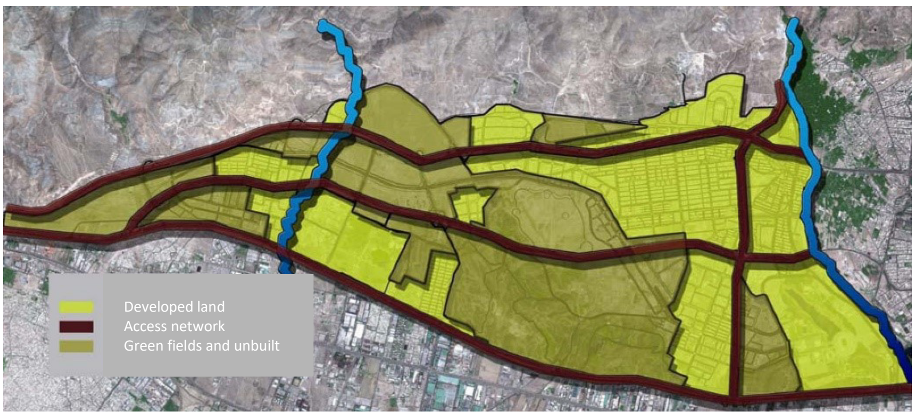
	2006	2012	2015	2016	2018	2021
Population	107802	193033	281880	319934	388339	532341

Source. Armanshahr, 2013

3.2.4 Physical characteristics of District 22

Generally speaking, a city's physical structure can be defined by two main elements, namely open and built up spaces. Development plans and regulations are key factors affecting the city's overall spatial organization. The quantity and quality of construction activities, the proportion of the built area to available space, and the quality of its visual corridors and city vistas are example of attributes created and influenced by spatial planning. In the metropolitan area of Tehran, the typology of new-constructions, their relation to open space and the proportion between open and built spaces differ across the various districts of the city. While the central part of Tehran and the southern half of the city are densely populated with small sized residential units, District 22 instead has the largest share of open and vacant spaces with great potential for future physical and functional developments (Figure 38).

Figure 38. Land use structure in District 22



Source. Armanshahr, 2013

As previously noted, a key characteristic of District 22, in comparison to other urban districts of Tehran, lies in its substantial and ongoing physical developments with emphasize on development of high density residential and commercial complexes. The fast-paced construction trend caused a significant increase in population density over only a short period of time. It is likely that this will result in effective service provision deficiencies. Unbalanced allocation of building densities plays another important role in physical development of District. The aerial illustration presented in figure above points to an unbalanced physical development pattern in District 22, especially in terms of building density. While some existing built areas have kept their low building height and population density, other new developed high rise complexes are much denser populated. The latter observation applies in particular to the southern and western parts of District 22. When it comes to the availability and adequacy of urban services and social infrastructure, the unbalanced physical development patterns have negatively influenced the self-sufficiency of neighborhoods and sub-districts. A comparative analysis by the municipality of Tehran shows that, even with existing low population densities, District 22 has one of the lowest share of urban and infrastructure services. If the given fast pace of development upholds in District 22, the situation is unlikely to improve (Tehran Atlas, 2006).

3.3 District 22 – Social Infrastructure

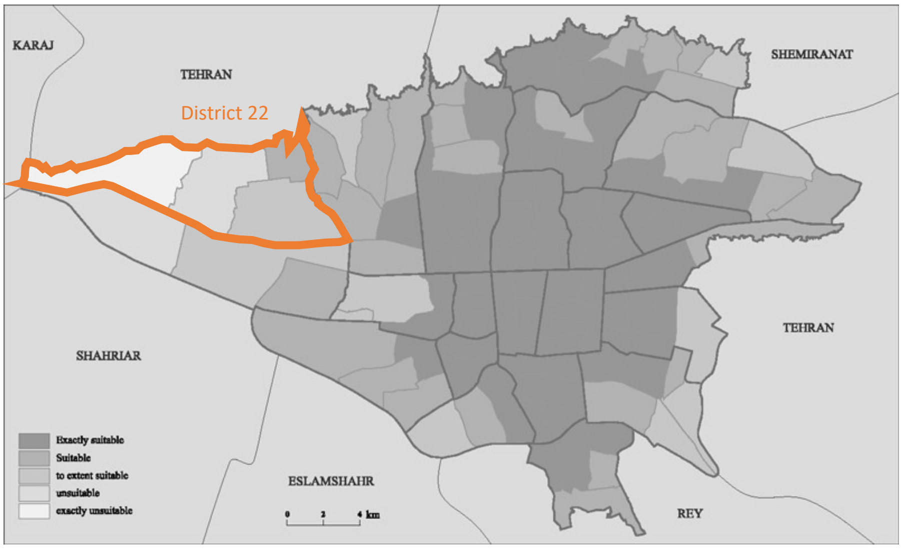
Introduction

According to existing planning standards, social infrastructures in District 22 can be classified along the lines of two levels: district-level services (serving the local inhabitants[28]) and urban services (serving a larger area than district 22). Field observations confirm that many of the neighbourhoods lack sufficient social infrastructure. That is to say, the majority of newly developed areas are mostly characterized by new residential complexes, which lack fundamental urban functions such as schools, kindergarten, recreational spaces, health centres etc. The rapid development of new residential complexes has also put additional pressure on the mobility of inhabitants, as a considerable share of residents have to travel long distances to other service centres within and outside District 22.

[28] The local scale land uses are foreseen to supply the requirements of the local inhabitants (this includes services in neighborhood, sub-district and district level).

In a comparative analysis the Tehran municipality analyses access quality to social infrastructures in all districts of Tehran. The analysis thereby focuses on urban services and facilities and includes indicators reflecting six types of services: education, emergency (security and safety), health and treatment, transportation, culture and recreation. While central districts of the city have the best access to selected urban services and facilities, the western districts and the districts in the suburbs have poor access to social infrastructures. This shows a clear difference between central and suburban districts in terms of access to public services and facilities. The western districts, especially Districts 21 and 22, characterized with a low population density, have the poorest access to these public facilities (Figure 39).

Figure 39. The quality of access to docial infrastructures in Tehran & District 22



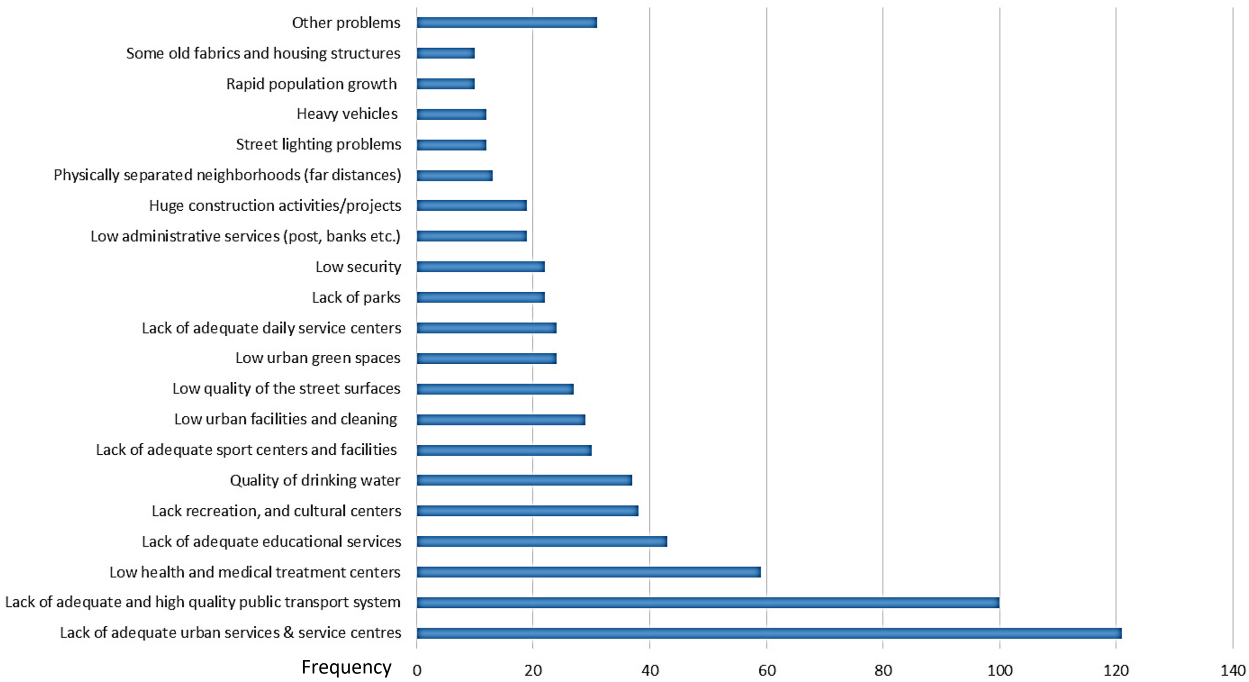
Source. Tehran Atlas, 2006[29]

The same analysis by the Tehran municipality on individual social infrastructure demonstrates a similar conditios in Tehran and District 22. Analysis on educational services in different districts of Tehran shows that the spatial distribution of educational services is good in most districts. However, only in three out of a total of 22 (including District 22) access to educational services is lower than the standards addressed in development plans. The distribution of the cultural centers i.e. public libraries, mosques, cinemas and cultural centers (or local houses of culture) is fairly decent all over Tehran; except for parts of the northeast and northwest (Districts 21 and 22), almost all other districts have a very good access to cultural centers. Health services are offered by

[29] Atlas of Tehran Metropolis. (n.d.). Retrieved January 10, 2018, from http://atlas.tehran.ir/Default.aspx?tabid=294

hospitals and other types of health facilities. Data obtained from the analysis shows that most hospitals are concentrated in the districts in the central north, center and central south of the city. Access to health centres in western areas (i.e. District 22), is considerably below the standards. Moreover, an analysis of the data collected from the emergency services centers (including fire station department, ambulance services and police stations) shows that, the western districts, especially those located in Districts 18, 21 and 22 have poor access to such services. In regard to open spaces and recreational services, District 22 is situated well in terms of access to recreation and sport facilities. This is mostly due to widespread green spaces and parks as well as the national sport complex located in the area. Overall, District 22 suffers from deficincies in terms of adequacy as well as access to several types of social infrastructures in comparison to other districts in Tehran. A public survey in the context of the new CDS plan of District 22 interviewed more than 400 citizens to gauge their satisfaction with service quality in District 22. A key finding is that most dissatisfaction exists with regard to the lack of adequate social infrastructure and low quality of the public transportation system. On the other hand, higher environmental quality, calmness of the area as well as low population and building densities as the main advantages of district 22 (see Figure 40).

Figure 40. Deficiencies in District 22 form citizens perspective



Source. Armanshahr, 2013[30]

[30] Retrieved originally from a public survey in the context of the new CDS plan of District 22. It comprises of more than 400 interviews with citizens to gauge their satisfaction with service quality in District 22

According to the results from the same survey, adequate social infrastructures are among the main priority factors for the future development of District 22 from citizen's perspective. Following figure addresses the main priorities proposed by the citizens in the future development of the District 22.

Figure 41. Propositions for improvements in District 22 from citizens perspective

Source. Armanshahr, 2013[31]

3.3.1 Qualitative & quantitative analysis of social infrastructure in District 22

District 22 hosts several large military areas, located mostly in the north and north-east of the area, as well as several transregional land uses and complexes, namely: Azadi stadium, national research institutions, hospitals, and recreational areas (see Table 15).

Table 15. Main transregional and national land uses in District 22

Land use	Area (hectare)
Azadi stadium complex	338
Chitgar park	869
Persian Gulf artificial lake	400
Rivers	103
Military lands	1060
Research and high education centres	300

Source. Armanshahr, 2013

Existing large-scale multi functional complexes have positive and negative impact on District 22. For instance, large-scale services bring about substantial internal and external urban mobility. Traffic analysis of the CDS plan indicates that existing urban scale land uses in District 22 generate 349,534 trips during the week and more than

[31] Retrieved originally from a public survey in the context of the new CDS plan of District 22. It comprises of more than 400 interviews with citizens to gauge their satisfaction with service quality in District 22

474,270 trips during the weekends (District 22 CDS Plan, 2013). Although District 22 posses several types of urban scale services, these services can not make up for service shortage in certain neighborhoods and sub-districts. The following tables provide a detailed view over social infrastructure status in different levels in District 22 (for an estimated population of 193033 persons). The analysis demonstrates shortcomings in all categories of social infratsrcutures and in all scales.

Table 16. Current and required transregional social infrastructures in District 22

Land use	Current area	Current per capita	Binding per capita	binding area	Require / surplus
Public green spaces	1,763,415	9.14	9.50	1,833,813	70,398
Educational and high education	3,463,732	17.94	2.90	559,795	-2,903,936
Medical and health	118,304	0.61	1.30	250,942	132,638
Cultural & religious	60,650	0.31	2.40	463,279	402,629
Sport	3,659,724	18.96	1.90	366,762	-3,292,961
Recreation	542,929	2.81	1.40	270,246	-272,682
Facilities and infrastructure	590,007	3.06	2.40	463,279	-126,727
Sum of services	8,435,346	43.70	12.30	2,374,305	-6,061,040
Services and Green spaces	10,198,761	52.83	21.80	4,208,119	-5,990,641

Source. Armanshahr, 2013

Table 17. Current and required District level social infrastructures in District 22

Land use	Current area	Current per capita	Binding per capita	binding area	Require / surplus
Public green spaces	0.00	0	70	13,512,310	13,512,310
Educational and high education	9,395	0.05	20.65	39,886,131	3,976,736
Medical and health	5,829	0.03	9.10	1,756,600	1750771
Cultural & religious	8,611	0.04	16.8	3, ,954	3,234,343
Sport	17,788	0.09	13.65	2,634,900	2,617,112
Recreation	14,191	0.07	9.8	1,891,723	1,877,532
Facilities and infrastructure	41,067	0.21	17.15	3,310,515	3,269,448
Sum of services	96,881	0.5	87.15	16,822,825	16,725,944
Services and Green spaces	96,881	0.5	157.15	30,335,135	30,238,254

Source. Armanshahr, 2013

Table 18. Current and required Sub-District level social infrastructures in District 22

Land use	Current area	Current per capita	Binding per capita	binding area	Require / surplus
Public green spaces	321,952	1.67	52.5	10,134,232	9,812,280
Educational and high education	98,893	0.51	13.30	2,567,338	2,468,445
Medical and health	750	0.00	5.95	1,148,546	1,147,796
Cultural & religious	5,414	0.03	10.75	2,075,104	2,069,690
Sport	26,209	0.14	8.75	1,689,038	1,662,829
Facilities and infrastructure	83,205	0.43	10.85	2,094,408	2,011,203
Sum of services	214,471	1.11	49.60	9,574,436	9,359,965
Services and Green spaces	536,423	2.78	102.10	19,708,669	19,172,246

Source. Armanshahr, 2013

Table 19. Current and required neighborhood level social infrastructures in District 22

Land use	Current area	Current per capita	Binding per capita	binding area	Require / surplus
Public green spaces	786,035	4.07	35.0	6,756,155	6,742,691
Educational	55,350	0.29	11.15	2,152,317	2,152,317
Medical & health	3040	0.02	5.25	1,013,423	1,012,559
Cultural & religious	50,160	0.26	9.45	1,824,161	1,822,944
Sport	59,454	0.31	7.7	1,486,354	1,484,778
Sum of services	4,349,012	22.53	48.60	9,381,403	6,472,600

Source. Armanshahr, 2013

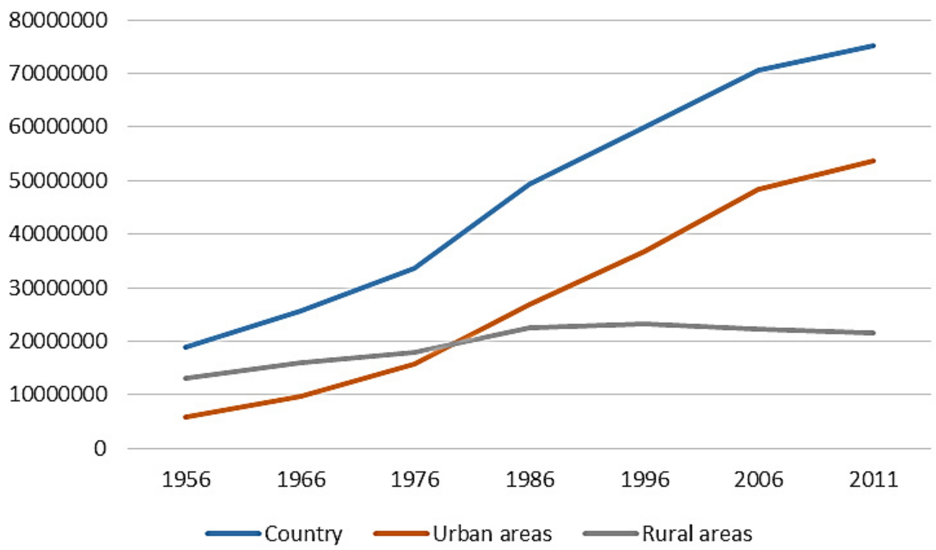
3.4 Rivew on energy fact and figures in the local context

An important mission in this part of the research is to provide a comprehensive overview on the main energy related fact and figures in the local context. The majority of the indicators comprises of macro-level statistics and data for Iran and Tehran. Several energy and climate related information are illustrated with the aim of providing the fundamental knowledge on the main factors and concerns around energy topic in the Iranian context. Findings from this part of the research provide a basis for detailed analysis for District 22.

3.4.1 Urbanization and energy parameters in Iran

During the 20th century, Iran gradually changed from a country dominated by a rural-nomad population to a largely urbanized one. The 1962 reform of agricultural land was a turning point for Iran's gradual transition from an agriculture-based to an oil-based economy as well as the acceleration of rural to urban migration (UNDP & DoE, 2010). Urbanization continued to increase at a rapid pace even after the Islamic revolution. In 2011 more than 70 % of the population lives in urban areas with a gowing tendency (Statistical Center of Iran, 2011).

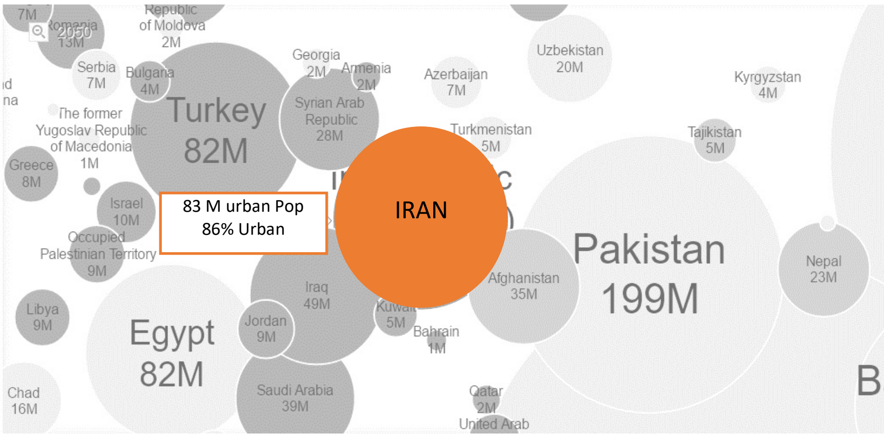
Figure 42. Population trends in urban and rural areas in Iran



Source. Statistical Center of Iran, 2011

From 2006 to 2011, the average annual population growth rate in urban areas was 2.14 %, while rural populations shrank by an average rate of -0.63 % (Statistical Center of Iran, 2011). As of 2011, there were 1,143 cities ("Shahr") and approximately 96,549 villages ("Deh" or "Roosta") in Iran (ibid.). Predictions by the United Nations indicate an uninterrupted growth with 86% of the total population of Iran living in urban areas by 2050 (UNICEF, 2012).

Figure 43. Countries and territories urban population projections for 2050



Source. UNICEF, 2012

The growing urban population figures in Iran can be traced back to three factors: the natural population growth, rural-urban migration motivated by comparatively better socio-economic conditions in cities, and changes to the official definition of rural areas, which allowed some former villages to become cities. Although urban-rural differences are an important factor for rural emigration, statistics show that the majority of migration happens between urban areas. From 1996 to 2006, 30% of migration was of rural origin, whereas the rest was from one city to another (Statistical Center of Iran, 2006). Tehran province in particular has been the primary destination of migrants, absorbing 30% of overall migratory movements within Iran (Pahl-Weber et al, 2013).

3.4.1.1 Energy sources and their consumption share in Iran

Iran has some of the largest oil and natural gas resources in the world. Not surprisingly, oil, petroleum products, and natural gas are the main energy sources in Iran (MoE, 2009). Although the country also has great potential for renewable energies such as solar energy, the current primary renewable energy supply is very low. This leaves room for improvement for the introduction of technologies and policy instruments as a means to stimulate the uptake of renewable sources of energy. Energy statistics show that the total energy consumption in Iran in 2012 added up to 162,620 ktoe. The U.S Energy Information Administration (EIA) indicates that, in the past decade, the primary energy consumption in Iran has grown by more than 50% [32]. Besides strong economic

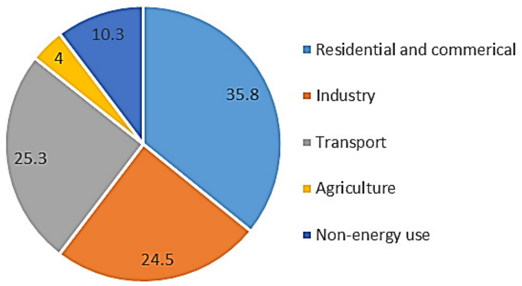
[32] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. (n.d.). Retrieved January 10, 2018, from http://www.eia.gov/countries/cab.cfm?fips=IR

development and improved living standards, demographic growth and urbanization have substantially raised the overall energy demand[33].

Figure 44 illustrate energy consumtion by sector. Not surprisingly, the building and transport sectors are the main energy consumers in Iran with approximately 36% and 25% of total consumed energy in 2013 followed by the industry sector (24.5 %).

Figure 44. Relative energy consumption by sector in Iran in 2013

Sector	in %
Residential and commercial (building)	35.8
Industry	24.5
Transport	25.3
Agriculture	4
Non-energy use[34]	10.3



Source. MOE, 2013 (Energy Balances 1987-2013)

Energy consumption in the residential/commercial and transport sectors exhibit the highest share in the overall Iranian energy consumption, consistent with the subsidies received by these sectors. Transport received 42% of the energy subsidies, household 30 %, and industry 13.5% (IEA, 2012). Iranian households use natural gas and oil mainly for heating, cooking, and hot water. Furthermore, lighting and appliances (including cooling systems) are the major components of household electricity use (IEA-WI, 2009). There is a considerable amount of energy waste in the building sector due to inefficient building construction and energy intensive appliances (Farahmandpour et al, 2008). As the sectors with the greatest share of energy consumption, it is therefore crucial to develop policies, strategies and measures for increasing the efficiency of building and transport energy use in Iran.

The energy intensity factor, defined as the ratio of the energy use growth rate to the GDP growth rate, is around 35% higher for Iran compared to the rest of the world for the period 2001-2011 (Moshiri & Lechtenböhmer, 2015). The primary energy supply and overall consumption have been increasing rather smoothly during the 70s and the early 80s. However, the rates of increase in consumption have risen substaitnially since then.

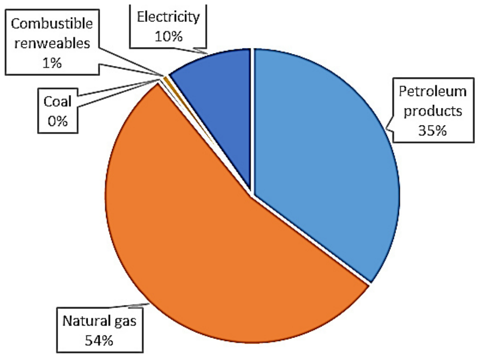
[33] Inter3, Institut for Resource Management. (n.d.). Retrieved January 10, 2018, from http://www.inter3.de/en/projects/details/article/potenziale-fuer-erneuerbare-energien-im-iran-und-moeglichkeiten-der-deutsch-iranischen-zusammenarbei.html

[34] This covers those fuels that are used as raw materials in the different sectors and are not consumed as a fuel or transformed into another fuel.

Figure 45 shows the share of different energy carriers in the total energy consumption in Iran.

Figure 45. Share of energy carriers in total final consumption in Iran 1987- 2013

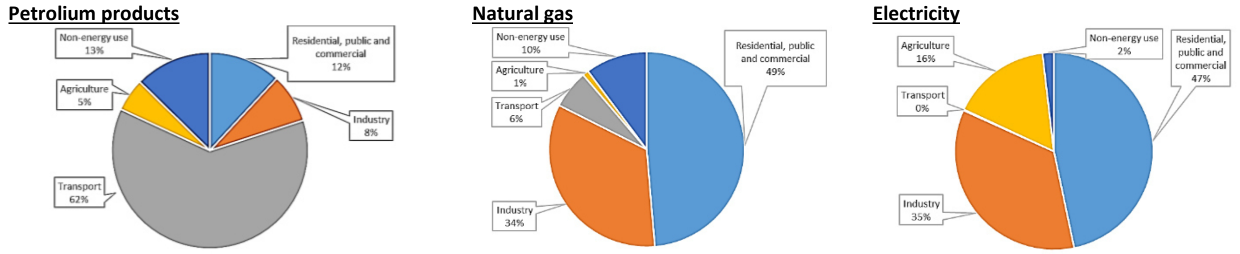
Sector	in %
Petroleum products	35.3
Natural gas	53.9
Coal	0.4
Combustible renewables	0.7
Electricity	9.8



Source. MOE, 2013 (Energy Balances 1987-2013)

The use of natural gas for primary energy supply increased from around 20% in 1990 to over 50% in 2009. While the decrease in use of oil and petroleum reduces CO_2 emissions, the high level of natural gas consumption counteracts this trend and produces considerable CO_2 emissions itself (MoE, 2006). The following figure shows the consumption of oil products, natural gas, and electricity by different sectors. The transport sector is the top runner in terms of oil consumption followed by buildings and the industry. When it comes to natural gas and electricity, most energy is consumed by households and the Industry sector (MoE, 2013)

Figure 46. Energy carrier consumption by sector in 2013



Residential, public and commercial ➔12%
Transport ➔ 62%
Industry ➔ 8%
Agriculture ➔ 5%
Non-energy use ➔ 13%

Residential, public and commercial ➔49%
Transport ➔ 6%
Industry ➔ 6%
Agriculture ➔ 1%
Non-energy use ➔ 10%

Residential, public and commercial ➔47%
Transport ➔ 0%
Industry ➔ 35%
Agriculture ➔ 16%
Non-energy use ➔ 2%

Source. MOE, 2013 (Energy Balances 1987-2013)

Finally, pertinent data furthermore shows an overall increasing trend in energy consumption as well as a high level of energy inefficiency in Iran across sectors. Energy use per-capita has been increasing on average by 4% annually between 2001 and 2010.

The energy intensity[35] has also been increasing on average by 1% in the same period, indicating a declining trend in the efficiency of energy use. As a point of comparison: energy intensity in Iran is 1.8 times higher than the EU average , and greater than the MENA (Middle East and Northern Africa) and low-income countries (Moshiri & Lechtenböhmer, 2015).

3.4.1.2 Emissions in Iran

Iran's large fossil resources and increasing consumption thereof has put in the country among the world's highest CO_2 emitting countries. Emissions increased rapidly in the 1960s, slowed slightly during the eight-year war period with Iraq, and have climbed steadily since the 1990s (Carbon Dioxide Information Analysis Center, 2012). Most CO_2 is emmited by commercial and public services (28%), followed by power generation plants (27%), the transport sector (24%) and manufacturing industries (19%). The transport sector's prominent role regarding CO_2 emissions stems mostly from the excessive use of private cars in combination with inadequate/inefficient public transport in urban and rural areas.

Table 20. Total emmissions by sector in Iran (2010 & 2030)

Sector	2010				2030			
	CO_2	CO	NO_X	SO_2	CO_2	CO	NO_X	SO_2
Household, commercial, public (%)	28	0.8	6	4	24	1	5	4
Manufacturing industry (%)	19	3	9	13	29	5	10	19
Agriculture (%)	2	0.2	3	4	1.4	0.1	2	3
Transportation (%)	24	94	47	29	21	91.9	61	48
Power generation plants (%)	27	2	34	50	24.6	2	22	26
Total emission (million tons)	737	8.25	1.84	1.43	1032	14.5	4.61	2.68

Source. MoE, 2010; Central Bank of Iran Economic Data, 2014; Moshiri & Lechtenböhmer, 2015

Table 21. Emmissions share by energy type in Iran (2010 & 2030)

Sector	2010				2030			
	CO_2	CO	NO_X	SO_2	CO_2	CO	NO_X	SO_2
Kerosene	3.6	0.1	0.0	0.8	0.6	0.0	0.0	0.1
Gas Oil	22	2.8	42.5	53.2	18	3	36.5	67.5
LPG	0.9	0.2	0.1	0.0	0.6	0.2	0.0	0.0
Fuel Oil	13.1	1.0	10	46	10.5	0.7	7.5	32.3
Natural gas	49	1.9	30.4	0.0	59.5	3	40	0.0
Gasoline	10.7	94	17	0.1	9.6	93.1	16	0.2
CNG	0.7	0.0	0.0	0.0	1.2	0.0	0.0	0.0
Total emission (million tons)	537	8.25	1.84	1.43	1032	14.5	4.61	2.68

Source. MoE, 2010; Central Bank of Iran Economic Data, 2014; Moshiri & Lechtenböhmer, 2015

3.4.1.3 Climate conditions and trends

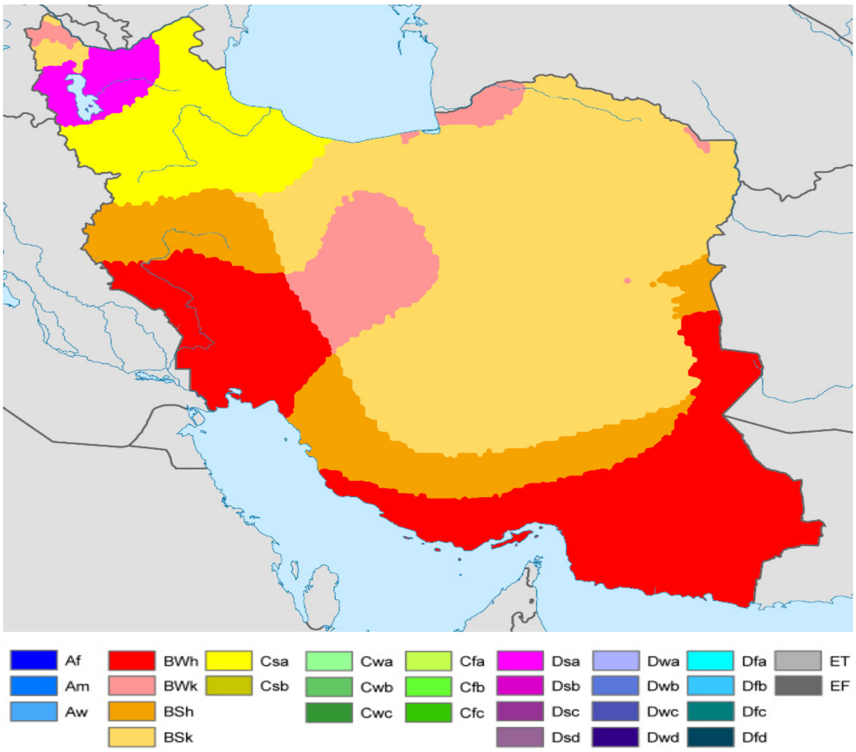
According to the Köppen climatic classification, there are three prevailing climate zones in Iran. The dominant climate type is arid and semi-arid climate, covering 81% of the country. 17% of the country is of temperate or mesothermal climate and 2% exhibits

[35] Defined as the ratio of the energy use growth rate to the GDP growth rate.

characteristic of acontinental-microclimate zone (UNDP & DoE, 2010). In most Iranian cities the coldest month is January (with a monthly average temperature between -6˚C and 21˚C) and the warmest is July with a monthly average temperature between 19˚C and 39˚C. In most regions, the highest precipitation occurs in winter with there falling almost barely rain in summer. Notwithstanding, there existing considerable regional differences in precipitation, with the average annual total ranging from 2,000 mm along the Caspian Sea to some areas in the central desert with almost no rainfall (UNDP & DoE, 2010).

In the coming decades, however, it is likely that Iran will fall prey to the severe effects of climate change. The changes are projected for the period between 2010 and 2039 (UNDP & DoE, 2010). Changing climate conditions, in turn, will likely have an observable impact on the level of energy consumption. For instance, the increasing number of hot days will raise the demand for cooling, resulting in increased energy use and, thus, higher CO_2 emissions.

Figure 47. Climate map of Iran



Source. Peel et al, 2007

3.4.2 Energy and emission parameters in Tehran

An overview

During the previous decades the population of Tehran has been growing rapidly, causing the place to grow from a small town into a metropolis. As a result of this rapid urban development, the periphery of Tehran continued to absorb more people and therefore several new urban districts started to form and grow[36] (Davoudpour, 2009). Other cities of the province have also grown very fast, and as the city of Tehran's population growth began a gradual decrease, they continued to absorb more population (Habibi & Hourcade, 2005). In other words, the city of Tehran has reached a stable position, while its hinterland and peripheral areas are still growing (Davoudpour, 2009). Among the main reasons for this population shift are: access to more affordable housing, better natural environment of the peripheral areas, plentiful physical and ecological assets of Tehran, as well as the strict rules imposed on its growth. The City of Karaj is a good example: it has grown from a small town in a rural area to a city with more than one million inhabitants which is now the capital of the newly established Alborz province.

In 2006 Tehran province had more than 13 million inhabitants. Although the 2010 separation of the Alborz province formally took away about 2.5 million inhabitants, the population of Tehran province had nevertheless grown counting 12 million in 2011 – more than 16% of the total population of Iran. Other provinces with a considerable share of population include the Khorasan Razavi province with 8%, and the Isfahan, Khouzestan, and Fars province each with around 6%. The remaining provinces are sparsely populated (Statistical Center of Iran, 2011). In 2006, Tehran province included 51 municipalities and 1,536 villages. 91.34% of its inhabitants reside in urban areas and 8.65% in rural areas (Statistical Center of Iran, 2006). The major agglomeration is the city of Tehran, which counted nearly 7.8 million inhabitants in 2006. Tehran was not mentioned on the list of the world's 30 largest urban areas before 1970, but has grown rapidly ever since, ranking 23rd in 1980 and 1985. However, after this period, which roughly coincides with the end of the eight year Iran–Iraq war, Tehran's fell back behind in the world ranking of the largest urban areas.

Concurrent with population growth, the number of households in Iran has also steadily increased. From 1956 to 2006, number of households increased by 3.7% annually

[36] In terms of topography, Tehran is located on the southern slope of Alborz Mountains as the main natural barrier for physical development in the northern part of the city. In the southern part, the desert is another natural barrier against physical expansion of the city. These natural barriers are among the main reasons for the westward physical development of the city.

(comparison: the annual population growth rate was 3%, for the same period). At the same time, however, household size has gradually decreased. This demographic trend is the result of a socio-economic transition in Iran beginning in the 20th century and caused by “the shift of [the] economic base from agriculture in favour of industry and services” (Encyclopædia Britannica n.d.). One of the main consequences of this trend is the replacement of extended family units by nuclear ones. The higher participation of women in both economic activities and education, coupled with the high expenses of urban living, are further contributing to the shrinking of households. As each family desires its own individual residential unit, these demographic trends translate into a growing demand for housing units which, in turn, is leading to greater energy consumption (Figure 48 and Figure 49).

Figure 48. Trends in the size of households in Iran 1956-2011

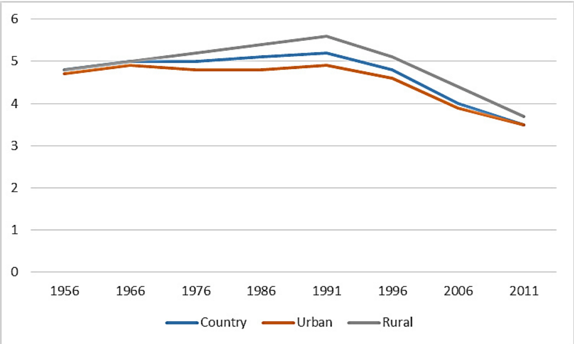
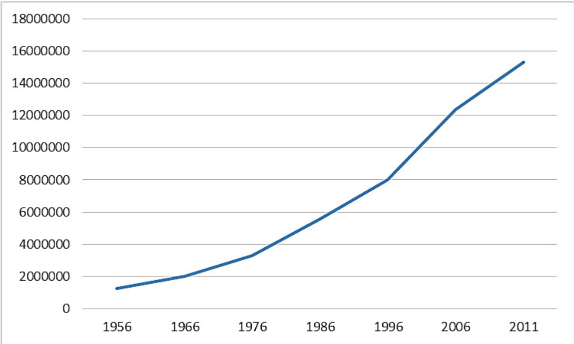


Figure 49. Trends in the number of urban households in Iran 1956-2011



Source. Statistical Center of Iran, 2016

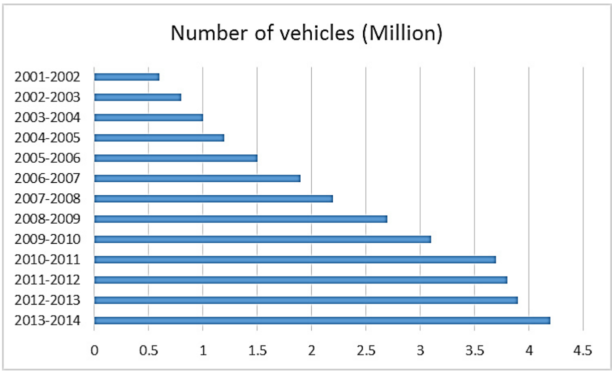
3.4.2.1 Energy consumption and CO_2 emissions

Tehran, as the political and economic center of Iran and the favorite place of residence for higher income groups, exhibits greater levels of energy consumption. In combination with higher population, more access to household facilities, and a greater percentage of residential area, the de facto energy demand in Tehran province is the highest in the whole of Iran (Nourouzpour, 2010). Fossil fuels are the main source of energy in Tehran, especially natural gas. There are some supportive government plans for the use of CNG (compressed natural gas) vehicles, which have a reduced environmental impact.

Electricity is the common energy source for lighting and cooling systems. In Tehran province, natural gas provides much of the energy for cooking, heating, and hot water. Piped natural gas infrastructure has been widely developed during the last 20 years, and access to piped gas is possible in most parts of the metropolitan area. This energy carrier has gradually replaced Liquefied Petroleum Gas, which was previously the main source for cooking, heating and generating hot water.

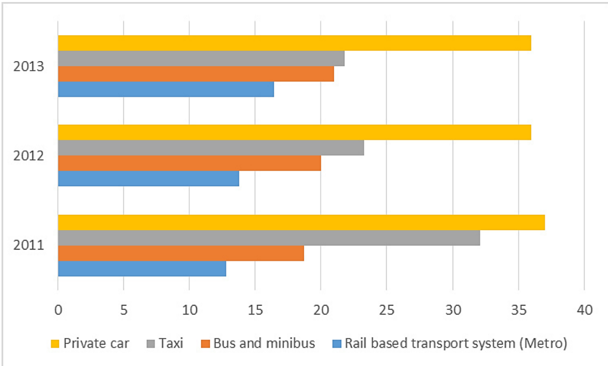
Among other energy sources for home appliance, which are very rarely used, can be named kerosene, diesel, and solid fuels (Statistical Center of Iran, 2006). Compared with other provinces, inhabitants of Tehran province cool or heat more rooms within their residential units. Data released by the Statistical Center of Iran (2011) shows that inhabitants of Tehran heat 91.7% and cool 90.4% of their units – comparison: Iranian urban families on average heat 77.1% and cool 67.7% of their living space. Vehicle exhaust is the main source of CO_2 emission and air pollution in Tehran. A case study by the Tehran municipality shows that among four popular vehicles (bus, taxi, private car and motorcycle), private car has the highest (88%) contribution of CO_2 emission in the city (Kakouei et al, 2012). The infromation from the Tehran yearly statistics book on motorized daily trips from 2011 to 2013 indicates that private cars are among the most favourable transport mean for the inhabitants of Tehran, with a share of more than 35% of all daily trips (Figure 51). Moreover, another study indicates the rapidly growing number of registered vehicles in Tehran with almost 4 million registration during 2013-14 (Figure 50).

Figure 50. Total number of registered vehicles in Tehran[37]



Source. Shahbazi et al, 2016

Figure 51. Share of daily trips in Tehran



Source. Tehran yearly statistics book, 2014

3.4.2.2 Climate conditions and trends

In terms of climate conditions, Tehran is characterized by a distinctive climatic and topographic context which impacts its built environment development. According to the Köppen's climate classification, Tehran is located in a semi-arid climate zone with warmer areas in the center and colder in the peripheral areas (Müller, 1983). In terms of temperature, the maximum temperature in summer can reach to 38 centigrade followed by relatively cold winter periods. The dominant wind direction is westerly accompanied

[37] Including: Passenger car, taxi, pickup, minibus, bus, truck, motorcycle

with warm and dry winds from the south and southeast in the summer, which are often dusty due to their origin (the central deserts). In 2014, the average annual temperature in Tehran was 18.6 °C. The hottest month is July (mean maximum temperature 37.9°C, mean minimum 26.2°C) and the coldest month is January (mean maximum temperature 11.2 °C, mean minimum 2.9°C). The average annual rainfall amounted to 138 mm. Precipitation is the lowest in August and July, with an average of 0 mm. Most of the precipitation occurs in March, averaging 28 mm (Tehran yearly statistics book, 2014).

Table 22. Monthly mean temperatures in Tehran based on Mehrabad synoptic station in 2014

Month	Temperature (C)				
	Mean maximum	Mean minimum	Absolute Max	Absolute Min	Average
January	11.2	2.9	16.3	-2.0	7.1
February	12.9	5.2	16.6	0.2	9.1
March	13.2	4.3	19.4	-3.4	8.7
April	20.3	10.2	26.4	-2.6	15.2
May	28.2	17.9	31.8	12.4	23.0
June	33.1	21.1	38.2	13.6	27.1
July	37.9	26.2	40.4	19.4	32.0
August	37.5	25.5	41.4	20	31.5
September	34.1	23.2	36.0	19.4	28.7
October	26.0	16.4	33.2	9.0	21.2
November	16.0	7.2	24.6	1.0	11.6
December	11.6	4.7	15.6	1.8	8.2
Year	23.5	13.7	41.6	-3.4	18.6

Source. Tehran yearly statistic book, 2014

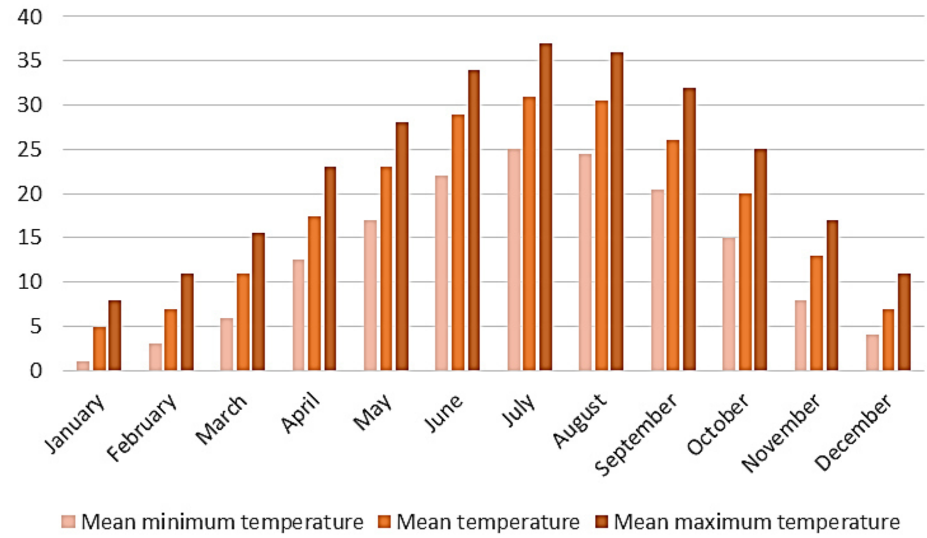
Table 23. Monthly precipitation and sun hours in Tehran based on Mehrabad synoptic station in 2014

Month	Monthly precipitation (mm)	Maximum precipitation in one day (mm)	Relevance humidity (%)		Freezing days	Sun hours	Maximum wind speed (ms)
			Max	Min			
January	4.8	4.8	62	30	2	215.0	12
February	22.0	5.4	65	29	0	152.6	14
March	28.0	11.2	67	28	5	207.0	15
April	13.1	5.2	55	18	1	258.0	15
May	10.4	3.0	46	14	0	265.8	20
June	10.4	6.2	42	11	0	307.4	33
July	2.4	2.4	34	10	0	309.2	10
August	0	0	29	10	0	344.2	10
September	0	0	33	11	0	327.5	10
October	10.4	8.6	52	20	0	240.5	15
November	9.6	5.0	62	29	0	206.4	14
December	26.8	16.0	69	37	0	155.1	12
Year	138.0	16.0	51	21	8	2988.7	33

Source. Tehran yearly statistic book, 2014

Roshan et al. (2010) and Alijani (2008) revealed important trends of climate change by comparing data from 1953 till 2006 on relevant climate factors for the City of Tehran. Data on the daily mean temperature reveals a significant increasing trend which is most obvious for the summer months. The same applies to the annual relative humidity. Annual average wind speed has decreased since 1953. Concerning the probable effect of climate change in the region, the situation will most likely become more critical in the short and mid-term. The climate forecasts predict that the rising mean temperature of Iran will increase the run-off volume of water during winter, but decrease the run-off during spring as rising temperatures turn snowfall into rain and shorten the snow-melting period. As a result, water scarcity is likely to become one of the major concerns in the country as well as Tehran region. In research on "urban heat island effects" in Tehran, micro-climatic data of the city has been compared with that of Varamin (a less developed urban area near Tehran) for a 40-year period from 1956 to 1995 (Ranjbar Saadatabadi et al, 2006). The results show a considerable increase in minimum temperature compared with that of maximum temperature in Tehran. The average annual minimum temperature in Tehran has increased by four times compared to Varamin. The main reason for this increase is humanly induced heating, the result of urban heat islands and changes in the micro-climatic condition of Tehran.

Figure 52. Monthly mean maximum, mean minimum, and mean temperatures in Tehran[38]



Source. Tehran yearly statistic book, 2014

3.4.3 Institutional dimension of energy efficiency in the local context

3.4.3.1 Organizational readiness and energy efficiency roadmaps

A review of Iran & Tehran energy facts and figures and their impact thereof shows its critical situation in terms of energy efficiency considerations. According to the data published by "Iran's energy balance sheet" in 2012:

- per capita usage of natural gas and crude oil is respectively 6 and 1.6 times more than global average;

[38] Based on 1985–2006 data from the Mehrabad synoptic station.

- energy end use in agriculture, residential and commercial, industry and transportation sectors are respectively 3.3, 1.9, 1.5 and 1.5 times higher than the global average;
- energy intensity in Iran is 1.5 times higher than global average and energy efficiency has been reduced compared to the previous years (VPPE, 2013).

The same set of data also shows a considerable share of fossil fuels (especially natural gas and oil products) in energy end use of the country, which is the main cause of green gas emissions. The highest energy use being generated by the building (i.e. residential, commercial) and transportation sectors indicates the pivotal role of urban related activities with regards to stimulating energy efficiency considerations.

Demographic changes play an important role in future trends of energy demand as well. As mentioned previously, during the 20th century, Iran has encountered a vast population growth with a considerable immigration from rural to urban areas. Although the population growth rate has been slowed down in recent years, urban growth is likely to continue. According to the last national census in 2011, about 70% of Iran's 75 million inhabitants are living in urban areas (SCI, 2011). Another critical demographic factor is ageing population, which, together with increasing household numbers but shrinking household size, pose fundamental challenges for the housing sector, with the potential of affecting the housing market and energy use in the country. In terms of planning procedures, Iran is a country with a centralized and sectorial planning system in which local governments have a key responsibility in the implementation of urban development plans. At the same time, however, local government are neither involved in the official process of development or decision-making regarding the plan, nor approval, review or amendment (Jasbi, 2012). In Iran, urban planning documents on the local level have been developed according to standard instructions, which are valid for the whole country. The standardized content of the plans neither provides any room for various geographical and climatic conditions nor energy and climatic considerations (Barakpour & Mosannenzadeh, 2012). What is more, there is no national energy master plan to harmonize different energy related activities in the whole country (Mobini Dehkordi & Houri Jafari, 2009).

At the same time, informal planning tools, which work like supporting documents to include new themes (like energy and climate), do not exist in Iranian planning system (Mirmoghtadaee & Seelig 2016). At any rate, in Iran, energy considerations and the issue of climate change are not high on the agenda. Iranian cities are vulnerable to climate change and will have a potentially significant impact on global GHG emission in the mid to long term, however this topic has been neglected in research and practice.

In recent years, however, the Iranian government has begun to acknowledge the importance of energy efficiency, the use of renewable energies in particular, and is trying take them into account in developing different energy policies and strategies. At the national level, the government has devised a national policy on energy-efficiency in the context of its Five- Year- Development-Plan (FYDP). Several sectorial policies have also been signed and ratified and energy related organizations have been established in governmental institutions (i.e. Iran Energy Efficiency Organization (IEEE-SABA)[39].

Despite these efforts, the initative has not been all too successful due to institutional problems such as parallel structures and a lack of effective coordination. On the local level, existing sectorial and national policies for energy efficiency and climate change mitigation have not been very effective either. Local actors, due to highly centralized and sectorial political structures, have comparably low influence in those matters. In the case of municipalities, there is a lack of recognition and knowledge concerning the municipal role in improving energy efficiency and climate change mitigation, which adds to the problematic discussed above. Furthermore, there is an absence of a well-defined autonomy for municipalities regarding energy issues at the local level. In some cases, municipalities are hindered by limitations associated with the power and competencies of municipal authorities and financial resources to implement energy efficient activities. Importantly, organizations responsible for the planning and management of cities are currently not sufficiently aware and have not performed adequately in this regard up till now (which is also the case in District 22 of Tehran[40]) (Jasbi, 2012). In terms of regulatory frameworks, the main legal instruments addressing energy efficiency and environmental protection with relevance for urban planning are the Air Pollution Prevention law, the Energy Consumption Reform Act, and No. 19 of the Iranian National Building Code: Energy Conservation in Buildings (TJA, 2003):

[39] Iran Energy Efficiency Organization. (n.d.). Retrieved January 10, 2018, from http://en.saba.org.ir/en/home
[40] The importance of energy conservation and CO_2 reduction becomes readily apparent if one considers, first, the growing trend of construction in District 22 and , second, that these urban growth areas, unlike existing ones, have the potential to be energy efficient from the start of their construction.

Article No. 25 Air Pollution Prevention Law:

When preparing spatial development plans, the Ministry of Housing and Urban Development[41] and the Ministry of Interior are obliged to add/contribute a separate chapter of the study reports on environmental issues and problems. The idea is to ensure that the design of cities, towns, and residential complexes (with regard to green and open spaces, juxtaposition of land uses, transportation networks, building densities, etc.) will be compatible with environmental criteria approved by the Department of Environment.

Article No. 26 Air Pollution Prevention Law:

The executive ordinance of Article No. 25 ought to be prepared jointly by the Ministry of Housing and Urban Development, the Ministry of Interior, and the Department of Environment and then approved by the cabinet.

National Building Code No. 19

The Iranian National Building Code No. 19 focuses on energy saving at the level of single buildings. The regulation was first devised in 1991, but it encountered rather negative practical repercussions. As an example, building specialists and controlling authorities as well as construction companies were unfamiliar with methods of insulating building components (Fayaz & Mohammad Kari, 2009). In 2010, another version (third revision) of Code 19 was developed in an attempt to simplify the code as well as to improve some of the technical chapters. However, the instrument turned out to be somewhat ineffective due to implementation challenges. Against this background, most recently, research was initiated for another round of revision and improvement for Code 19. Nevertheless, officials appear to be putting only little priority into developing energy efficiency mechanisms in urban planning, especially at the local level.

3.4.3.2 Urban development plans and energy efficiency

The urban governance structure in Iran can be differentiated across three levels: macro (national), regional and local levels.[42] On the macro level, ministries or organizations develop and decide on country-wide strategy to be implemented by local and regional governments. Usually, all administrative organizations in Iran follow the levels set out by political divisions. Thus, the government system has a very top-down hierarchical order.

[41] Currently The Ministry of Road and Urban Development (MRUD)
[42] The main units of political and administrative organization in Iran are: country, province, county, district, city and village.

On the regional level, There are no independent organizations but existing organizations function as province branches of the ministries and state organizations. On the local or urban levels official[43] organizations are de facto in charge of the operative business of running the city. Policy objectives and measures in Iran are set out by three planning instruments:

- Five-year economic, social and cultural development plan of the country;
- Urban development plans and;
- Regulations of municipalities.

The five-year development plan is a key document in that it sets the overarching goals for local governments (Taheri, 1992). Analyzing the objectives and policies as formulated in the five year development plan, reveal the following problems and weaknesses:

Lack of codified, specific and specialized objectives and policies:

Often objectives are implicitly propounded in the scope of local government in the framework of urban development discussions and have not a special part in official documents of the country's managerial and planning sections. This reflects the lack of legal recognition and enforcement of local government and urban management scope in policy making, planning, legislating, and executing as a principal.

Lack of an integrated and comprehensive approach

Conflict of interests within key organizations developing urban policies and objectives, frequent change of top managers, and immoderation in basic principles related to local government caused dispersed sectorial approaches "led to non-coordinated efforts" proving expensive, inefficient or faling altogether.

Lack of a long term thinking and planning and mismatch between objectives and policies

A key reason for the planning not being succesful lies in the fact that objectives and policies on the macro level are not sufficiently linked to micro level conditions on the ground. In practice, this is the consequence of limited consideration of micro urban management level, particularly municipalities as well as lack of active integration of

[43] Official authorities include municipality, city council, governor, county planning council and organizations related to infrastructure and urban services like water, electricity and gas departments.

policies and responsible authorities at national, regional and local levels in local governance [44].

The problem is that the Iran urban planning and implementation system is characterized by overlapping and conflicting institutional rules. On the one hand, urban development led by the Ministry of Road and Urban Development and under the supervision of the Supreme Council of Urban Development and Architecture. On the other hand, implementation of the approved plans is a duty of the executive system, i.e. the municipality (Kazemian, 1995). This dilemma brings about the problem that planning made by the overarching authorities and implementation by the municipalities diverge. What is more, within this structure, public participation is attributed no role at all. In fact, the Ministry of Road and Urban Development being the lead actor has de facto taken away room for public input altogether. At the same time, municipalities have not established a working mechanism for public participation either; if anything at all, participatory initatives at the local level are at very early stages.

In terms of execution of plans, municipalities encounter several problems, of which the most important are: overlapping duties and parallel managements in different urban scopes, ambiguity of authorisation and responsibilities of organizations and lack of coordination among other influential organizations. This matter emphasized on the current urban disintegration in Iranian cities. Another important aspect is capacity and effectiveness of municipal organizational structure, human and financial resources as well as interaction with other influential organizations (Barakpour, 2010). In the Iranian planning system, integrity and cooperation framework among organizations and related institutions are not adequately established. As a result, resources are not used efficiently, current situation became unorganized and public benefits are often violated and unfair. The unstructured nature of the administration indicates the necessity for reorganizing the actor landscape by delineating adequate and clear tasks and responsibilites, at the very minimum. Ideally, an organization is needed which would function as an “interface” and point of coordination between different organizations and institutions within the local planning system.

[44] In current situation, municipalities, as key elements of current local government in Iran, are responsible mostly for execution of urban development plans and have low rights in: decision-making, preparing plans, supervision on plan preparation, approval, review and amendment. However, there are execptions in larger urban areas such as Tehran, with municipality having a broader range of responsibility and decision making power.

Focusing on energy effiiciency issue in the local planning context, overall, besides financial barriers, responsible authorities (i.e. the municipal organizations and departments) lack reliable and credible information about energy performance and the costs and benefits of efficiency improvements. Further complications arise due to a lack of implementation capacity and relevant technical skills to ensure compliance with building energy efficiency codes. In terms of policy and regulations, there is a lack of national and/or local commitment to energy efficiency enhancements (especially when it comes to urban structures and buildings). In the specific case of social infrastructures, the government internal procedures and lines of responsibility discourage energy efficiency in public buildings (i.e. budgetary and procurement policies) and are thus not conducive to contracting energy efficiency services.

3.4.3.3 Existing energy efficiency & environmental initiatives

As addressed in the literature survey (chapter 2), there exist different types of urban planning and design measures influencing the energy performance of cities. These measures often target the physical, functional as well as socio-economic and cultural dimensions of cities. They have a great potential to be integrated in existing urban planning and development practices. Despite these benefits, no such measures are identifiable in the current planning system in Iran – neither in large scale comprehensive planning nor in detailed planning and design activities. However, there exists few provisions, which are sparsely mentioned in planning studies without a consolidated and clear implication on energy efficiency and environmental considerations. Measures such as balances allocation of urban services and per-capita of urban basic services are examples of these types of criteria.

Most recently, a few local governments have started new environmental and energy efficiency initiatives with the aim of integrating new qualities in their local planning frameworks. An example of such attempts is Tehran District 22 municipality by establishing the “Urban Design and Environment Commission - UDEC”[45] with the main focus on integrating climate, environmental, energy as well as urban design quality measures in the process of physical development. Similar to Code No-19 mentioned

[45] In accordance to implementation of the protocol, No 320 of the commission 5, the municipality and urban management authority has started to improve the environmental conditions and sustainability values parallel to application of the new technologies along with the local climate characteristics to enhance the energy efficiency in District 22. These include allocation of buildings and services for optimized solar energy absorbance, wind, topography, earthquake and other considerations. For this aim, the Urban Design and Environment Commission of the District 22 was established in 2000. The commission comprises of experts and practitioners from the relevant fields of urban design, architecture, urban planning, energy and environmental issues and takes place in a weekly manner.

earlier, this initiative emphasizes on energy and design tweaks with regards to buildings, independent of development plans [46].

The UDE Commission aims at maximizing energy efficiency and conservation of natural equities in the development of urban structure. It uses the existing knowledge and experience of the developers for creating a better urban image and environmental quality. The Commission's efforts to reduce energy consumption and raise attention to environmental issues in the process of building design and construction. In doing so, the Commission established a planning and design guideline, rendering it obligatory for all types of buildings and physical developments in District 22. The guideline, for instance, stipulates taking into account features such as sun light, relative humidity, temperature, wind and topography when developing new physical structures in District 22.

Overview on UDEC guiding measures

Building and block orientation is an important measure addressed in the UDEC guideline. Particular importance is ascribed to building orientation as a mean to maximize sun light absorbance, considering heating and light factors with respect to the particular climate conditions. Acording to the UDEC guideline, the lowest sun light angle in the winter is 30 degrees above the horizon. Therefore, in order to maximize the use of natural sun light, buildings shall be oriented in the range of 10:30 to 13:30.

Furthermore, the distance between buildings shall not create any interference with light and passive solar absorbance. Accordingly, buildings should have the distance of 1:1 in order to gain full solar absorbance during winter. In terms of solar radiation, in the winter time and the north latitude 40 degrees, the southern walls receive almost three times more solar energy in comparison to the eastern and western walls. During summer, the amount of solar energy transmitted to the southern and northern walls are ½ of the energy transmitted to the eastern and western walls.

Stimulating natural ventilation is another important measure in UDEC. District 22 is located in a warm and dry climate. In such climates, natural ventilation during cooling days of a year should be maximized to avoid a negative impact of the external warm air. Considering the dominant wind directions in the western part of Tehran (District 22)

[46] In other words, essential energy and environmental elements, which have not been integrated in process of development plans i.e. master plan or detailed plans, are forced to be partially integrated in the construction of single buildings. Although the creation of the commission is a step forward, a clear integration of energy and environmental criteria in the local planning processes as a whole is still missing.

and an average humidity level of 40.4%, the natural ventilation in and outside buildings can play an important role in minimizing the cooling demand during summer time. Furthermore, buildings and other physical features shall be designed to counteract the long wind corridors (east-west). This translates to an optimal building orientation to south east. Natural light is an important factor while planning and developing buildings (i.e. concerning hygiene factors). Therefore the UDEC defines guidelines in terms of openings to maximize the absorbance of natural light. The guideline proposes that the area of the windows shall be 1:6 to 1:8 of the area of the rooms. Openings have another implication in terms of enhancing the natural ventilation in buildings. Therefore it is proposed to established windows up to 15 cm of the ceiling for effective circulation of warm and fresh air in the building. This will help to keep the optimum temperature of the rooms between 20-21 degrees Celsius.

Distance from sources of noise pollution is yet another important criteria in the UDEC guideline. The guideline provides rules and regulations concerning the distance to sources of noise, materials and characteristics of the external and internal walls, openings, double-glazed windows, internal separation of the rooms according to their functions (quite rooms, living rooms and etc.) as well as using green spaces and trees.

Besides climatic planning and design measures to maximize the utilization of natural energy sources, the UDEC guidelines furthermore introduces obligatory provisions in terms of technical thermodynamic features of buildings. Examples are:

- Technical solutions: e.g. central temperature controlling systems equipped with thermal sensors, thermos hot water tanks, insulation of the warm water and heating system as well as the piping system, using an efficient pumping system, etc.
- Insulations: Using foam insulations for the ceilings, walls and floors, external walls insulations, double-glazed windows etc.
- Lighting systems: Changing the lighting materials to more efficient lighting systems, enhancing natural lights usage, using light colours etc.

In the context of the UDEC guidelines, the proposed planning and design measures are categorized in the form of obligatory and recommendable measures. Table 24 provides a summary thereof:

Table 24. Proposed environmental criteria by the UDE Commission in District 22

	Closed spaces							Open spaces							
Land uses	annoying wind direction	Sun light	Light exposure of the windows	Economic heating and cooling systems	Favourable wind direction	Humidity balance using the mechanical facilities for cooling and heating	Heat exchange of the windows	Artificial materials i.e. shutters	Access network orientation in relation to wind	Access network orientation in relation to sun light	Consuls of the first floor avoiding the rain and sun light	Breaks in buildings, avoiding the annoying wind	Retreat of southern buildings for sun exposure to the access network	Plantation for shadowing aims	Plantation for wind prevention
Residential	O	O	S	S	S	S	O	S	S	S	S	S	S	S	S
Commercial (neighborhood center)	O	O	S	S	S	S	S	N	S	S	S	S	S	S	S
Commercial, administrative (district center)	O	S	S	S	S	S	S	S	S	S	S	S	O	N	S
Commercial, administrative (urban center)	O	S	S	S	S	S	S	S	S	O	O	O	O	N	S
Educational	O	O	O	N	S	S	O	S	O	O	S	O	S	N	S
Recreational	S	S	S	N	S	S	S	N	S	S	N	S	S	S	S
Obligatory: O **Suitable/Recommended: S**															

Source. UDEC Guideline of District 22, 2016

3.4.4 Energy efficiency planning and design measures in practice

Introduction and focus area

Achieving a high level of energy efficiency and livability at the same time requires deliberate and consistent urban planning policies promoting such convergence, persistent city leadership efforts spanning decades, capable local institutions, and broad-based citizen support. As explained in Chapter 2, the city's livability and its level of energy performance are closely linked to its physical from and functional features. This include the geometric dimensions of buildings and urban built structures, spatial distribution of buildings, access networks and facilities, as well as functional coordination and allocation of residence, jobs and social infrastructures. Literature review shows that, in general terms, energy efficient cities often demonstrated the following characteristics:

- Compact built-up areas with residents, jobs and social services strategically distributed along transit corridors

- Dense and interconnected street networks with a variety of functions which emphasize the need of all users, particularly so pedestrians, cyclists and public transport users
- Public transport modes correspond to population, jobs and social infrastructures with accessible stops in walking distance
- Social infrastructure and amenities (i.e. schools, health centres, parks and administrative spaces) are designed and allocated to maximize accessibility by walking
- Mixed uses and multifunctional activities/services are integrated in neighbourhoods and urban districts
- Streets are designed in a way to promote walking and cycling
- Design and layout of buildings and access network are adapted to the local climate conditions.

It is worth mentioning that urban spatial development has a very strong "Lock-in" effect, meaning that once urban forms are put into place and as cities grow, it is very costly to retrofit. This demonstrates the importance of laying the foundations for urban development right, especially in growth areas such as District 22. The theoretical model and its exemplary practical applications have been discussed comprehensively in Chapter 2. A detailed framework of guidelines for planning social infrastructures was also presented to support the optimization, adaptation and development of energy efficiency. This includes measures on spatial structure and the layout of social infrastructures, utilization of natural environment such as wind and topography, effective use of passive solar energy as well as enhancing efficiency in urban transport and mobility. The promotion of energy efficient urban planning measures is a key step towards creating opportunities for both reducing energy consumption and supporting the stimulation of passive energy gain in the urban context. Against this background, identified planning and design measures will be analyzed in the case study. The aim is, on the one hand, to monitor the existing status and analyze the level of consideration of energy efficiency and design measures in existing social infrastructures. On the other hand, the availability and integration of said measures will be surveyed in existing urban development plans and current planning regulations. These two analyes combined will serve as the foundation for a later examination in Chapter 4, identifying existing gaps and providing recommendations for future development.

3.4.4.1 Energy efficiency analysis in existing social infrastrucrures – District 22

As discussed previously, social infrastructure's energy performance is affected by several factors related to urban morphology. The spatial dimensions, the coordination of built densities, the quality of accessibility as well as the extent to which the built environment adapts to local climate conditions are amongst the most influential variables. The above mentioned measures influence from one hand on the level of motorized transportation, and on the other hand affect the energy demand within social infrastructure buildings (i.e. heating, cooling and lighting demand). Againts this background, the analysis in this part of the reseatch focuses on:

a) Measures to minimize energy demand and loss of energy in social infrastructures

b) Measures to maximize the utilization of passive energy in social infrastructures

c) Measures to reduce the need for movement and maximizing the use of efficient transport modes to access the social infrastructures

Each of the above mentioned set of measures will be analyzed in District 22[47].

a) Measures to minimize energy demand and loss of energy

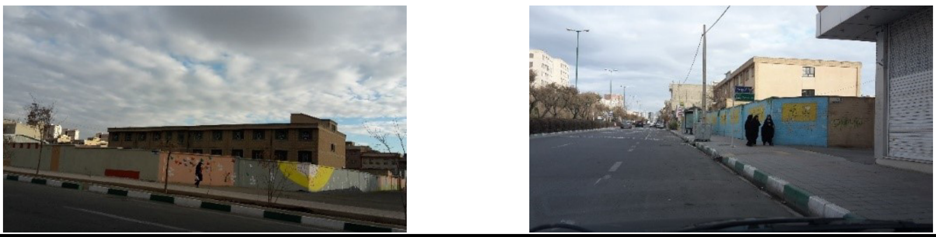
The physical features of built structures impact the level of energy efficiency. These include the structure and distribution of buildings, the form, sizing, and scaling of urban plots, and the sizing and scaling of street networks. Optimizing these aspects of urban form can reduce energy needs by a factor of two to four (Salat and Bourdic 2013). Energy efficient urban forms, as shown in many historic city centers around the world, display a fine-tuned balance between street size and function: a few very large streets, a medium number of medium-size streets, and a large number of narrow streets that promote walking. By contrast, urban sprawl, made possible by automobiles, makes driving a necessity and is responsible for high-energy needs for transportation (Rickwood et al, 2008). Urban sprawl combines low density and fragmentation of the urban area, increases the average travel distances for daily trips, and hinders a shift toward less energy-intensive transportation modes.

[47] In order to acquire a better understanding of the current situation of social infrastructures, a comprehensive set of supportive spatial analysis maps are developed (see annex 3)

Field observations from District 22 indicate a limited consideration of above-mentioned geometrical measures in the development social infrastructures. As a general trend and in contrast to existing built areas, the majority of new structures are either single buildings or complexes in the form of high-rises with a considerable heat transfer envelope area in relation to building volume. However, when it comes to social infrastructure, the pattern differs. Depending on the type, an individual and detached building morphology is dominant. In other words, the majority of social infrastructures (e.g. educational centers) are low-rise detached buildings with a maximum of two stories, exhibiting a high heat-transfer envelope area. As mentioned previously, one criteria to assess the heat transfer status of buildings is the A/V ratio. Although a few existing social infrastrucres have an effective range of A/V ratio, the majority of buildings are outside the optimum range with a considerable heat loss due to their inefficient building forms.

Figure 53. Examples of building structures and layout in district 22

Low rise structure of social infrastructures (example of primary education centers)

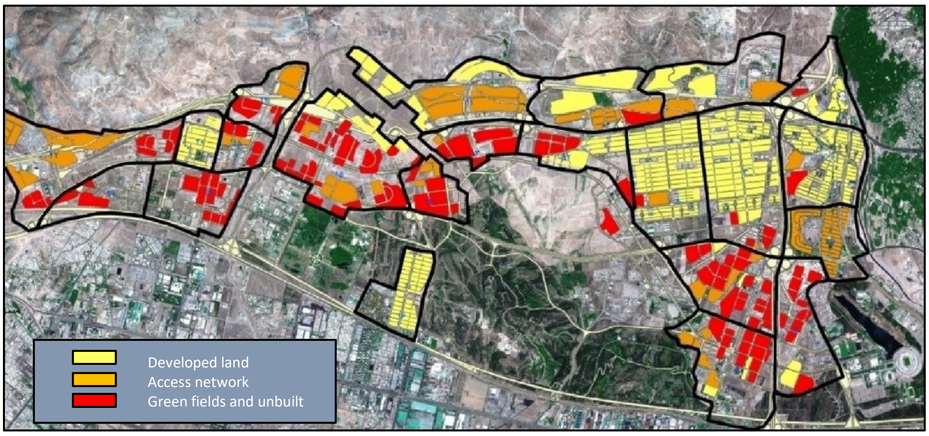


Source. Khodabakhsh, 2017 (based on field observation)

As discussed in Chapter 2, compactness of urban form as well as the optimum ratio of building density are important factors in regard to an energy efficient urban morphology. Studies have shown a direct correlation between unbalanced density and deficiencies in energy consumption, both in the building (through improper shadowing and limited passive solar absorbance) and transport sector (through inadequate social infrastructure delivery and an increased number of generated trips as well as trip's length). In this context, observations in District 22 demonstrate an unbalanced composition of building densities. Here, one explicit feature is the adjustment of high-rises residential complexes with very low-density urban structures of social infrastructures. This phenomenon can be analysed from two aspects. For one side, both low-and super high-density buildings (residential as well as social infrastructures) are not considered to be energy efficient morphologies due to higher level of thermal loss. For another, the adjacent allocation of diverse and extreme building types will affect the level of passive energy absorbance (i.e. passive solar gain as a result of shadowing effects by high-rises on neighbouring low-rise buildings).

Furthermore, both building and population densities directly influence the sufficiency level of social infrastructures in different spatial division of urban areas. The existing unbalanced building and population density concept in District 22 has a bearing on the level of self-sufficiency of neighbourhoods and sub-districts. In other words, the population increase brought by high-rises dvelopments involves additional pressure in terms of need for extra/adequate social infrastructures, overpassing the threshold level of service centres planned for each urban division (neighbourhoods, sub-districts and districts). The inadequate distribution of social infrastructure, as a consequence, forces inhabitants to travel longer distances, potentially to other districts in order to find service centres. The downside, in turn, manifests itself in increased levels of energy consumption in the transport sector.

Figure 54. Unbalanced building density throughout District 22



Source. Armanshahr, 2013

b) Measures to maximize the utilization of passive energy

Adapting design and layout of buildings and streets to fit local climatic conditions reduces energy use for space conditioning. Streets and buildings need to be designed and configured to support day-lighting, ventilation, and passive cooling or heating. In a dense urban environment, clusters of buildings, urban blocks, and urban textures constitute right points for intervention in designing energy efficient built environments.

Wind and topography

The utilization of environmental features (such as wind and topography) provide considerable opportunities for reducing the level of energy demand in urban structures such as social infrastructures. Evidently meaningful in this regard is taking into account characteristics of wind and topography. Natural wind can be utilized in a way to maximize the natural ventilation both inside and outside the social infrastructure buildings. Both the orientation of buildings and blocks as well as the allocation and distribution of built urban structures influence the level and quality of natural ventilation. This issue is of utmost important in hot and aird climates such as District 22 with a high share of cooling days over the year. The configuration of social infrastructure buildings and access network can considerably enhance the level of air circulation and minimize the cooling demand in buildings.

Field observations in District 22 indicate shortcomings with regards to the issues described above. For one thing, there appears no systematic use of patterns in terms of utilizatio of natural wind. Yet another deficiency is observable in terms of the utilization of the wind corridors for the benefit of local climate and natural air circulation (i.e. urban canyons). Figure 55 depicts that no common pre-planned access network and block orientation pattern is observable in District 22. The same applys to the social infrastructure built environemnts.

Figure 55. Eenvironmental features (topograpohy[48] and wind) in District 22

No consideration of topographical structures | Large scale high density building complexes

Source. Khodabakhsh, 2017 (based on field observation)

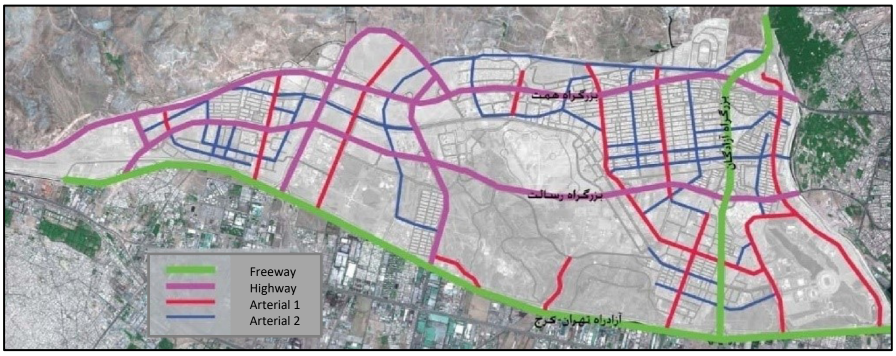
Passive solar energy gain

As discussed in Chapter 2, several factors influence the level of passive solar energy utilization. These include building, block and access network orientation, building façade features such as materials and colours, openings (especially the south-face surfaces), shading effects by neighbouring built structures as well as vegetation. Field observations in District 22 reveal that in terms of building and access network orientation no common pattern is observable. However, the majority of social infrastructures are south-faced built structures with a diagonal range from south west to southeast. This indicates the

[48] The map depicted in Annex 3 shows the location of social infrastructure in relation to the topographical features of District 22.

importance of south solar radiation in building structures as a general rule during the development of District 22[49].

Figure 56. Main access networks in District 22



Source. Armanshahr, 2013

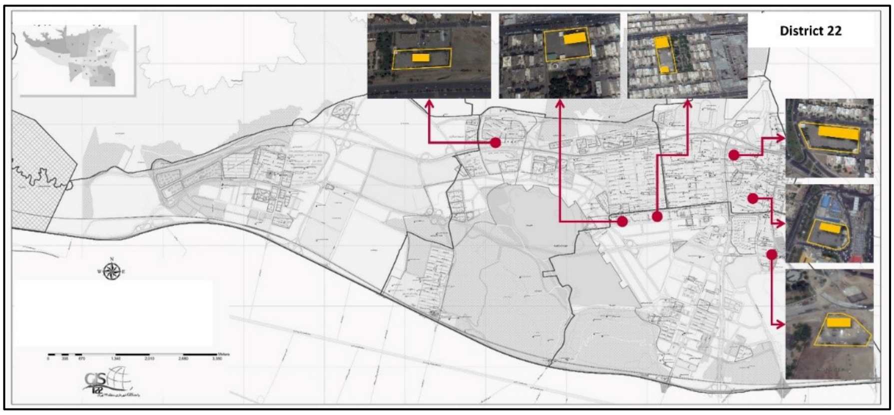
In terms of large-scale social infrastructures, the size of parcel provides opportunities for flexible configurations of mass and space. Yet, the field observations reveals a limited common pattern in terms of optimum orientation of building mass for passive solar energy gain (south orientation tendencies). Consequently, the mass-space configuration of social infrastructure follow no common pattern with regard to enery efficiency optimization in District 22.[50]

Figure 57. Examples of building and block orientation and mass and space pattern in selected primary schools in District 22

Source. Khodabakhsh, 2017 (based on field observation)

[49] As a general rule, buildings and blocks, follow the access network orientation. Planning of access networks is also a component of higher-level comprehensive plans, where no energy and environmental measures are applied during their preparation process.
[50] The most explicit physical feature is the position of mass on the northern part of plot.

Figure 58. Examples of builindg and blocks orientation and mass and space pattern in selected high schools in District 22



Source. Khodabakhsh, 2017 (based on field observation)

Figure 59. Examples of builindg and blocks orientation and mass and space pattern in selected community centers and libraries in Distrcit 22

Source. Khodabakhsh, 2017 (based on field observation)

Figure 60. Examples of builindg and blocks orientation and mass and space pattern in selected health centers in Distrcit 22

Source. Khodabakhsh, 2017 (based on field observation)

Another measure in maximizing the utilization of passive energy gain resides with the building façade and its energy absorption capacity. This includes façade material, colours as well as opening's characteristics. Field observations indicate that in existing social infrastructures various materials, colors and opening confiuration patterns are applied. In terms of façade colors, the majority of the buildings are covered with light color façade materials to increase the level of solar reflection and minimize heat absorbance especially during the cooling days of the year. The light-colour building façade materials helps to keep the in- building temperature within a convenient range and contributes to reducing the cooling demand during summer time. South faced openings (e.g. windows) are important components in regard to passive energy as well as natural light gain. Despite the massive cooling demand of buildings in District 22 during summer time, the buildings possess no external shading elements to minimize solar radiation in summer.

Figure 61. Building façade colours of selected social infrastructures in District 22

Source. Khodabakhsh, 2017 (based on field observation)

One important planning aspect affecting the energy performance of buildings, as communicated in the pertinent literature, is the height of built structures, particularly so the height of adjacent buildings. The building height has a bearing on the A/V ratio and building heat envelope, which, in turn, influences the level of energy loss (both heating and cooling). On the other hand, the morphology of the neighbouring built environment hinges upon the level of desired/undesired shading by adjacent buildings. Local observations indicate that, in this regard too, no common pattern is observable regarding the height of adjacent physical structures. There exist massive built structures adjacent to low-rise buildings of social infrastructures, which negatively influence their passive solar and wind energy gain performance. Figure above provides examples of the described disproportionate adjacency in existing built structures in District 22.

Figure 62. Examples of shadowing effect of building structures in District 22

Source. Khodabakhsh, 2017 (based on field observation)

Impact of vegetation

Green spaces, trees and vegetation, as mentioned, form yet another set of influential energy efficiency measures in built areas, especially through shadowing and air-refreshing effects. Despite that, field observations show a very limited use of green spces for the above-mentioned objectives in District 22 social infrastructures (see Figure 63).

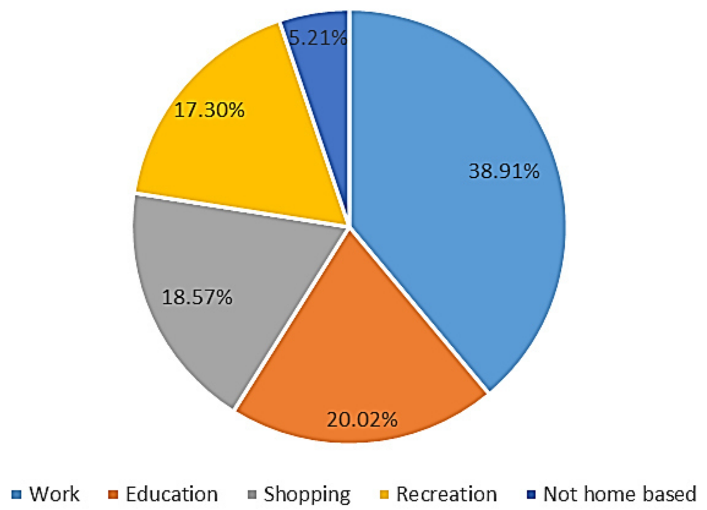
Figure 63. Green spaces configuration within/adjacent to social infrastructures in District 22

Source. Khodabakhsh, 2017 (based on field observation)

c) Measures to reduce the need for movement and maximizing the use of efficient transport modes

Transport and mobility is yet another area that has a significant bearing on the urban energy efficiency function. By way of deliberate social infrastructure planning, it is possible to minimize generated trips and reduce VMT[51]. The dispersed nature of social infrastructure in District 22 generates a considerable amount of motorized trips. An examination of the traffic data from Tehran Coprehensive Transportation and Traffic Co. indicates that 38% of generated trips belong to work-home commutes. The remaining 62% largely stem from trips generated with the aim of access to social infrastructures (Tehran Comprehensive Transportation and Traffic Co, 2014).

Figure 64. Share of daily generated trips in Tehran district 22



Source. Tehran Comprehensive Transportation and Traffic Co, 2014

In terms of external factors, for urban transportation to be energy efficient, building and population densities together with the allocation of social infrastructures are amongst the most influential factors. Generally speaking, where social infrastructures are easily accessible (i.e. less than 10 minutes by walking) and walking is safe and comfortable, people tend to forgo driving. If urban design were to combine walking accessibility with reliable public transport services, the need to drive by car within cities would have been drastically reduced. The sizing and the scaling of social infrastructure amenities should thus be finely tuned. Achieving this balance depends upon an optimal distribution of large-, medium-, and small-scale urban amenities and social infrastructures. For example, a balanced urban fabric has a few large hospitals, shops, and parks, and a large

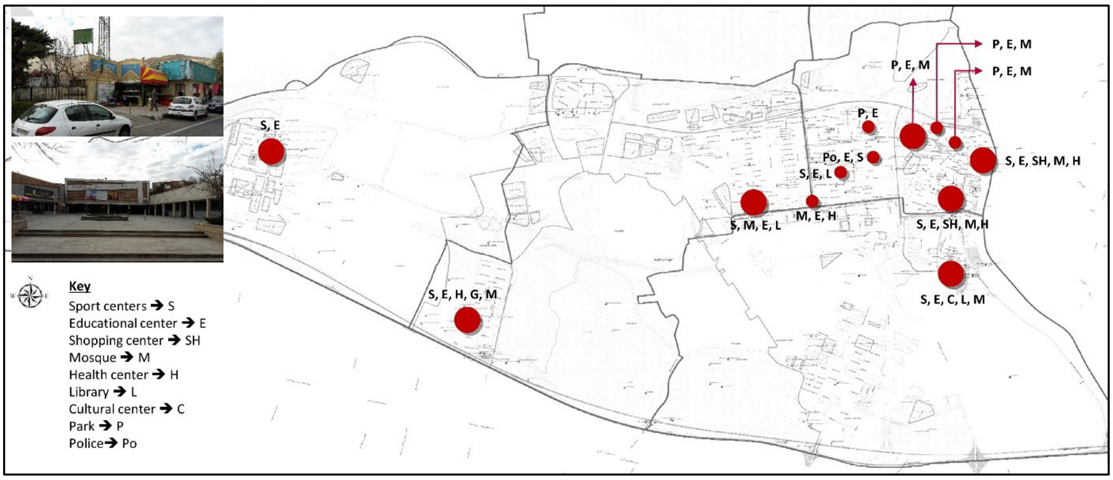
[51] Vehicle Mile Traveled

number of small-scale clinics, small shops, and pocket parks. This high-density distribution of small-scale amenities in the urban fabric ensures that social infrastructures are close and accessible for every citizen. To this end, the application of mixed use concepts, planning for shorter distances through optimized allocation of urban services in relation to building and population densities, minimizing traffic areas as well as push and pull strategies to stimulate public transport, walking and cycling are key measures.

Functional dimensions

Zooming in on District 22, mixed-use service centers exist in only few neighbourhoods. In fact, a large number of social infrastructure are located in isolation. Overall, the vast area of the district together with an uneven distribution of social infrastructure pose difficulties in terms of accessibility and cause a high share of motorized trips over long distances (Figure 65).

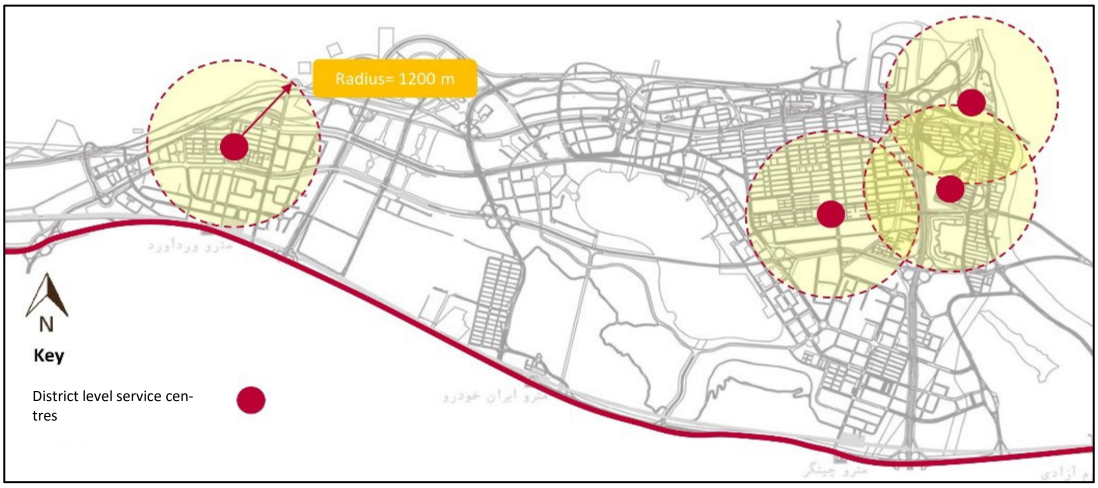
Figure 65. Example of existing mixed-use urban service centers in District 22



Source. Khodabakhsh, 2017 (based on field observation)

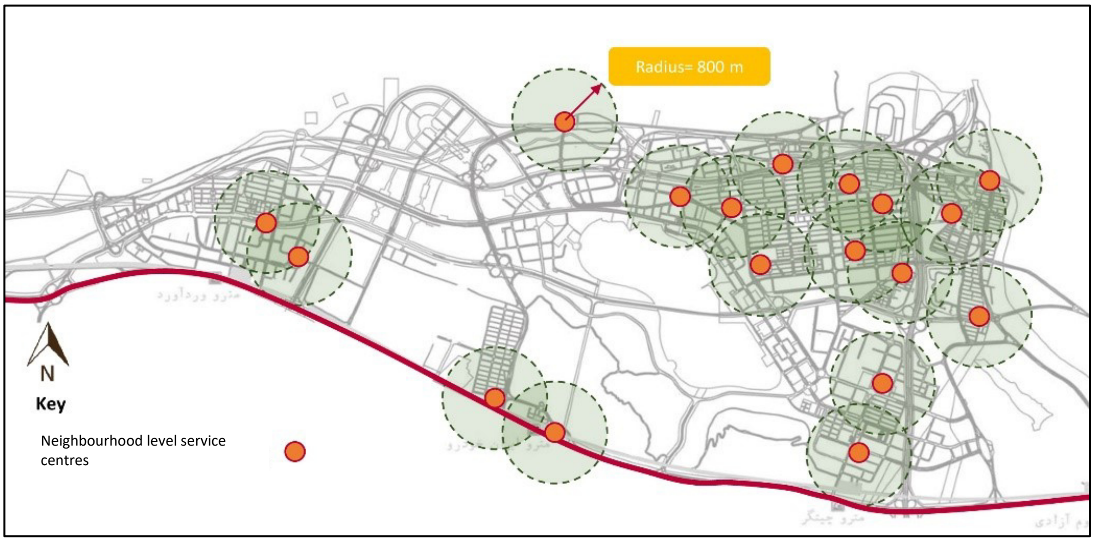
Looking at the catchment area of existing social infrastructure and service centers on different levels, ranging from the neighborhood, to the sub-district and district level, overall coverage appears poor (see Annex 3). There are several residential areas, which are located outside of the catchment area of existing service centers. This situation is aggravated by ongoing rapid physical development and a fast pace of inward migration as these trends are likely to further increase the demand for services in the future, especially in the western and northern parts of the district.

Figure 66. District and sub-district level service centers and their catchment range in District 22



Source. Khodabakhsh, 2017 (based on field observation)

Figure 67. Neighbourhood level service centers and their catchment range in District 22



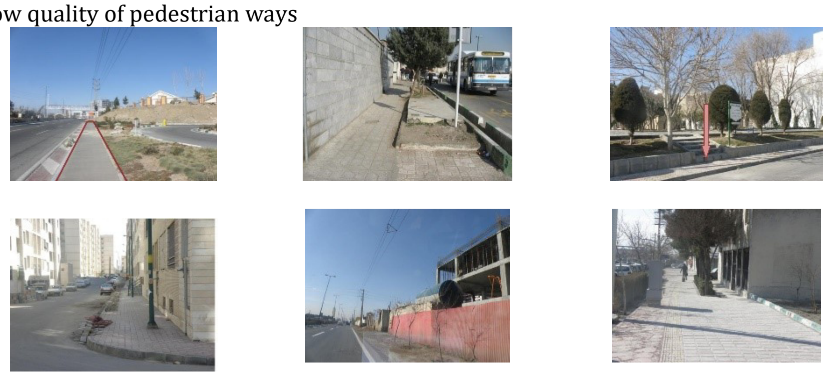
Source. Khodabakhsh, 2017 (based on field observation)

Quality of access network

A majority of access networks throughout the district suffer from a low quality of pedestrian networks and a lack of dedicated cycling paths. The problem is aggravated by the steep topographical features of District 22. Topographical features can become an important barrier for efficient transport modes such as walking and cycling. The allocation of social infrastructures in areas with a steep topography negatively affect accessability and therefore increase the use of motorized transport modes (see Map 3). The building of large scale residential and social infrastructures in steepy areas of the district forces inhabitants to use motorized transport as their only possible means of access. Correspondingly, cycling and walking is not very popular, especially so in the northern part of the district. Another related issue is the widespread cultural attitude for using cars as the preferred means of transportation, even for short distances.

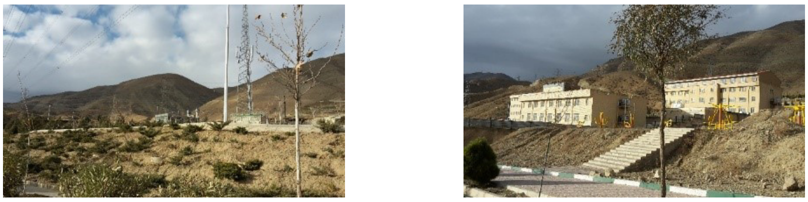
Figure 68. Quality of pedestrian ways in District 22

Low quality of pedestrian ways



Source. Khodabakhsh, 2017 (based on field observation)

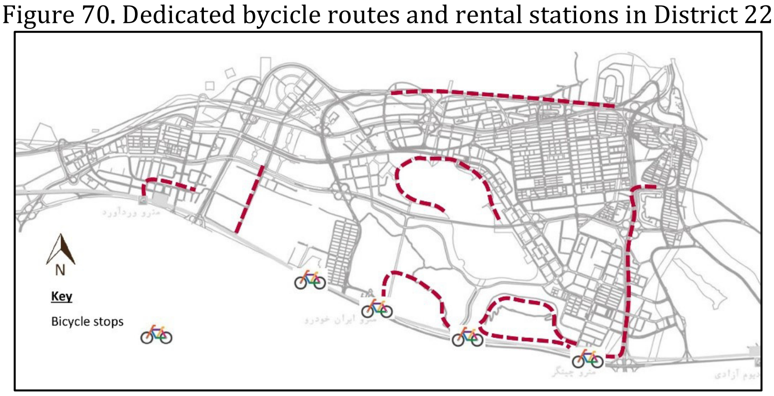
Figure 69. Extreme topography in the northern part of District 22



Source. Khodabakhsh, 2017 (based on field observation)

In addition, there are almost no predefined or separate cycling paths in District 22. Recently, a manageable number bicycle rental stations have been established adjacent to the existing subway stations. The aim is to promote the use of cycling as a sustainable mode of transport in District 22. However, field observations and interviews with local authorities indicate that these service stations are rarely used by inhabitants for daily mobility purposes.

Figure 70. Dedicated bycicle routes and rental stations in District 22



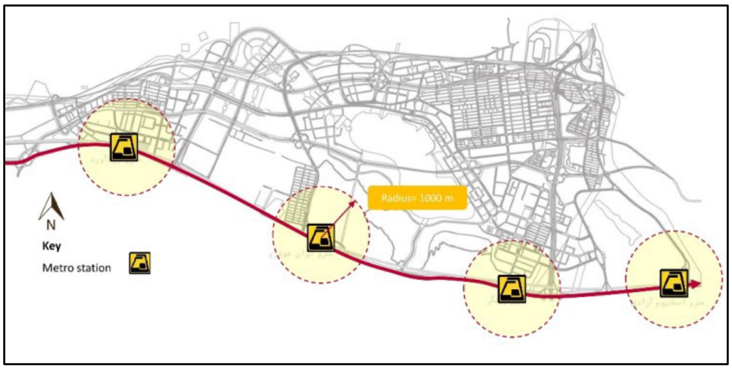
Source. Tehran Municipality online platform, 2017[52]

[52] Tehran Municipality online interactive map. (n.d.). Retrieved January 10, 2018, from http://map.tehran.ir/?lang=fa#

Quality of public transport

As to the public transport systems, four types of public and semi-public transport modes are in operation in District 22. These include, subway system (with four stations along the southern boundary of the district); bus Rapid Transit (BRT) system with dedicated lines (BRT); standard buses and taxi system with defined routes and destinations. The subway system comprises four stations located in the southern edge of the district. The subway being on the southern edge of District 22, however, reduces its practical value for the majority of residents, especially in the northern parts.

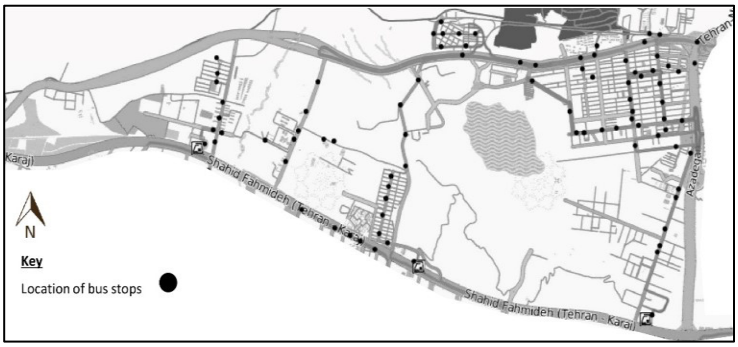
Figure 71. Location of existing subway stations in District 22



Source. Tehran Municipality online platform, 2017 [53]

The coverage and accessibility of the bus system is markedly better compared to the subway. District 22 is fully served by bus service lines. However, due to a perceivably low level of convenience and service quality (i.e. delays, long distances and inconvenient routes) the bus system is not a preferred means of transportation among the citizenry, neither in District 22 in particular nor in Tehran as a whole.

Figure 72. Location of the bus stations in District 22



Source. Tehran Municipality online platform, 2017 [54]

[53] Tehran Municipality online interactive map. (n.d.). Retrieved January 10, 2018, from http://map.tehran.ir/?lang=fa#
[54] Tehran Municipality online interactive map. (n.d.). Retrieved January 10, 2018, from http://map.tehran.ir/?lang=fa#

Conclusion

As a conclusion, the following table provides a comprehensive overview on the status of existing social infrastructures in relation to the identified energy efficiency measures and patterns. The table comprises a comprehensive list of energy efficiency and design measures in relation to building and transport sector. It demonstrates the existing common patterns for each of the planning measures in District 22 social infrastructures.

As observabale in the first view, there exist no common patterns for the majority of the listed planning and design measures. For limited number of measures such as surface design materials, mass and space configuration as well as orientation measure, partially common patterns are observable.

Table 25. Status quo of energy efficiency and design measures of existing social infrastructures in District 22

Energy efficiency measures for social infrastructures		**Common patterns**		
		Not existence	**Partial existence**	**Full existence**
Building sector	Density and compactness configurations	×		
	Building volume (i.e. surface to volume ratio)	×		
	Building typology (length of the building body, depth of the building, number of floors, roof shape/roof pitch)		×[1]	
	Surface design and materials		×[2]	
	Architectural design (i.e. floor plans & openings)	×[3]		
	Vegetation coverage and configuration (i.e. for shadowing purposes)	×		
	Utilizing the topographical conditions (i.e. south facing slopes)	×		
	Building and block orientation to regulate passive wind utilization	×		
	Building and block orientation to regulate passive solar utilization		×[4]	
	Street network orientation and dimension to regulate passive solar and wind utilization	×		
	Configuration of urban blocks and building arrangements		×[5]	
	Mass & space configuration & positioning		×[6]	
	Renewables, technologies and external devices	×		
Transport sector	Urban development pattern (synergies among densities, street layout & land uses)	×[7]		
	Integrated land use concept (allocation and coordination with the transport system)	×		
	Vertical & horizontal mixed use concepts		×	
	Providing safe, attractive and affordable public transport	×		
	Optimized accessibility of non-motorized transport mode (i.e. cycling and walking) i.e. through barrier free access (steep inclinations, equipped sidewalks, obstacle free access for disables etc.)	×		

1. Sectorial standards (i.e. number of floors for educational or health services) are influential. Furthermore, in terms of roof shape, the common pattern is a flat roof configuration in all buildings.
2. There are no common pattern in terms of building surface material. However, a common light colour pattern for building façade is observable.
3. No common pattern in terms of optimized configuration of architectural design in relation to energy efficiency. Sectorial standards are also influential.
4. Dominance of south oriented buildings.
5. A linear configuration of building blocks.
6. Allocation of building mass in the northern part of the parcel.
7. Dominance of dispersed development pattern. Existence of partially super-high density built structures in new developed areas.

Source. Khodabakhsh, 2017

3.4.4.2 Energy efficiency and design measures within the local urban planning system

Introduction and focus area

Local authorities and urban development experts often lack the technical background and expertise to understand energy efficiency methods and technologies for reducing energy consumption and replacing fossil fuels with renewable energy sources. One major challenge is to ensure concsciousness among local authorities that there is a gap between the level of energy consumption of the facility they are administering and the level which could be achieved as well as financial benefits if a specific energy conservation effort were to be employed.

This lack of awareness can usually be explained by the absence of methods for monitoring energy consumption and energy related regulations. A further technical challenge is to demonstrate that there are proven technologies, methods and services that can be used to substantially reduce energy consumption or substitute the energy consumed with other forms that are potentially cheaper and less polluting. The introduction of energy efficiency measures or the implementation of energy efficiency investments in public buildings such as social infrastructure may also be hampered by a series of issues relating to the prevailing legal, regulatory and institutional framework.

It is against this backdrop that the analysis in this section revolves around energy efficiency measures in terms of the prevailing institutional framework, urban development plans and regulations. In order to acquire practical information, besides desk research and survey on existing local development plans and regulations, targeted interviews were conducted. The aim is to achieve a better understanding of local planning procedures and identify gaps in terms of energy efficiency considerations. To this end, a total of 30 experts (local authorities, consultants as well as academic experts) were interviewed. Credibility assessment of the data so obtained was done via triangulation with other information sources from local planning practice. Here, credibility refers to the confidence in the truth-value or believability of the study's findings (Polit, Beck, & Hungler, 2006; Sandelowski, 1986; Streubert-Speziale, 2007).

The validity of the data is ensured by triangulation (use of multiple sources of data and/or methods) and through repeated contact with participants, peer debriefing (sharing questions about the research process and/or findings with a peer who provides an additional perspective on analysis and interpretation), and member checking (returning findings to participants to determine if the findings reflect their experiences)

(Jeanfreau & Jack L, 2010). The interviews[55] were designed to tap into the following issue areas:

- Assessing the importance of energy efficiency in the local planning context
- Role of different local authorities together with different types of planning and legal instruments
- Existing challenges/gaps for integrating energy efficiency and design measures in current local development plans and regulations

Results from the interviews, in combination with information obtained through desk research (i.e. analysis of development plans and planning regulation) will be utilized for identifying existing gaps in local planning practice and serve as a basis for recommendations developed later in chapter 4.

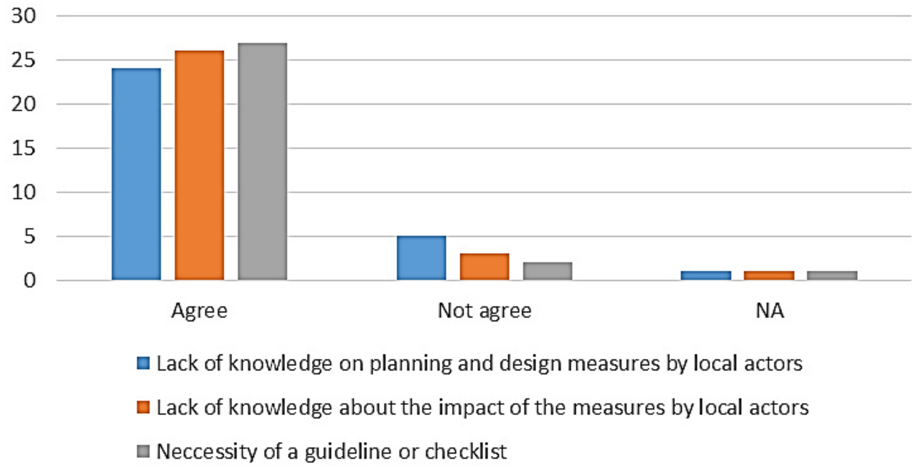
Overview of institutional and instrumental barriers

The analysis of existing planning regulations as well as results from interviews demonstrate that the topic of energy efficiency is often neglected in current planning practices. There are no energy efficiency and deisgn measures in current urban development plans, namely comprehensive and detailed plans. Although most interviewed experts believe in the importance of energy and environmental topics and their integration within the urban planning process, the contribution of related measures within existing planning regulations remains vague at best.

What is more, the majority of interviewees believe that limited awareness and a lack of guiding measures pose the main barrier for integrating environmental and energy efficiency topics in the urban development process (Figure 73).

[55] The outcome of the questionnaires/interviews is not intended for statistical analysis purposes.

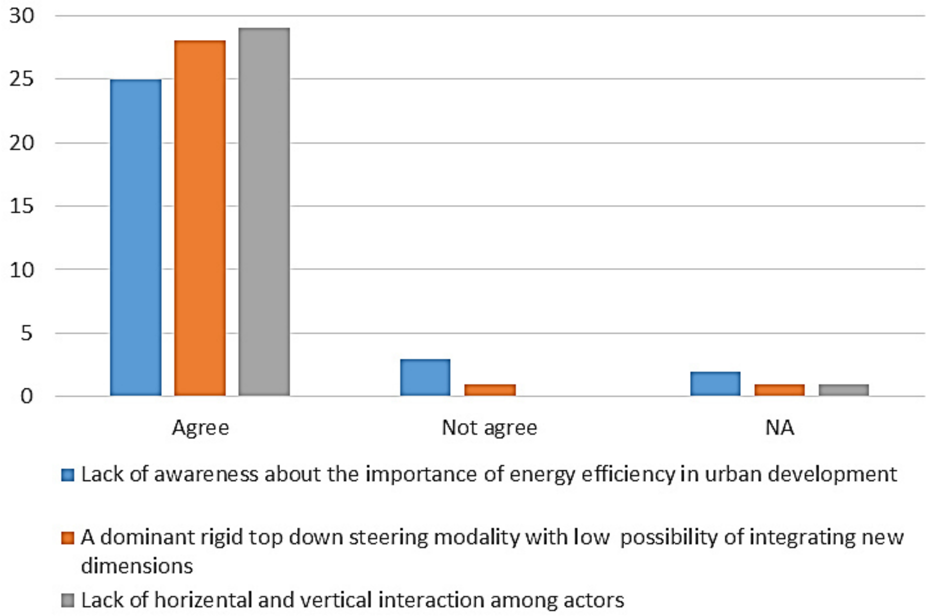
Figure 73. Barriers in effective integration of energy efficiency and design measures in local development plans



Source. Khodabakhsh, 2017 (based on energy efficient social infrastructure planning and provision interviews – Annex 1)

Another problem field are organizational barriers and stem from rigid planning regulations and the lack of flexibility in the existing comprehensive planning system. What is more, there exists no dedicated department or organization on the local level that especially deal with energy and environmental concerns in urban development practices.

Figure 74. Organizational barriers in effective integration of energy efficiency measures in local development plans

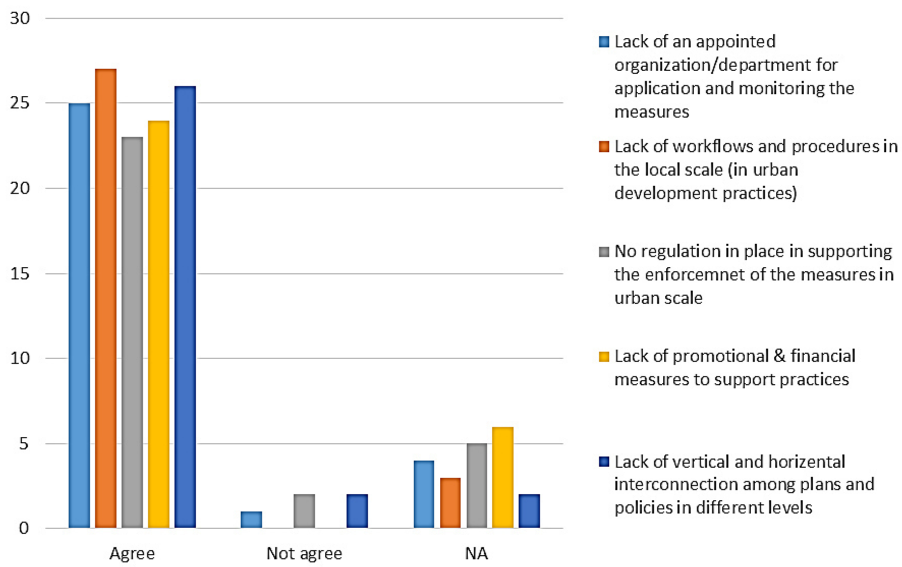


Source. Khodabakhsh, 2017 (based on energy efficient social infrastructure planning and provision interviews – Annex 1)

Lacking political commitment represents yet another area mentioned by interviewees. Although several energy efficiency policies exists across different governmental departments, a harmonized policy guidepost is missing; one which helps to integrate and translate objectives into concrete actions at the local level. This adds to hurdles in terms of regulation and enforcement mechanisms.

Importantly, there is no regulatory framework for enforcing the implementation and implication of energy efficiency measures in the planning and spatial development of cities and urban areas. Furthermore, there is no promotional mechanism designed to encourage energy efficiency measures in spatial developments of cities (Figure 75). As a result, the topic of energy efficiency is of no or low priority in exitsing development plans.

Figure 75. Priority areas for effective integration of energy efficiency measures in urban development plans



Source. Khodabakhsh, 2017 (based on energy efficient social infrastructure planning and provision interviews – Annex 1)

While the topic of energy efficiency is not explicitly stipulated by development plans[56], the fact that there is a small array of planning and design measures in place bears some potential to improve the energy performance of cities. Table 26 provides an overview of such measures. The overview suggests, perhaps most strikingly, a limited horizontal and vertical link among actors and planning instruments. That is to say, existing policies on higher levels of planning are not translated into operational measures at the local level.

[56] With exception of building construction based on Code No. 19 of building development

Table 26. Status quo of energy and environmental considerations in different scales of planning with respective authorities and the main content of the instruments

Respective actors	scale	Main plans	Scales of focus	Energy efficiency related contribution
National executive Bodies (i.e. ministries)	Country	National Development Plan	General environmental consideration/strategies 1:100000	General/ sectoral environmental and energy conservation strategies in the national scale
Regional Bodies (i.e. Province and regional branches of national bodies)	Region/province	Regional development Plans	General environmental consideration/strategies 1:50000	Transmission of the general/sectoral environmental related strategies and roadmaps for more sustainable development of the regions and sectoral energy conservation
Municipality	City	Comprehensive plans	Urban development strategies (1:10000)	Limited environmental consideration Integration of planning measures such as access to services, thresholds, allocations, densities etc. without any explicit implication to energy and environmental considerations
		Detailed plans	Detailed development maps (1:2000)	Integration of planning measures such as access to services, thresholds, allocations, densities etc. without any explicit implication to energy and environmental considerations
District municipality	Districts	Detailed plans	Detailed development maps (1:2000)	Integration of planning measures such as access to services, thresholds, allocations, densities etc. without any explicit implication to energy and environmental considerations
		Urban design plans	1:500	Depending on the case (no relevant standard or guideline in place)
District and sub district municipality	Neighbourhoods	Detailed plans	Detailed development maps (1:2000)	Integration of planning measures such as access to services, thresholds, allocations, densities etc. without any explicit implication to energy and environmental considerations
		Urban design plans	1:500	Depending on the case (no relevant standard or guideline in place) Partially considered in single buildings, while issuing the construction permit (through urban design and environment supervision) and during the construction phase (through the municipality monitoring mechanisms)
	Buildings	Building design	1:100-20	Energy related building codes i.e. Code 19 (focused on technical dimension i.e. thermodynamic and insulation standards) Partially considered in single buildings, while issuing the construction permit (through urban design and environment supervision) and during the construction phase (through the municipality monitoring mechanisms)

Source. Khodabakhsh, 2017 (based on energy efficient social infrastructure planning and provision interviews – Annex 1, and analysis of the local development plans and regulations)

Zooming in on the direct and indirect integration of identified energy efficiency measures (from Chapter 2) in existing urban development plans yields yet another informative picture. Table 27 below shows the current status on how and to which extent energy efficiency and design measures are considered within the current spatial development planning process. The overview thereby differentiates between:

- Types of development plans
- Types of enforcement instruments
- The responsible controlling authority/ies

Reviewing the following table indicates that a limited number of energy efficiency measures considered partially in some types of development plans with limited dedicated enforcement instruments and responsible authorities are foreseen.

Table 27. Status quo of energy efficiency and design measures in the local planning and design process

Criteria in relation to energy		Existing obligatory planning and design measures		
		Type of development plan	**Type of enforcement instruments**	**Controlling authority/ies**
Building sector	Density and compactness configurations	CP/DP	M/R/S	MU
	Building volume (i.e. surface to volume ratio)	-	-	-
	Building typology (length of the building body, depth of the building, number of floors, roof shape/roof pitch)	-	-	-
	Surface design and materials	-	G	CEO
	Architectural design (i.e. floor plans & openings)	-	-	-
	Vegetation coverage and configuration (i.e. for shadowing purposes)	-	-	-
	Utilizing the topographical conditions (i.e. south facing slopes)	-	-	-
	Building and block orientation to regulate passive wind utilization	-	-	-
	Building and block orientation to regulate passive solar utilization	-	G	CEO/MU
	Street network orientation and dimension to regulate passive solar and wind utilization	-	-	-
	Configuration of urban blocks and building arrangements	-	-	-
	Mass & space configuration & positioning	CP/DP	R	MU
	Renewables, technologies and external devices	-	-	-
Transport sector	Urban development pattern (synergies among densities, street layout & land uses)	CP/DP	M/R/G/S	MU
	Integrated land use concept (allocation and coordination with the transport system)	-	G	MU
	Vertical & horizontal mixed use concepts	CP/DP	M/R	MU
	Providing safe, attractive and affordable public transport	CP/DP	S	-
	Optimized accessibility of non-motorized transport mode (i.e. cycling and walking) i.e. through barrier free access (steep inclinations, equipped sidewalks, obstacle free access for disables etc.)	CP/DP	S/G	MU

CP (Comprehensive Plan), DP (Detailed Plan), M (Maps), R (Regulations), S (Strategies), DC (Design Code), AP (Architecture Plan), G (Guidelines), MU (Municipality), CEO (Construction Engineering Organization)

Source. Khodabakhsh, 2017 (based on energy efficient social infrastructure planning and provision interviews – Annex 1, and analysis of the local development plans and regulations)

3.4.5 Analysis of the electronic delivery of social infrastructures in the case study[57]

3.4.5.1 E-services initiatives and plans in the national scale - IRAN

With the growing recognition of ICT as a driver for social development and economic growth, there is a need for clear strategies and roadmaps for improving the ICT to support government, citizens and in general living quality. Iran as a fast developing economy has been investing on ICT as the result of several policy measures established in different decision making stages from national to the very local level. As the main development roadmap of the whole country, policies have been addressed in the "sixth national development plan" in terms of improving the ICT conditions. These measures include:

- Distinguishing position in the region for development of e-government in national information network
- Developing content in cyberspace according to the cultural engineering roadmap of Iran
- Implementing, completing and developing national information network and securing this network
- Introducing Iran as an exchange centre of postal, communication and information traffic in the region
- Efficient, effective and goal-oriented participation in the cyberspace international interactions
- Increasing the share of infrastructure investments in ICT sector (Official Portal of Measuring Information Society of Iran, 2014)

Obviously, some of the above mentioned measures target rapid development of ICT infrastructure and services. These include measures for increasing the share of infrastructure investment in ICT sector, especially the e-government to create a reliable basis for the benefit of economy, science and technology as well as citizens welfare.

In addition to the sixth development plan, other governmental directives have recently been enacted. With a focus on e-services, in the 164th session of July 1st, 2014, the Supreme Council of Administration approved "The Bylaw of Development of E-services

[57] Due to lack of detailed information/statistics, analysis in this section are based on fact and figures presented in larger scales or by using qualitative analysis methods.

of Governmental Organizations" upon recommendation of Vice President for Management and Human Capital Development, following articles 36, 37, 38 and 40 of State Management Law, article 46 of the Fifth Development Plan and realization of sections 10 to 12, 15 to 18, 24 and 25 of General Policies of Administrative System notified by Supreme Leader.

According to the bylaw, all Executive Bodies must provide a list of their services with the following content up to the end of 1393 (March 21, 2015) and put it in their portal for public access. Vice President must review the lists of services and put them in Service Delivery Single Window. For decreasing the response-time, reducing costs and improving the quality of service for end users, Executive Bodies must review and improve their methods and processes every year. Executive Bodies must take the following measures with the aim of improving the quality of services delivered to the public upon observation of the concerned operational instructions.

- Electronic and online information about the way of service delivery as well as its time schedule and documents to be presented by the applicant.
- Submitting standard forms required for service delivery through electronic means and media.
- Providing citizens with all possible services by online and electronic means through the Executive Body's portal as well as local and nationwide portals and other electronic means in order to eliminate the necessity of physical presence of people in Executive Bodies to receive services.

Service delivery through the portal of the main Executive Body should be made in such a way that the service applicant be able to observe all stages of the request processing and the latest status in the Internet site of the main Executive Body (Iran Ministry of ICT, 2014). Governor Generals across the country must take appropriate measures to extend the portal of their city as the single portal of the city so that at least the information and services discussed herein becomes accessible online by the order of topic and category (Iran Ministry of ICT, 2014).

3.4.5.2 E-services initiatives and plans in Tehran

With the aim of stimulating the electronic service delivery, Tehran Municipality has been moving forward quite fast in recent years in terms of developing the fundaments for creating e-municipality platforms in accordance with the existing infrastructure, human sources and their target groups' demands. Currently, several electronic services are presented on Tehran Municipality portal at www.tehran.ir. In addition, there are some other services that Tehran Municipality has presented through mobile sets, services of the private sector such as the electronic services offices, and systems related to participation of citizens in urban management such as hotlines. According to the head of the Information and Communications Technology Organization of Tehran Municipality, this organization has so far presented more than 140 electronic services to citizens. These services range from a plan for rendering traffic zone entry permit to online issuance of construction permit. Even an organization such as cemetery (Behest-e Zahra) provides online search service (Tehran Municipality Portal, 2015).

One important initiative took by Tehran municipality is the establishment of the “Electronic Services Offices” throughout the city. These electronic offices are the outsourced version of municipality departments and are initiated with the aim of improving the service delivery to citizens. Electronic offices are established as private entities with the target of delivering easier, faster and high quality services in different districts of the capital.

They support municipalities in accomplishing their daily tasks. Their activities comprise of issuance of all types of building permits, technical supervision services (especially in construction procedures and permit gathering), services for career and businesses, inquiries requests for construction permits, citizens complaint follow up, tax payment inquiry and related services, transport and traffic services such as traffic zone permissions etc. Although many of the procedures are facilitated by electronic offices, there still exist the need for physical presence in certain steps of service delivery process. Furthermore, the offered services are limited to outsourced administrative procedures which have been previously carried out by municipality departments themselves. Therefore, the range of the services do not cover the social infrastructures and only is limited to a part of municipality’s administrative procedures.

3.4.6 Three dimensional analysis of the E-service delivery in District 22

Introduction and focus area

An important factor in implementing the e-municipality and stimulating the provision of electronic services is the readiness level of its fundamental factors (Lighthouses, 2007)[58]. The level of electronic readiness (e-readiness) is the scale of ICT readiness, which is available in a local government system, a city, an organization or institution, and even a society (Ghavamifar et al, 2008; Alshawi, 2007). Moon and Norris (2005), believe that the realization of goals in order to establish e-municipality in the first step depends on the examination of conditions and the amount of readiness. In other words, e-readiness is a prerequisite for successful launch of e-services projects. However, the extent varies in accordance to the level of development in different countries and contexts. One comprehensive approach illustrates the e-readiness as a composition of "organizational readiness", "services and system readiness" and "infrastructure readiness". (Roy, 2006; Streib and Katherine, 2005; Koh and Prybutok, 2002; Ho, 2002).

Organizational readiness relies on employing the Information and Communication Technology (ICT) in order to integrate business processes (Aicholzer and Schmutzer, 2000), strategic alignment of the organization with the information technology (Beig et al., 2006; Molla, 2004; Choucri et al, 2003), taking attention to the legal aspects of information technology (Bridges.org, 2005) and the education of human resources (DESA, 2005). Many researchers investigated on organizational readiness and they believe that an organization has enough e-readiness to offer services to its employees and clients electronically, when it uses strong and integrated information systems in all of its sections. Organizational readiness can be translated to the employees education (Strohmeier and Kabst, 2009; Dada, 2006); IT strategic planning (Dallas, 2002; Kovacic, 2005); alignment of business strategies (Scholl, 2005; Krishnaswamy, 2005; Scholl, 2003) and attention to the legal readiness (World Bank Group, 2001) as fundamental factors for achieving the organizational readiness goals.

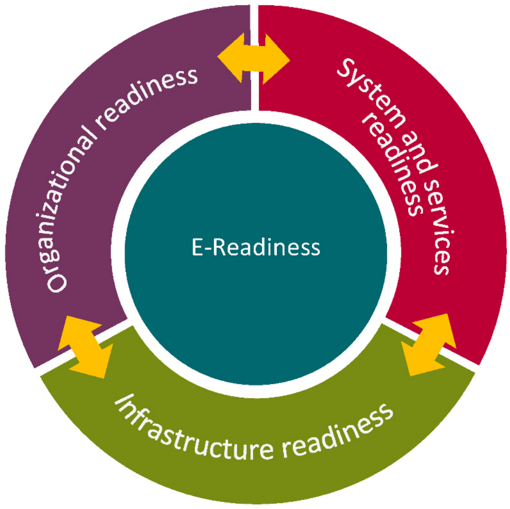
Besides the organizational aspects, other factors such as transmission of organizational knowledge from traditional systems to modern ones based on the new information technology, designing and launching websites and portals, offering municipality services in electronic form and also integration of the systems, are important to achieving the e-

[58] UNPAN. (2007). Retrieved January 10, 2018, from http://unpan1.un.org/intradoc/groups/public/documents/unpan/un-pan026739.pdf

services goals. In the literature of the e-readiness these dimensions are called as "system and services readiness". System and services readiness are applied to a readiness in which the government, the public sector organizations and private sector businesses change the virtual space as a platform to serve customers by some tools such as information systems, websites, portal etc. (Melitski, 2005). The occurrence of this kind of readiness depends on enough knowledge in mathematics (Fuzzy Logic, Neural Networks), IT, ICT and marketing. Moreover some researchers like Elwood et al., (2006); Loyarte & Rivera, (2007); Money & Turner, (2004); investigated on technological acceptance models in order to establish information systems and offering services based on virtual space and found that an organization will be successful in achieving its goals of electronic services if it can integrate and coordinate soft and hard tools, skills, structures, strategies and human resources based on a systematic framework.

Beside the software readiness, other important factor is hardware readiness. This includes factors such as: Local Networks, Internet Networks (Optical Fibre, Wireless Networks, DSL), Networked Value-Added Services (Video Conference, FTP, etc.), which can be considered as hardware or in other words the infrastructural dimension (Montazer, 2006; EIU, 2006; McClure, 2000; Bonham et al, 2001). In this point of view, the level of municipality's readiness can be evaluated through the availability of suitable infrastructures by some variables like bandwidth, coverage and high speed internet uptake and subscription rates. Some researches like Kalu, 2007; Chen and Wellman, 2003; Chen and Gant, 2001; Tambouris et al, 2001; Joshi et al, 2001; Norris, Fletcher and Holden, 2001; Ho, 2002 believe that the most important readiness criterion in an organization is infrastructure readiness, because it is the main cornerstone of any interaction based on the available network of communication infrastructures. Toots, 2007; Moon, 2002 and Gusev, 2004 believe that attention to the information and communication infrastructures is a prerequisite for establishing of the projects like e-government or e-municipality. In accordance to the abovementioned e-readiness dimensions, similar e-readiness dimensions are applied to assess the status quo in the local context (Figure 76). The analysis provides useful information to indicate the main barriers in each of the above mentioned categories namely; infrastructure readiness, organizational readiness as well as services and system readiness. Analysis of these measures provides a good knowledge and a basis for gap analysis and recommendations in chapter 4.

Figure 76. E-readiness factors for planning and provision of electronic services



Source. Khodabakhsh, 2017 retrieved from Roy, 2006; Streib and Katherine, 2005; Koh and Prybutok, 2002; Ho, 2002

3.4.6.1 Infrastructure readiness

Access to fast broadband is a necessary condition for e-government practices and the fundamental element for any types of e-services development. Tehran as the capital of Iran and the political and economic centre of Iran has the best position regarding the availability of ICT infrastructure and services in comparison to other regions in Iran. The ICT ministry statistics from 2016 indicates that more than 69% of the inhabitants of Tehran have access to internet at home which is considerably higher than the average numbers in Iran (62%). According to the ministry's annual ICT reports, Tehran is the pioneer city concerning investment, development, subscription and use of ICT infrastructure and services in the Iranian context (Table 28).

Table 28. Infrastructure readiness factors of Iran and Tehran in 2016

Dimension	Indicators	Tehran %	Country %
Infrastructure	Internet access at home	69	62
	Access to computer	68	61
	People using mobile phone	74	71
	Individuals using the Internet (over 6 years old)	67	53

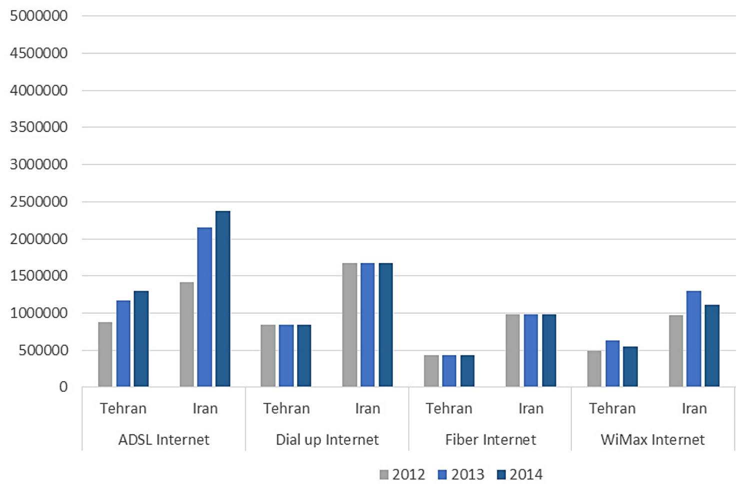
Source. Iran Ministry of ICT (The Official Portal of Measuring Information Society of Iran), 2016[59]

According to the survey of measuring ICT access and use by households and individuals in I. R. Iran in 2013, the Internet penetration rate was 31.4 percent. In the mid of 2014, 3G license was given to the first and second mobile operators with the highest number of

[59] The Official Portal of Measuring Information Society of Iran. (n.d.). Events Events. Retrieved January 10, 2018, from http://mis.ito.gov.ir/web/en

subscribers followed by developing new generation of 4G mobile-broadband (Ministry of ICT, 2015)[60]. As a result, the share of mobile internet subscription has been increasing rapidly during 2014. According to the Ministry of ICT announced statistics from 2016, both 3G and 4G services has more than 10 million subscribers in Tehran. This number is ca. 47 million subscribers in the whole country (Ministry of ICT (The Official Portal of Measuring Information Society of Iran), 2016)[61].

Figure 77. Internet subscribers based on technology 2012-2014 (Tehran & Iran)



Source. Iran ministry of ICT (The Official Portal of Measuring Information Society of Iran), 2015[62]

3.4.6.2 Organizational readiness

One aspect of the organizational readiness deals with the human capital and digital divide. The human capital dimension, measures the skills needed to take advantage of the possibilities offered by a digital society. Such skills range from basic user skills (that enable individuals to interact online and consume digital goods and services), to advanced skills (that empower the workforce to take advantage of technology for enhanced productivity and economic growth). Although the Internet is part of daily life for many of the inhabitants in the case study, a considerable share of the inhabitants are still excluded from having access to superfast internet as a result of low level of digital literacy. A similar condition is observable in terms of employees with digital skills.

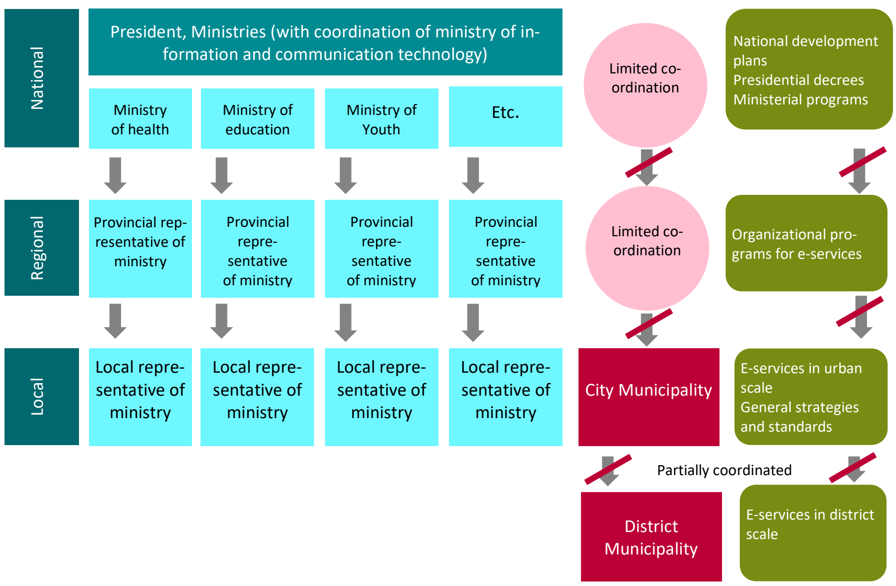
Besides the human factors (i.e. digital literacy and digital skills), another influential dimension is the political commitment of local authorities towards change. Similar to the

[60] The Official Portal of Measuring Information Society of Iran. (n.d.). Events Events. Retrieved January 10, 2018, from http://mis.ito.gov.ir/web/en
[61] The Official Portal of Measuring Information Society of Iran. (n.d.). Events Events. Retrieved January 10, 2018, from http://mis.ito.gov.ir/web/guest/fava-development?city=tehran
[62] The Official Portal of Measuring Information Society of Iran. (n.d.). Events Events. Retrieved January 10, 2018, from http://mis.ito.gov.ir/web/en

general planning system in Iran, planning and provision of electronic services often follow a top down hierarchy, where upper level strategies are not usually effectively translated to actions in local scale. In other words, there is no structured legal framework to enforce the implementation of the policies and plans in local context. Actors in different scales, often develop sectoral strategies in terms of digital services, experiencing a very low horizontal interaction with parallel organizations and initiatives. As a result, several types of deficiencies occurs in the process of planning and provision of electronic services. Some of the main organizational deficiencies are listed below (see also Figure 78):

- Limited coordination of actors in a same level (horizontal coordination)
- Limited coordination of actors in different levels (vertical coordination)
- Unclear legal role of local government (i.e. municipality) in terms of operation of the plans and initiatives introduced by higher level authorities
- Dominance of top down steering modalities with a limited room for bottom up and participatory approaches
- Lack of a single information point (especially in the local scale).

Figure 78. The local framework of actors, instruments and their interaction for planning and provision of e-services



Source. Khodabakhsh, 2017 (based on electronic services planning and provision interviews – Annex 2)

Focusing on the case study of this research, constant development of ICT services and infrastructures is a part of the development vision in District 22. The municipality considers ICT services as fundamental component as well as a facilitator toward more sustainable development of the district. Against this background, District 22 has developed an ICT strategy in 2105. The strategy aims at fastening the pace of technological and infrastructural development in line with building capacity for further application and use of ICT services in the territory. It comprises of strategic measures in eight categories, covering multiple ICT dimensions with a focus on enhanced electronic delivery of public services (District 22 ICT strategy, 2015). Table below gives an insight of the strategies and programs which are addressed towards further improvement of electronic services in District 22.

Table 29. E-services strategic measures by District 22 ICT department

Strategies	Targets/programs
Improvement of services quality with support from the municipal systems for high quality service delivery to the citizens	Need analysis and survey concerning the quality of services
	Evaluation and constant monitoring of the portal
Management and development of the municipality networks for faster development of e-Services to municipal employees and citizens	100% coverage of internet network throughout the whole district
	Improvement of the Fibre Optic broadband network
Faster development of the electronic services and digital content with the aim of reducing the municipal costs and easier access for citizens	Application of the digital telephone lines and development of VoIP to all administrative buildings of the district
	Digital documentation and archive of all information and inquiries
Development and improvement of geographical information systems by integrating new tools, equipment and services	Transferring all the GIS data layers of the district on the webGIS service for public access
Capacity building and enabling human resources for further development of the ICT department	Improving the digital skills of the department employees in accordance to their relevant organizational responsibilities
Enhancing citizens awareness	Programmes for enhancing the awareness of citizens about the advantages of ICT and secured use of ICT services
	Public educational programs in the field of ICT for all

Source. District 22 ICT strategy, 2015

3.4.6.3 Services and system readiness

Generally speaking, there are several barriers in moving towards digital content and service. These include, high upfront expenses and time consuming procedures accompanied by security considerations applied by different layers of government. Looking at the initial targets of district 22 website, one of the most important rationale in its early stages was to create a platform for active communication with municipality departments and other organizations within and outside the municipality. The municipality aimed at expanding the vision of healthy work, service delivery enhancement, reducing the number of complaints and enhancing the speed and accuracy of the procedures. In doing so, the establishment of District 22 online platform has started in 2000, and the test version was launched and publicly available in 2006 (Tehran Municipality 2nd sub portals festivals, 2010) [63].

The existing municipality platform contain several thematic sections, however is generally limited to provision of administrative procedures, general information as well as physical development administrative procedures. The following table gives a detailed insight of all available online services through district 22 municipality portal. In terms social infrastructure, District 22 website provides contact information as well as the location of the main services (i.e. schools, health centres, cultural centres etc.) supported by a GIS online tool.

Table 30. The current online services delivered through District 22 municipality portal

The main online services of District 22 Municipality	
Introductions on the District	Geography and climate/ History/ Formation aims/ Development vision/ Remarkable places and projects/ Maps/ Info graphs
Introduction on the District Municipality	Duties and tasks/ Organizational structure/ Rules and regulations/ Honours and successes/ Mayor introduction/ Roadmaps and integrated management/ Neighbourhood Councils (Shorayari)
Departments and their field of expertise and services	Economic and accounting deputy/ Urban affairs and environment deputy/ Traffic and transportation deputy/ Civil and construction deputy/ Socio-cultural deputy/ Urban development and architecture deputy/ Planning deputy/ Human resources development deputy
Urban information databank	A GIS web based map of urban features in District 22 containing geographical information on existing land uses and services.
Taxes	Real-time tax inquiry system, vehicles electronic toll collection, renovation tax payment system
Urban development	Urban planning guide, urban planning records, call for building permits and certificates
Geographical information	Map of the region as well as Tehran Metropolitan Area Atlas
Information & statistics	Tehran Statistics and Information, City electronic services centre, Municipality rules and regulations
Transportation and traffic	Traffic zones permit application and issuance (daily/weekly)
Urban Management and citizens' complaints	Public Supervision centre 1888 and 137
Other services	Emergency telephone numbers, daily news journal, software & applications, district Infrastructure studies, public courses, student information request, expert thematic articles, centre of urban studies

Source: Tehran District 22 official Portal, 2016

Conclusions from interviews

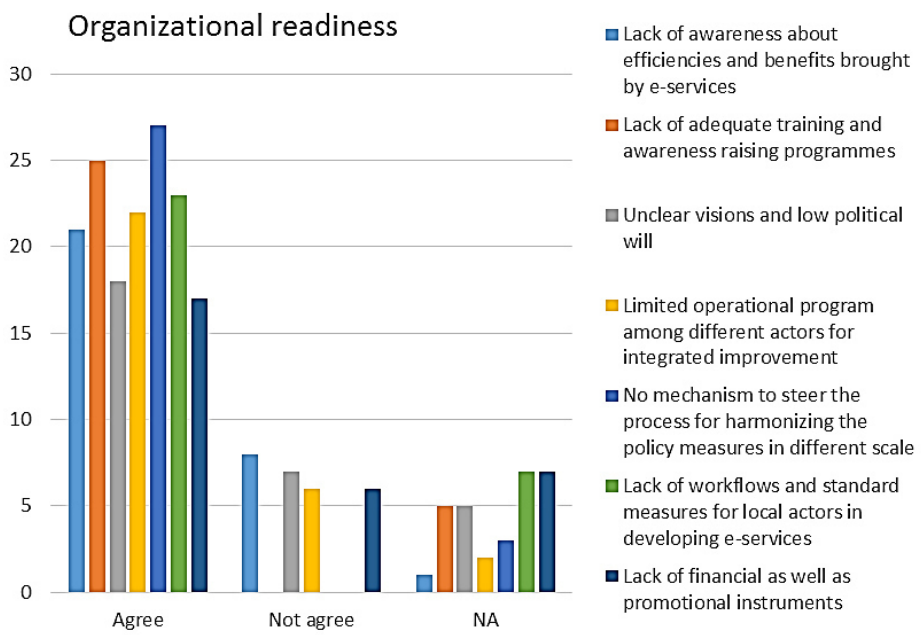
Results of interviews from local actors and experts demonstrate that the main focus in e-services development in the Iranian context has been limited to services dedicated to internal communication among organizations as well as administrative procedures [64]. Besides this, the majority of currently available electronic services are limited to

[63] Tehran municipality Sub-Portals festival association. (n.d.). Retrieved January 10, 2018, from http://festival.tehran.ir/
[64] An example is the Tehran municipality, by developing an Intranet network (Fibre Optic) infrastructure which provides a common communication platform for all municipality branches. Furthermore, the system connect municipalities to more than 70 city organizations as well as utility providers. The aim is to establish an integrated urban management platform.

administrative procedures such as building and construction permit gathering as well as tax accounts and inqueries. In the case of Tehran, many of these services have been transferred to decentralized Municipality Electronic Offices (daftar khadamate shahrdari) in all 22 Districts of the city.

In terms of political commitment, there exist few policy measures and legal frameworks in the national and regional level dedicated to e-services planning and provision in the local scale. Often, local digital strategies and initiatives developed by municipalities are the only official documents, which design a roadmap towards planning and provision of electronic services. Experience in practices also shows that these initiatives often face difficulties in the implementation phase. In most cases, the initiatives stop at visioning stage without being transformed to operational plans and implementable actions. Furthermore, no dedicated organization or department is appointed to coordinate strategies and action plans at the local level. As a result, the majority of policy measures and initiatives are being communicated in a top-down manner with very limited horizontal and bottom-up coordination at local scale. In this context, one of the main gap addressed by interviewees is the lack of multi-level commitment of governmental authorities for integrated development and take up of electronic services (see Figure 79).

Figure 79. Organizational barriers in stimulation of e-services



Source. Khodabakhsh, 2017 (based on electronic services planning and provision interviews – Annex 2)

While surveying on e-services planning and provision, infrastructure and technological readiness play a fundamental role. Nevertheless organizational issues are of similar importance. Lack of a unified system and coordinated organizational structure is among the main gaps in the local context. Authorities in charge of e-services are often not aware of the potential benefits and improvements in this area. In some cases, they even prefer to stay with obsolete (paper based) procedures, where transparency is limited and monitoring of the results are more difficult or even impossible. Short management periods often influence policy settings of local authorities, by forcing them to focus on short term actions with tangible results.

Besides organizational barriers addressed above, no clear monitoring and enforcement mechanism is planned/put in place to monitor the progress of implementing strategies/actions in regard to e-services planning and provision. Similar to the general planning structures, a sectoral top-down system is observable, where authorities in the similar level experience a limited cooperation and coordination. This increases the number of parallel organizational initiatives. This is even more challenging when it comes to social infrastructures. Because social infrastructures have different dedicated responsible authorities (sectoral ministries and organizations). This is followed by barriers in terms of adequate technical awareness, especially in the management structures as well as limited digital skills of employees.

Access to adequate financial sources is another main challenge in successful implementation of ICT and electronic services initiatives. This is accompanied by barriers in terms of high upfront investment for ICT infrastructures such as superfast broadband networks. Local enterprises also show limited interest in developing innovative services and products. Other barriers are content filtering as well as affordability of internet for middle and low income social groups together with their limited digital skills. Notwithstanding these challenges, no clear promotional and training programmes are put in place to increase the digital knowledge and skills of end users and city authorities.

CHAPTER 4

Energy efficiency and design measures

Chapter 4 is built on a two-step analysis. The expected results are to carry out an integrated analysis, propose recommendations in the form of strategies as well as introduce an integrated energy efficiency and design checklist for planners and local authorities. First, a GAP analysis is carried out in order to identify the technical, organizational as well as regulatory shortcomings in the local planning system. Built on this, a SWOT analysis implemented in similar categories and with the aim of developing classified set of recommendations and strategies. Another important output/deliverable of the research is a checklist for experts and local authorities. The checklist contains a comprehensive set of energy efficieny and design measures and their application in the planning process (modified for social infrastructure).

Chapter 4. Energy efficiency and design measures

4.1 Introduction and process design

One key target of this research, as has previously been addressed, is to integrate energy efficiency considerations in the planning of social infrastructure. These include spatial measures with direct and indirect impact (i.e. building and transport) on saving energy as well as incorporation of electronic delivery of social infrastructures. Studies demonstrated that, the "form and functional" measures of urban planning & design are yet crucial dimensions influencing energy consumption in any types of urban structures, including the social infrastructures. On the output side, I compiled a comprehensive set of urban planning and design measures taking account of interlinkages with energy consumption in two critical sectors: the building sector (by reducing the demand for space cooling, heating and lighting) and the transport sector (through minimization of motorized VMT and need to travel). The combination of these measures forms the basis of a planning checklist for planners and local authorities and includes spatial planning and design measures, criteria and strategies for enhancing energy efficiency in social infrastructure planning. Here, urban growth areas figure prominently in this regard as they bear high potential for integrating energy efficiency/environmental planning measures in the process of physical development.

Studies on the Iranian urban planning system indicate that there is a limited room for integration of addressed energy efficiency measures. In the current Iranian system of detailed planning, the issues of building densities and traffic zones can only be addressed by the regulation of mass and space of the plots (built-up areas) and by defining the route and width of circulation access areas. These urban form regulations have been supplemented with a range of energy-related regulations on the building level, e.g. on the positioning of openings or the location of the setbacks (through building codes i.e. code No.19). The combination of existing regulations on urban form and on the appearance of single buildings together with new measures in terms of land-use and mobility considerations would open up new dimensions in achieving energy efficiency and environmental targets.

Taking the above-mentioned points into consideration, the research methodology is based on the integration of theoretical knowledge and identifying local procedures to introduce recommendations for improving energy efficiency in planning social infrastructure in urban growth areas. In terms of integrating the energy efficiency and design measures, the main steps comprises of the followings:

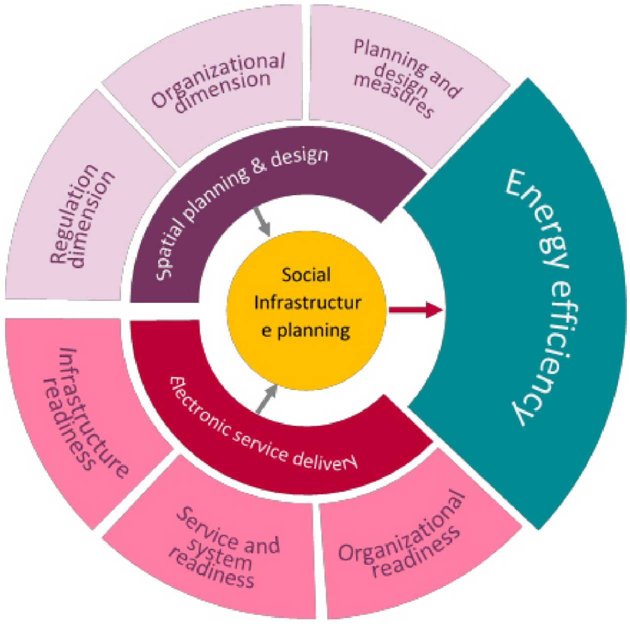
- Defining criteria and objectives for energy efficiency in planning and development of social infrastructure in urban growth areas with high physical development potentials
- Analysing the technical and non-technical solutions for reducing energy consumption and increasing climate-change adaptation in the urban development (i.e. planning and design measures)
- Developing methodologies in the form of guidelines and checklists for energy efficient planning and design of social infrastructure resulting in adapted or new policies. This will be followed by recommendations for integration of energy efficiency and design measures in the process of social infrastructure planning

In addition to spatial planning measures, a brief survey and analysis is carried out in terms of electronic delivery of social infrastructure and its potential impact on energy saving. The research applied a three dimensional analysis called "readiness level analysis". The layers include infrastructure readiness, organizational readiness as well as services and systems readiness. Here an expected outcome is to develop a set of recommendations to improve electronic delivery of social infrastructure (e-services) in the local context (as a supportive tool towards a more efficient provision of social infrastructures).

4.1.1 Analysis methodology

A two-step analysis approach is selected for this research. These steps include GAP analysis as well as SWOT analysis. As regard content, the spatial factors in the planning and provision of energy efficient social infrastructure and means for improving the electronic delivery of social infrastructure shall be analysed. In a first step, a GAP analysis is carried out and the influential factors in planning for energy efficient social infrastructures are surveyed. The aim is to identify existing shortcomings and priority areas in the local planning system. The second step revolves around deriving strategies and recommendations for energy efficiency improvement. In doing so, a SWOT analysis is carried out to identify weaknesses and opportunities in the local context. The analysis will result in formulating an integrated set of recommendations for improving energy efficiency in the planning and delivery of social infrastructures. These measures will be designed as to cover all dimensions of social infrastructure planning (planning & design measures, actors' involvement (organizational aspects), as well as regulatory mechanisms). Besides spatial dimensions, an analysis of electronic service delivery will be included as well (Figure 80).

Figure 80. Energy efficient social infrastructure planning dimensions



Source. Khodabakhsh, 2017

In addition to the recommendations (resulted from the SWOT analysis), another important output/deliverable of the research is an energy efficiency and design checklist for experts and local authorities. The checklist will contain a comprehensive set of measures and their application in the planning process (modified for social infrastructure). It will support the systematic integration of energy efficiency measures in the process of social infrastructure planning and its provision on different scales. The checklist comprises of the following elements:

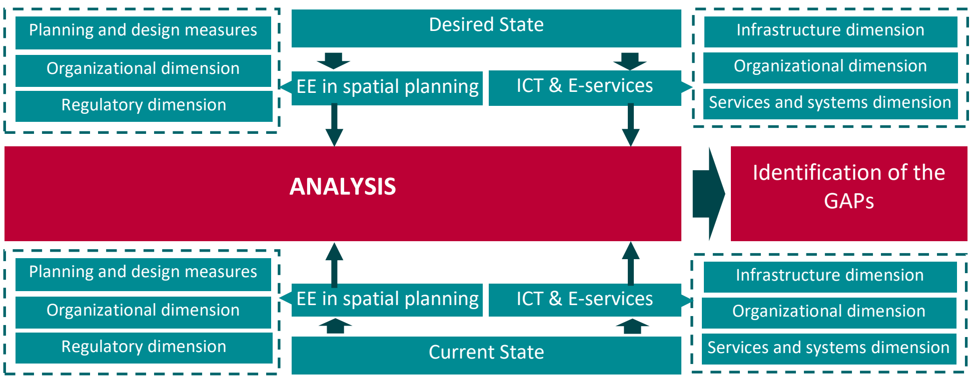
- Types of planning criteria/measures
- Stage of integration in the development plans process,
- Scale of integration in the development plans process
- Role and responsibilities of the local actors
- Planning instruments and enforcement mechanisms

4.2 Integrated analysis in the local context

4.2.1 GAP analysis

A proper examination of the urban planning system of a country (here Iran), enables devising strategies in harmony with the existing local conditions. As mentioned earlier elements considered influential in obtaining energy efficiency are planning and design measures, planning actors and their cooperation (organizational dimension) as well as the planning enforcement measures (regulation dimension). A similar set of elements are explored in terms of the planning and provision of electronic social infrastructures; namely: infrastructure readiness, services and systems readiness and organizational readiness. A combination of the above mentioned dimensions is likely to support a planning system in creating opportunities to achieve environmental and energy efficiency targets. According to the above-mentioned classification of social infrastructure planning, a GAP analysis is carried out. The aim of the gap analysis is to identify the shortcomings in each categories. In general, gap analysis has been extensively drawn upon in domains such as business process management and supply chain management (Nguyen et al, 2009). Several approaches have emerged which aim to help organizations obtain a better understanding of improving their business and procedures. The same procedure is being applied in this research, aiming at analysing the main shortcomings in current planning practices in Iran.

Figure 81. GAP Analysis categories in the case study



Source. Khodabakhsh, 2017 based on Nguyen et al, 2009

The gap analysis thereby draws upon primary and secondary data sources. In terms of the former, development plans, existing planning regulations and qualitative interviews are drawn upon. Secondary data is inter alia derived from the pertinent literature. Validity is assessed by triangulating (i.e. Delphi Model) the data so derived with other sources in the local planning practice. The following figure gives an insight over the GAP analysis concept [65]. The GAP analysis shows that shortcomings in the current Iranian planning practices, appear in terms of limited know-how on energy efficiency measures in the spatial planning process of social infrastructures. With the exception of a building code dedicated to energy and environmental issues (Code no.19), no other planning and design measures exists in the planning system to cover the issue. It appears that most actors and stakeholders involved in urban development activities in Iran neglect energy efficiency and environmental designs issues. Nor is there any special incentive program which emphasizes improving energy efficiency in planning and design activities. In addition no particular monitoring and enforcement mechanisms are in place. Lack of incentives to motivate the developers and planners in integrating new environmental qualities is yet another shortcoming. On a more general level energy efficiency items are not among the compulsory spatial planning codes yet. The following table gives a more detailed overview on the main gaps in the current planning system.

Table 31. Gap Analysis for integration of energy efficiency in the local spatial planning process

Dimensions		Expectations	Gaps
Planning & design measures	Energy efficiency planning measures	Identification, definition & importance of energy efficiency and design measures in the spatial planning (which measures should be integrated?)	- Lack of clear definition and the impact of planning and design measure on environment and energy savings - Lack of an EE[66] checklist/guideline for local actors
	Integration of measures in the planning process	Integration of the EE measures in the local planning system. Contribution scale and phase (where the planning measures should be integrated?)	- Lack of EE measures in the current planning practices - Lack of clarity where each criteria should be integrated in the local planning system (which phase of planning?) - Complexities concerning the scale of contribution (i.e. building, urban district)
Organizational dimension (actors and stakeholders)	Awareness of the actors	Enhanced sensitivity and awareness of the actors concerning the importance of EE	- Lack of know-how among local actors about the potential energy gains in the physical development of cities - Lack of know-how about energy efficiency and design measures (no training and capacity building programme)
	Participation of the local actors	Contribution and participation of involved local actors i.e. planner, developer, administration	- Lack of political commitment to put energy efficiency on top of the agenda - Lack of multilevel (horizontal and vertical) communication and cooperation among involved authorities (i.e. municipalities, ministerial organizations and NGOs involved in energy efficiency topics). - Rigid top down modalities with limited participatory approaches - Overlapping responsibilities with inefficient workflows

[65] A total of 30 interviews have been carried out with local authorities and academic experts – Annex 1
[66] Energy Efficiency

Regulation dimension (planning instruments and enforcement)	Control and monitoring	Existence of special department/organization to steer, promote, control and monitor the process in the local urban planning practices	- Lack of competent department/organization responsible for promoting, monitoring and authorizing energy efficiency considerations in the spatial development of cities - Lack of an integrated workflow, dedicated tasks and responsibilities for actors (especially at local level)
	Planning instruments	Dedicated obligatory & promotional instruments and measures	- Lack of energy efficiency guideline, regulation or checklist available for spatial development in cities (with an exception of Code 19 on buildings) - Lack of energy efficiency incentives and promotional measures (i.e. energy efficiency certificates, tax deductions) for planners and developers - Lack of financial instrument/support dedicated on this topic - Lack of an enforcement/monitoring mechanism in place
	Integrated political will among actors	Enhanced & integrated commitment among actors in all levels (national, regional and local)	- Lack of a clear link between policy/strategy measures and the local regulatory measures and actions in the field (divergence of priorities & policies within and among different decision making levels)

Source. Khodabakhsh, 2017 (based on field observations and energy efficient social infrastructure planning and provision interviews – Annex 1)

A similar process has been applied to identify the main gaps and shortcomings in the planning and provision of electronic social infrastructures. As explained previously, electronic services as a new form of service delivery possess contribution potentials to decrease energy consumption in cities. From one hand, they impact on reducing the meeting and working spaces (front and back offices) for almost all types of social infrastructures such as the administrative, educational or health services.

Reducing space, in turn, directly affects the energy demand for heating, cooling and lighting purposes. On the other hand, electronic services minimize the urban movement by diverting working procedures to online means. From an energy perspective, this dimension of electronic services, considerably impacts energy demand in the transport sector (more precisely the reduction of VMT and as a result less traffic congestion and less energy consumption in the transport sector). Therefore, electronic services as a new form of service delivery can be considered as an energy efficient alternative to existing physical service spaces.

As illustrated in chapter 3, a three dimensional analysis concept is selected to assess the readiness level in the case study. These dimensions (infrastructure readiness, organizational readiness and system and services readiness) are the prerequisites for a successful and complete electronic service design and delivery. The following gap analysis identifies existing shortcomings within each of those dimensions.

Table 32. Gap Analysis for improving e-services planning and provision of social infrastructures

Dimensions		Expectations	Gaps
Infrastructure readiness	Reliable infrastructure and updated technologies	Improved coverage and uptake of high speed internet infrastructure	- ICT infrastructure is not considered as part of the basic infrastructure in the Iranian urban planning processes - Slow improvement in internet infrastructure due to high upfront investments for telecommunications infrastructure projects. As a result, the main focus has been on improving the quality of mobile internet. - Lack of updated/latest version of technologies as the result of very high infrastructure costs - Old and not updated IT support systems in municipalities and other service providers
Organizational readiness	Actors and digital literacy	Enhanced skills of users and involved actors (i.e. the local authorities)	- limited digital skills and competencies among citizens and local authorities - Limited trust to ICT driven solutions and procedures such as e-services (due to cultural and educational backgrounds)
	Awareness of the actors	Enhanced awareness on the benefits of e-services among all the relevant actors in different scales	- Many local actors (i.e. local authorities and communities) are not aware of the benefits and efficiencies of electronic service delivery - Lack of adequate training and awareness raising programs
	Integrated political will among actors	Multilayer and integrated commitment in different decision making layers from national to the very local level	- Lack of clear visions which has resulted in limited operational plans on the local level - Fragmented initiatives and targets by different actors in different scales - Lack of multilayer communication mechanisms for harmonizing the policy measures in different scale (lack of coordination)
	Planning, implementation and monitoring mechanism	Special department/organization for steering the process (i.e. promote, control and monitor the process)	- Lack of appointed coordinators (i.e. on behalf of local authorities and service providers) - Lack of a common planning, implementation and monitoring mechanism - Lack of standard measures, workflows and procedures
Service and system readiness	Digital content	Improving digital content	- Restriction on open data due to security considerations by authorities - Lack of digital content and digital data and high upfront investment to change paper-based procedures - Limited awareness to keep obsolete/traditional and inefficient working procedures
	e-services design	User friendly, one-stop shop e-services platform for end users	- Slow transformation pace towards planning and provision of e-services by local authorities - Diversity of interfaces and lack of a single point of information - The current e-services are limited to administrative workflows not the services themselves - Lack of trust among actors on e-services (low level of transparency) - Inefficient design of current e-services

Source. Khodabakhsh, 2017 (based on field observations and electronic services planning and provision interviews – Annex 2)

4.2.2 SWOT analysis

The method of SWOT analysis is a commonly used tool for analysing internal and external environments of a given situation in order to attain a founded results for decision-making (Wheelen and Hunger, 1995 and Kangas et al., 2003). As a matter of fact, almost any situation can be characterized in terms of positive and negative factors affecting its development, of both internal and external origin. Consequently the (SWOT) analysis is a commonly used tool for analysing both environments in order to attain a systematic approach and support for a decision situation (Wheelen and Hunger, 1995; Kangas et al., 2003). SWOT analysis was first used in the 1960s as a tool for business management, in contexts characterized by uncertainty and high competitiveness. In recent years SWOT analysis has reached wider fields of application and is now commonly applied to support strategic planning procedures, to analyse alternative scenarios of urban and territorial development and to evaluate projects, plans and programs at both the local and global level. SWOT analysis has thus become a well-consolidated approach in the field of sustainability assessments thanks to its ability to represent in a rational and organized way the influence played by multiple factors on different decision contexts (Comino & Ferretti, 2016).

From a methodological point of view, SWOT analysis allows to distinguish between:

- endogenous factors (i.e. variables that are part of the system and that can be directly modified);
- exogenous factors (i.e. variables that are external to the system but that can influence it; these variables cannot be directly modified but it is important to keep them under control in order to take advantage from the positive aspects and prevent negative consequences).

Table 33. A synthetic definition of the SWOT analysis components

	Helpful to achieving the objective	**Harmful to achieving the objective**
Internal (attributes of the project)	Strengths: endogenous factors that describe the characteristics of the system. These characteristics are the resources with which the system is equipped and that is able to use in order to achieve its objectives.	Weaknesses: endogenous factors that describe the deficiencies of the system and the obstacles to the development processes. These characteristics refer to the internal limits of the system which make the achievement of the objectives more difficult.
External (attributes of the environment)	Opportunities: circumstances that are exogenous to the system and that can be enhanced by proper politics in order to increase the strengths or reduce the negative effects of the weaknesses. The	Threats: circumstances that are exogenous to the system, as for instance socio-cultural trends of the local system, which could weaken the strengths of the system, exacerbate the weaknesses, prevent the system from catching the opportunities and increase the risk of the

	opportunities are situations belonging to the external context that are favourable to the system and that can activate or support development processes.	development processes. The threats are situations belonging to the external context that are unfavourable to the system and that can frustrate its short-term, medium or long-term strategy.

Source. Comino & Ferretti, 2016

The SWOT analysis can be used as input to the creative generation of possible strategies, by repeatedly asking and answering the following four questions:

- How can we capitalize on each strength?
- How can we ameliorate each weakness?
- How can we take advantage of each opportunity?
- How can we defend against each threat?

When used properly, the SWOT analysis can provide a good basis for strategy formulation (McDonald, 1993). A potential shortcoming is that SWOT analysis lacks the possibility of comprehensively appraising the strategic decision-making situation. The analysis often remains at the level of merely pinpointing factors. In addition, the expression of individual factors is often of a very general nature and brief (Hill and Westbrook, 1997).

The objective of the SWOT analysis in the present context is to develop recommendations for improvement in the local planning practices towards achieving energy efficiency in planning for social infrastructures. The analysis emphasizes both spatial dimension of social infrastructure planning and their impact on energy efficiency, as well as the electronic service delivery dimension and their potential impact on energy consumption. The analysis is carried out in three dimensions:

- Planning and design measures (technical dimensions)
- Actors and their integration in the process (organizational dimension)
- Instruments and enforcement measures (regulatory dimension)

Table 34. SWOT - Spatial energy efficiency planning and design measures for social infrastructures

Categories	Strength	Weakness	Opportunities	Threats
Planning and design measures (Technical dimension)	▪ Existence of an environmental design checklist by the UDEC in district 22 - focused on building scale	▪ High energy consumption (both in building and transport sector) resulted from inefficient planning of social infrastructure ▪ Lack of classified list of criteria, measures or guideline regarding energy and environmental issues in current local planning practices.	▪ The possibility of achieving considerable energy efficiency by application of new planning measures in the process of spatial development (especially in an urban growth area with massive physical development potential) ▪ Existence of few number of criteria in the statutory planning process (i.e. detailed plan) with impacts on environment and energy consumption	▪ Lack of know how about spatial planning & design measures and their impact on energy efficiency (sole attention in the area of energy efficiency has been appointed to technological solutions as well as appliances efficiency) however, there is a considerable efficiency potential through planning and design of built environment ▪ Lack of energy efficiency planning support measures/tools (i.e. regulations or guidelines)
Planning Actors and stakeholders (Organizational dimension)	▪ Establishment of the Urban Design and Environment Commission in district 22 municipality.	▪ Top down and centralized steering modalities with limited flexibility for integrating new planning and design measures ▪ Limited awareness of local authorities about the dimensions, criteria and possibilities to enhance energy performance of cities through application of spatial planning and design measures ▪ Inefficient management structure and lack of skilled human resources in the local context	▪ Capacity of District 22 urban managers to work on new innovative ideas and approaches (i.e. recent activities to establish the Urban Design and Environment Commission)	▪ Unstable and rapid changes in the management and organizations structure of city and therefore lack of a clear vision and strategies ahead. ▪ Lack of commitment to integrate energy efficiency and environmental consideration in all dimensions of urban development ▪ Limited multi-layer and multi-scale cooperation and communication. i.e. existence of sectoral policy and strategy instruments with no link to operational plans and actions in the local scale
Planning instruments and enforcement measures (Regulatory dimension)	▪ Mandatory integration of few environmental considerations in the process of building permit issuance in District 22 by establishing the Urban Design and Environment Commission in district municipality (However, the existing obligations are incomplete and limited to building scale)	▪ Old fashioned master planning approaches without flexibility and consideration of economic framework complexities (city as an ever evolving context- dynamicity and the need for flexible solutions) ▪ Rigid top-down planning approaches with limited possibilities for integrating new approaches ▪ Complexity of multi-dimensional planning and regulatory instruments (especially the legally binding plans) ▪ Lack of integrated set of planning instruments and measures (i.e. regulations, maps, criteria, strategies) on the topic of energy efficiency in current urban spatial planning practices. ▪ Except building code Nr. 19, which provide few measures on energy performance in building scale, no other standards covers energy and environmental topics for spatial development.	▪ Tendencies to test new planning approaches such as strategic planning approaches (i.e. CDS Plan) in District 22. ▪ Potentials for improving the UDEC guidelines ▪ Possibilities for streamlining the UDEC approach and achievements to other managing authorities in District 22 and Tehran.	▪ Dominance of the traditional comprehensive and physical planning approaches, with limited environmental and qualitative emphasis ▪ Existence of the rigid regulatory measures (mostly quantitative) in urban planning and difficulties to promote/integrate new approaches in the current traditional planning procedures/frameworks. ▪ Lack of incentives and promotional measures (i.e. certificates) for developers/consultancies to improve the energy performance in their planning and development activities. ▪ Regulatory complexities for comprehensive integration of energy efficiency planning and design measures in the current statutory planning system

Source. Khodabakhsh, 2017

Table 35. SWOT – Electronic delivery of social infrastructures

Categories	Strength	Weakness	Opportunities	Threats
Infrastructure, services and systems dimension (Technical dimension)	▪ Rapid uptake of high-speed mobile broadband as well as ICT application and services	▪ Limitations and weaknesses in broadband infrastructure, access and application of latest technology advances ▪ Limited digital content and the tendency to stick on conventional paper-based procedures among local authorities. ▪ Credibility and provision of up-to-date information (lack of effective maintenance of existing platforms) ▪ Lack of full provision of e-services: for example many existing e-services by local authorities (i.e. municipalities) are limited to permit gathering procedures, payments, tax accounts and some general geographical information system applications. Most of these services are also outsourced and transferred to the city's electronic office. ▪ Poor platform designs with limited attention to the target group's demands	▪ Establishment of the municipality portals as a step forward, containing basic information (i.e. the location of urban services in District 22). ▪ Application of online GIS tools on the current online platform of District 22 municipality as well as other platforms hosted by the Tehran municipality ▪ New transactional possibilities for several administrative and financial services (i.e. tax payment, building permit)	▪ Limited cooperation and coordination among local authorities and different public service providers responsible for planning and provision of social infrastructure ▪ High upfront investments for telecommunications infrastructure improvement projects
Planning Actors and stakeholders (Organizational dimension)	▪ Distribution of promotional materials (i.e. concerning the municipality website and available online services) at the municipality and municipal public buildings to enhance the publicity of District 22 ICT activities	▪ Complexity of involved actors and overlapping roles ▪ Inefficient and complex management structure together with limited digital skills and competences (among involved local authorities and service providers) ▪ Lack of an operational plan in developing single point of information (i.e. for basic urban services)- especially in the local/urban context ▪ Citizens limited digital skills together with lack of trust on e-services and online procedures ▪ Inefficient bureaucratic procedures and preferences to keep the obsolete procedures and structures with limited transparency ▪ Lack of coordination and cooperation among responsible organizations, public services providers and decision makers (i.e. a coordination department) in efficient planning and provision of e-services ▪ Lack of awareness among managers and decision makers about the potentials/benefits of e-services (i.e. cost and energy efficiencies)	▪ District 22 strategic priorities in developing innovative approaches, such as establishing the municipality portal and continues development of e-services ▪ Tehran municipality vision for stimulating the electronic service delivery in all municipality districts of Tehran ▪ Existence of few awareness raising and training programs for enhancing digital competencies of the citizens by the municipality District 22 (i.e. internet training sessions and workshops)	▪ Lack of strategic training and awareness raising programmes ▪ Sectoral and top down decision making system with limited cooperation and coordination in different levels (fragmented strategies and actions in planning and development of electronic services) ▪ Short management period, rapid changes of management structure and therefore prioritizing/focusing on short term projects and changes
Instruments and enforcement (Regulatory dimension)	▪ New ICT plans and initiatives by Tehran municipality towards making Tehran a smart city ▪ ICT enabled obligatory procedures for several administrative procedures of municipalities ▪ National bylaws mandating the development of e-services by all executive bodies ▪ Preparation of the ICT strategy of district 22 municipality	▪ Complexity of the existing regulatory system as a barrier to rapid development of electronic services. ▪ Difficulties in creating a single pint of information ▪ Limited financial instruments and deficiencies in budgets being allocated for ICT and e-services improvements accompanied by difficulties to attract private investments ▪ Weaknesses in developing incentives and introducing promotional measures. i.e. by showing how cost, energy and time efficiencies can be gained by the new generation of services ▪ Absence of harmonized and cross sectoral initiatives and roadmaps by local authorities (especially local municipalities) for developing/enhancing the e-services.	▪ Electronic coordination activities of the Municipality of District 22 with some of the local service providers (such as water, electricity, gas and other service providers). ▪ Establishment and operation of the Tehran Electronic Services Offices in all districts (as well as District 22) as a transition towards full application of e-services. ▪ Workshops and conferences managed by Tehran municipality focused on the regulatory dimensions of e-services ▪ Obligations for boosting the provision of e-services by the executive bodies as well as municipalities (i.e. fifth and sixth national development plans and presidential decrees).	▪ Limited operational initiatives for integrated planning and provision of e-services by local authorities and different service providers ▪ Deficiencies in regulatory frameworks in planning and provision of electronic services ▪ Limited resources dedicated to studies for planning and provision of electronic public services

Source. Khodabakhsh, 2017

4.3 Integrated recommendations for the local context

The result of the abovementioned SWOT analysis is followed-up by devising recommendations in the following categories (Table 36):

- Improving technical knowledge and integration of new planning and design measures
- Improving organizational readiness and effective interaction of actors and stake-holders
- Enhancing the regulators environment and improvement of the planning instru-ments and enforcement mechanisms

Table 36. Strategies to facilitate the integration and implementation of energy efficient planning and design measures

Categories		Recommendations
Improving technical knowledge and integration of new planning and design measures	Developing energy efficiency and design measures	- Establishing a classified set of energy efficiency and design measures, frameworks and guidelines with potentials for integration in the statuary planning process. - Developing a comprehensive checklist of energy efficient and design measures (in accordance to the respective local socio-cultural and specific historical contexts) and their contribution in the existing planning system.
	Effective integration of EE measures in different stages of the planning process	- Designation of the measures, their contribution scale and respective planning instrument (i.e. relevant measures in the level of master planning, detailed planning, urban design and architectural design)
	Boosting further development of current energy related initiatives	- Empowering the UDSC together with mainstreaming its activities and success throughout other district municipalities - Promotion of the current pilot practices /projects (e.g. the development of the photovoltaic building by the municipality)
Improving organizational readiness and effective interaction of actors and stakeholders	Enhancing the importance of energy considerations in planning	- Enhancing the commitment on different levels by streamlining the benefits of energy efficiency measures to higher level authorities, based on tangible results of local experiences - Identification of the influential actors on different levels, clear tasks and responsibilities and interaction/communication structure among them - Establishing multilevel mechanisms among different actors in all levels of planning process
	Creating a participatory environment for all involved actors	- Identifying different target groups and their needs - Choosing appropriate communication message and communication channels: "awareness raising matters!"
	Enhancing capacities for the local authorities and experts for integration of new planning criteria and measures	- Initiatives to improve the awareness and know-how among experts and local authorities (i.e. training and local workshops) in regard to new planning qualities such as environmental considerations and energy efficiency.
Enhancing the regulators environment and improvement of the planning instruments and enforcement mechanisms	Integrating the new EE planning measures and criteria in statutory development plans	- Developing obligatory measures for integrating energy efficiency measures in different development phases in accordance to the existing regulatory environment - Introducing promotional measures and incentives (i.e. energy efficient building certificates, tax deductions etc.) - Designation of the monitoring mechanisms and enforcement measures such as energy efficiency planning codes and standards.
	Improving the current planning procedures	- Determination of the roles and responsibilities of the actors, together with an integrated mechanism for their multilayer and multiscale coordination. - Setting up a clear structure, regulatory and statuary framework with clear responsibilities and transparent decision-making processes. The starting point can be a guideline/checklist to determine the contribution of each energy efficiency measure in the process of spatial planning. Furthermore, empowering and dissemination of existing environmental initiatives such as UDEC could be a door opener towards wider scale change in the regulatory system.
	Setting up regular reviews, feedbacks and constant improvements	- Necessity to review objectives, structures and processes regularly. In long term projects, fluctuating external circumstances, technical and organizational innovations, and changes in the attitude of individual partners are to be expected. Therefore, regular assurance mechanisms are required.

Source. Khodabakhsh, 2017

In terms of electronic services planning and provisions, the strategies are focused on the following three fundamental dimensions (see Table 37):

- Measures for stimulating infrastructural readiness
- Measures for stimulating organizational readiness
- Measures for stimulating the system and services readiness

Table 37. Strategies for stimulating electronic services planning and provision

Categories		Recommendations
Stimulating infrastructure readiness	**Improving the infrastructural conditions**	- Integrating the telecommunication infrastructure as a topic similar to other basic infrastructures in urban spatial development plans - Stimulating the expansion of modern broadband infrastructure (fixed and mobile)
	Creating the essential fundaments for digital content	- Creating the required basis for the security of data as one of the concerns by end users and local authorities (it is necessary to communicate the data protection solutions actively and positively)
	Stimulating internet uptake and use	- Developing programs to enhance the ICT skills of the actors (citizens, authorities etc.) - Promoting training programs for the citizens as well as local authorities - Promotional programs to publicize the importance and benefit of the ICT and e-services among local authorities and citizens
Stimulating the organizational readiness	**Creating a multilevel participatory mechanism for actors**	- Improving communication and creating a platform for active cooperation and coordination between involved actors (i.e. local authorities, citizens and service providers) - Create an atmosphere where parties complement each other and do not compete by establishing clear link (vertical and horizontal) among plans and strategies on different levels and across entities. Followed by a clear identification of how the policies in national and regional level will turn into concerted actions by local authorities. Application of new participatory methods like public-private-partnerships PPP can be put on the agenda
	Enhancing the awareness and skills of providers, managers, and end users	- Properly Identifying different target groups, using appropriate communication messages and channels to increase their awareness (i.e. press, radio, events, testimonials, newsletter, database, web, blog, wiki, social networks). - Developing promotional programs for all the relevant target groups and actors (i.e. establishing regular training programs and training sessions)
	Setting clear planning procedures for e-services	- A step by step procedure in the operationalization of the concepts is crucial - Clear identification of the roles and responsibilities within the local government - Clear identification and design of the work flow (internally and among different actors) – Cross-sectoral & multilevel
	Setting up a clear structure, regulatory and statuary framework	- It is essential to set up a joint project structure with responsibilities and decision-making processes that are transparent both internally and externally with the support of respective regulatory measures.
Stimulating services and systems readiness	**Improved service design and promotion of e-services**	- Develop user friendly, reliable and comprehensive e-services - Use consolidated promotional measures to stimulate further use of e-services - Enhancing the acceptance and participation of all actors as a key success factor (using methods, such as ICT ambassadors) - Considering the respective local socio-cultural contexts into account in planning and provision of e-services

Source. Khodabakhsh, 2017

4.4 Energy Efficiency and design measures

City planning is one of the major drivers of enhancing the energy performance in urban areas. It is therefore essential that city officials ensure that city planning accommodates and integrate a variety set of policy goals in that regard. The decisions on urban density, mixed uses and in general the form and functional configuration of cities can have a direct impact on building heating and cooling needs, the cost effectiveness of public transport, and the vulnerability of the built environment to extreme weather conditions. The overall message is that, the energy demand and supply needs can thus be reduced by design as much as or even more through integration of new technologies (IEA, 2012).

As discussed previously, the influence of urban development policy in regard to energy efficiency is to a large extent on two sectors, namely; building sector and transport sector. The building sector is the primary energy consuming sector at the city level. Energy efficiency policies for this sector should therefore be developed early on in the design of urban policy packages. As an example, the policy packages, therefore requires to include building energy codes as well as energy labelling schemes that aim to reduce the energy demand of both new and existing buildings, without compromising comfort levels.

Transport is another important energy consuming sector at the city level, which requires a similar considerations early in urban policy design. Transport policy to reduce energy consumption comprises of different solutions and often includes the implementation of efficient, high quality and safe public transport systems; schemes to discourage the use of personal vehicles, and policies that turn multi-modal trips into seamless journeys. Furthermore, it includes measures for the minimization of distances and reducing the need for movement through appropriate functional planning of cities. In this context, the mixed use areas can also save energy by reducing the average distances city dwellers need to travel on a normal day (IEA, 2012). Policies to ensure reliable energy supply and sustainable energy generation will generally be designed and implemented at the local level. However, the impacts of national and regional policies on the overall urban policy and planning process is crucial. Energy wise, the policies should therefore create an effective link between national, regional, and local needs. Examples of the most important areas to address include city development planning, building energy efficiency, transportation efficiency, as well as energy generation, distribution and delivery. Furthermore, the analysis of such policy areas should also employ a cross-sectoral approach. The link between energy and transport for example is apparent, but less obvious interdependencies can also be important, such as the interplay of energy policies with waste and water management.

When it comes to urban development, for example, policy-makers should include energy demand and generation requirements in all stages of city planning policy design. In planning and development of more efficient cities, not only traditional technologies, but also passive solutions shall be considered. Examples are taking into account the local climate and natural environment characteristics towards enhancing the utilization of passive energy gain and minimization of loss of energy (IEA, 2012).

In this context, in order to achieve more energy efficient cities, laws and regulations should play a vital role. For example, in 2000, the city of Barcelona introduced its mandatory "solar ordinance". According to the law, all new housing, offices, restaurants, and public buildings have to install solar hot water systems if they use substantial amount of hot water. Old buildings also have to be fitted with solar hot water systems when they are refurbished. In Japan, for instance, about 10% of all dwellings have their own solar hot water systems. In German cities, solar PV panels are becoming commonplace, despite the country's climate. This is primarily due to the German government's supportive legislation, which offers fixed subsidies and favourable tariffs for owners of PV roofs. This policy has led to a massive growth in demand for solar PV technology across the country. Similar policy measures have been introduced in Austria, France and Spain (Khalil, 2015). In regard to the policy development as well as regulatory frameworks, there is always a relationship between the scale of the environmental burdens and the appropriate roles of different levels of government. Some governance failures can be traced to a mismatch between the scale of the problem and the scale at which the response has been articulated. For example, local governance should not be expected to reduce the carbon emissions voluntarily, although it can be very appropriate for driving local water and sanitation improvements.

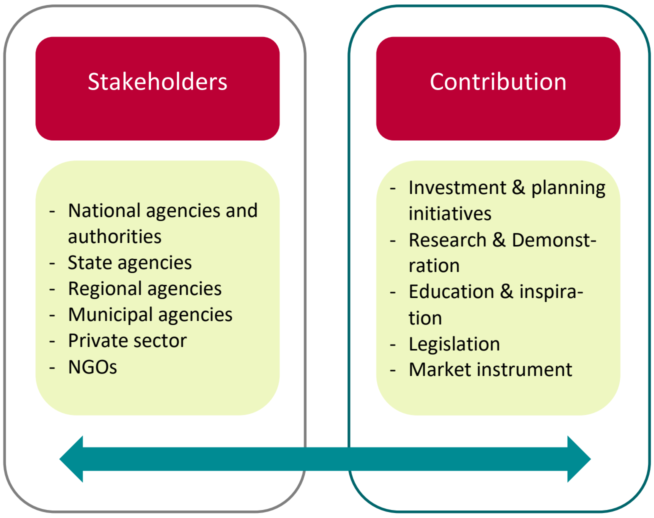
Global governance, on the other hand, is clearly needed to help develop institutional mechanisms to reduce contributions to global climate change, but it is inappropriate for developing institutional mechanism for managing local water and sanitation systems. On the other hand, reducing local environmental burden often requires support (or at least the absence of opposition) from global processes and institutions, while response to global burdens often need to be rooted in local agency. Moreover, cities and their needs are complex, and the traditional, departmentally organized approach to city governance needs to be rethought to enable more holistic solutions on the one hand and more responsiveness and accountability to citizens at a local level on the other (GlobeScan and MRC McLean Hazel, 2007).

In planning for energy efficiency in urban context, a particular role is accorded to municipalities. Brandoni and Polonara (2012) addresses the importance of municipal energy planning processes especially in identifying the crucial aspects in energy consumption as well as assessing the most suitable energy-saving initiatives and identifying renewable sources that can be more properly exploited in a given local area.

Williams (1999), however, questions the power of the (local) planning system. Williams considers the process of policy implementation as responsible for the divergence between theory and planning practice. In many planning systems, local policy making takes place within policy regulations from higher tiers of government that determine the range of local options (van Stigt, Driessen & Spit, 2013). According to Bulkeley and Betsill (2005), solutions remain tied to the local level instead of exceeding the local frame due to the neglect of interactions of economic, social and political processes across different governance levels and systems as well as gaps in cooperation at the regional level and among constituent municipalities (Geerlings & Stead, 2003). Furthermore, Brandoni and Polonara (2012) consider coordination at the regional and national level as fundamental to enable municipalities to concentrate their efforts on their agenda (Große et al., 2016). To conclude, ambitious and purposeful municipal energy planning requires, on the one hand, policy-wise support from the national level and, on the other hand, coordination at the regional level. This implies examining governance structures and their influence on urban form in more depth to identify and establish “helpful governance structures” (Schwarz 2010: 44).

Urban energy systems are highly complex, span over multiple physical and temporal scales, and involve a multitude of actors. Today, urban planners are regarded as key actors in the process of developing low-carbon cities, and new decision support methodologies are required to assist them in this task. Figure 82 gives an insight of the main urban energy stakeholders and their potential contribution towards improving energy efficiency initiatives in cities (World Bank, 2010).

Figure 82. Urban energy efficiency stakeholder matrix

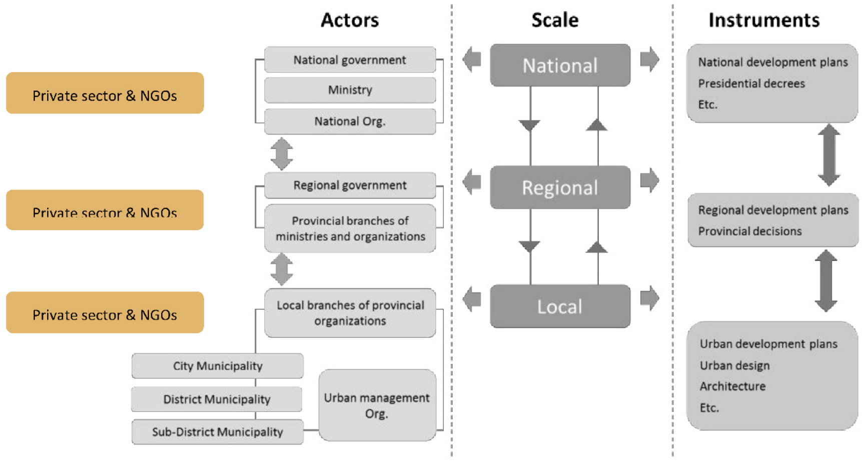


Source. UN-HABITAT (2012), adopted from World Bank, 2010

There exist a multitude of planning instruments in which the topic of urban energy efficiency planning can be integrated. Additionally, there should also be a clear contribution by and integration of different actors from the national to the very local level with adequate steering modalities (i.e. both bottom up and top down) accompanied by dedicated legal instruments and enforcement measures. Correspondingly, deep knowledge about the relevant actors and the relevant planning and legal instruments are critical in the context, while improving the planning system.

Focusing on the local context of Iran, in order to create legal frameworks and enforce the implementation of new planning measures in urban development practices, a multilevel interaction among authorities on different levels is required. The same applies to planning instruments and enforcement measures. Studies on current situation (chapter 3) showed a not effective interconnection of actors and instruments in different levels of planning. Here and in accordance to the analysis carried out in the previous section, a modified conceptual interactive model of actors and instruments are presented in Figure 83. The figure conceptually demonstrates, how influential actors and instruments can effectively be coordinated, when it comes to planning for energy efficiency in cities. One core idea is the creation of multilayer coordinated structure with both top-down as well as bottom-up modalities.

Figure 83. The conceptual model for actors and instruments in planning for energy efficiency



Source. Khodabakhsh, 2017 (based on energy efficient social infrastructure planning and provision interviews – Annex 1)

As addressed before, a key problem is the operationalization (i.e. "putting to work") of general policy and strategy measures in the local context. When it comes to energy efficiency and environmental considerations in planning the social infrastructures, most strategies and statements fail in the practical realization phase. Lack of integrated approach to create interlink among planning measures, actors and enforcement instruments in different scales. Table 38 provides an example of such integrated approach for energy efficiency measures in urban development.

Table 38. An integrated set of energy efficiency planing and design measures for social infrastructures

Scale	Main actors	Unit of Action	Main plans	Scale of contribution	Measures	Energy efficiency related contribution
National Level	Ministries and national organizations	Country	National Development Plan, Sectoral development plans	General Environmental consideration/strategies 1:100000	- Policy	Sectoral, environmental, and energy conservation policies on the national level
Regional Level	Regional Bodies (i.e. Province and regional branches of national organizations)	Region/province	Regional Development Plans, Sectoral regional/provincial development plans	General Environmental consideration/strategies 1:50000	- Policy & strategy - Regional development plans	Transfer of the sectoral environmental related policies and roadmaps onto regional level
Local Level	Municipality	City	Comprehensive plans	Urban development strategies (1:10000)	- Strategy - Regulation & codes - Plans/maps	- Integration of energy efficiency and design measures in the legal process of urban development - Energy related codes and standards together with checklists and guidelines for experts and local authorities - Enforcement and monitoring mechanisms
			Detailed plans	Detailed development maps & regulations (1:2000)		
	District & sub district municipalities	Districts	Detailed plans	Detailed development maps and regulations (1:2000)		
			Urban design plans	Urban design concept and design codes (1:500)		
		Neighbourhoods	Detailed plans	Detailed development maps & regulations (1:2000)		
			Urban design plans	Urban design concept and design codes (1:500)		
		Buildings	Building design	Architectural plans and building codes (1:100-20)		

Source. Khodabakhsh, 2017 (based on the Iranian planning system and energy efficient social infrastructure planning and provision interviews – Annex 1)

Against this backdrop one can propose a set of common policy and regulation instruments and tools which can potentially increase the implementation of energy efficiency in the process of social infrastructure planning lacking in the local planning context. These include: energy regulatory policies; mandatory standards and codes; labels and certificates; financial facilitation schemes; and awareness-raising and capacity-building initiatives.

A survey of pertinent results within the literature indicate that the integration of spatial energy efficiency measures can highly impact the energy performance of cities. Urban development plans such as master/comprehensive or detailed plans – as the main statutory development roadmaps, which steer the future physical and functional development of cities – are the best spot to integrate new energy and environmental measures. This is even more crucial in urban growth areas due to their higher physical development potential. Identification of concrete planning and design measures and their potential impact and contribution on energy savings in different sectors (building and transport) is an important dimension that recommendations have to take into account.

A properly integrated development plan requires not only considering the design of buildings (in a physical sense), but also integrating people and places, movement and urban form, nature and the built environment (Urbandesign.org, 2012). From a holistic urban design perspective, in order to reflect the uniqueness of a city, a district or a neighbourhood, a crucial factor is to analyse the local conditions, the climatic, environmental, social, cultural and political context. The combination of these factors, helps planners to choose appropriate development scenarios, compatible with local features and characteristics. Doing so also positively affects the acceptancy of a plan by end users and other involved actors in the process of urban development.

When it comes to enhancing energy efficiency in social infrastructures, several technical, behavioural and planning aspects are influential. However, the focus on this research is on the form and functional dimension of spatial planning and the discernment of their effect on energy efficiency.

This refers to the physical layout and design of social infrastructure built spaces, such as densities, uses, street design and layout, transport systems, building typologies in different scales (Dempsey et al. 2010: 22). Different formal and functional configuration of cities affect users' life style and, as a result, levels of energy consumption in relation to social infrastructures. Considering energy efficiency in social infrastructure planning as the main thematic focus, this research emphasizes the following two dimensions:

A. planning measures to improve the energy performance of social infrastructure buildings

B. planning measures for social infrastructures to improve energy efficiency in the transport/mobility sector

A detailed description of recommended spatial measures in both dimensions are presented below[67].

A. Energy efficiency in the building sector - Planning measures to enhance energy efficiency in social infrastructure building structures

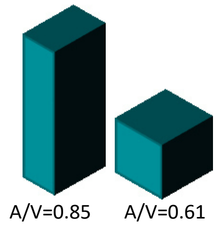
The geometry and design of buildings is a key aspect impacting energy consumption levels. Factors such as building density and types, height of building, distance to adjacent buildings, vegetation, orientation etc. will influence solar potential and shading, which directly affect the heating, cooling and lighting demand of buildings. Several researches and pilot projects have analysed these measures for residential buildings. However the potential saving effects of these measures are often neglected regarding other physical structures such as social infrastructures. Environmental planning and configuration of these built structures allows solar gain which reduces the heating demand especially in colder climates.

However, shaded objects may have lower cooling demand especially in hotter climates and during summer. Sun light and the configuration of openings can also impact on absorbing adequate natural light and therefore less energy demand for lighting purposes in the building. Influential design elements in this regard are the orientation to the sun, shading consideration, building compactness, openings and building facades, which impact the passive heat and light gain of a building. Urban planning and design strategies allow considerable energy savings by applying the above mentioned measures at little or no extra costs. This covers measures to minimize the thermal loss and measures to maximize passive energy impacts.

[67] Introduced measures in the following part of the research are calibrated/adapted to the conditions in District 22 of Tehran, however can be applied in other similar cases.

A.1. Minimization of thermal loss

Figure 84. Optimization of surface & volume



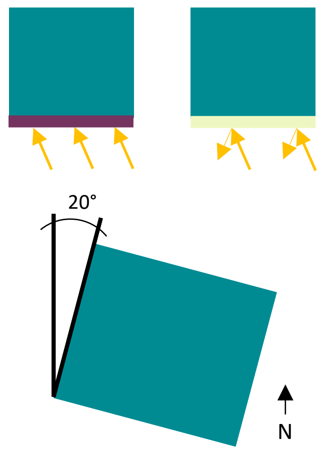
Source. Khodabakhsh, 2017

Optimizing the social infrastructure's building volume stabilizes the building's thermal behaviour through measures such as compactness and surface to volume ratios. Applying this measure reduces thermal loss through building surfaces and efficiently regulates the interior climate against outside temperatures and seasonal or daily temperature peaks. One example is the surface design and materials which can reduce the impact of outside climate on interior spaces. This measure shall be jointly considered with architectural design. In essence, the compact building form hides building volumes from climate effects and thus helps avoid thermal loss (Brunner et al., 2009). The thermal envelope (roofs, facades and ground-slaps) is the most important element to control the energy benefits and loss in the built structures such as social infrastructure buildings. Furthermore, due to the high demand for quality in construction and detailing, the surface is a cost intensive building element. By optimizing the surface area through compactness, building costs can be reduced and a permanent desirable interior climate can be achieved.

In the local context of Iran, considering the local climate conditions, the A/V ration should not exceed 0.65 for buildings with 3 external walls and 0.5 for buildings with 2 external walls.

A.2. Maximizing passive energy impact

Figure 85.Orientation and surface design and passive energy absorbance

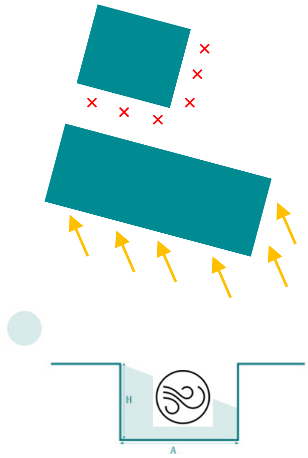


Source. Khodabakhsh, 2017

Maximizing passive energy use in the social infrastructure buildings can be achieved by adapting the building form to use natural energy. The main natural energy sources are the sun and wind. Passive energy helps to reduce the active energy demand for cooling, lighting and heating and, in turn, CO_2 emissions.

The planning and design of social infrastructure building structures ought thus to be oriented towards maximizing the sun exposure in winter to reduce the heating demand and minimizing it in summer to reduce the cooling demand by shading. Solar radiation in Tehran is very intense, meaning that the sun is a valuable source of energy for heating. What is more, the high solar incidence can create a surplus of heat, especially in summer. This fact must be considered in the planning of building volumes and south orientated surfaces to absorb solar energy for natural heating purposes during cold days. In addition, the facade should be designed with shading devices to combat over-heating in summer. Regarding the location on a slope, south- or southwest facing slopes are particularly suitable due to greater solar gain of the social infrastructure buildings (Stadt Essen, 2009: 5).

Figure 86. Prohibiting blocking by other physical structures



Source. Khodabakhsh, 2017

In addition to solar energy, wind has a great potential for natural ventilation of indoor and outdoor spaces. This shall be harnessed through jointly design of street and buildings layouts and orientation as well as openings of the social infrastructure buildings to channel the wind (canyons). Cool winds shall be harnessed for ventilation and cooling in summer by avoiding buildings in breezeways and by blocking hot winds with buildings and building groups.

Notwithstanding the importance of climate response design in the traditional architecture and urban development in Iranian cities, consideration of climate factors (i.e. sun and wind) has been reducing during the time. This evolution from traditional climate responsive urban form to more recent fragmented and unstructured patterns can be traced in the following eras:

- The old traditional compact inner area urban blocks which is a courtyard-structure urban block. In this common type of blocks, ventilation is through wind catchers connected to Ivans, basements, and courtyards.
- Middle area urban blocks, produced by reducing the size of the old large traditional urban blocks. This is a type that was restructured in the first decades of twentieth century in more affluent neighbourhoods. Altogether, in this typology accesses were opened, and although the structure is more exposed to excessive heat and glaring sun, it utilizes more natural light and air flow.
- After a few decades, in mid-twentieth century a more rectangular residential block based on courtyard row houses took shape. Plot of land was divided into two pieces, and the building mass was constructed on the one side of the plot,

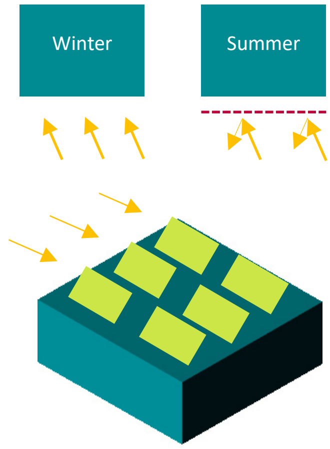
looking to the south. The streets were widened to improve access to motorists. Decline in household size and changes in socioeconomic and cultural conditions in modern Iran led to emergence of this new block form. In response to climatic issues, the structure is integrated with mechanical ventilation.

- Since the last three decades, following the act of selling building density and developer's activity in the construction of apartment blocks, a low-quality multi-storey building form in different climatic regions of the country has been dominant. Climatically and culturally, this structure is incompatible with the urban fabric of the hot and arid zone cities (Tavassoli, 2016).

Traditional planning and design principles addressed above, have great potential to be reawakened and adapted in the contemporary development of social infrastructures with the aim of maximizing the utilization of passive energy.

The orientation and dimension of streets affects their passive energy absorbance capacity. In the case of Tehran, east-west orientation of streets promotes the north and south solar exposure of the buildings, which can be more readily controlled as a result of the greater solar altitude (according to Givoni, 1998: 368). Streets running north-south have better shading conditions in summer and better light conditions in winter. This is a conflict that can be solved by diagonal streets, orientated northeast-southwest (Ibid.). Such street orientation allows natural ventilation by afternoon and evening winds for the social infrastructure buildings.

Figure 87. Shading regulation and passive energy absorbance



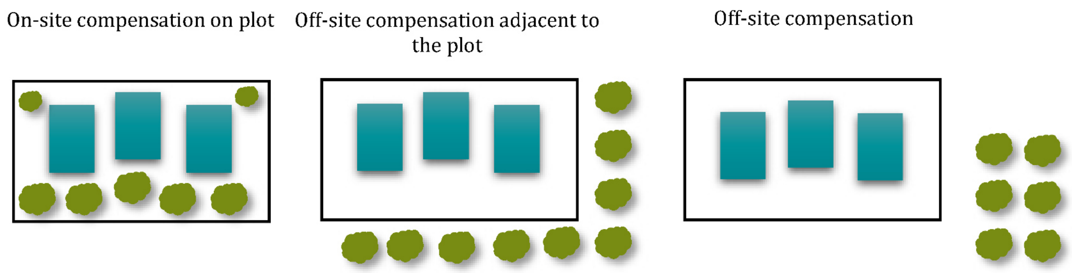
Source. Khodabakhsh, 2017

Another strategy which is briefly mentioned above, is the integration of new technologies as an additional layer of design. One example is the installation of external shading devices, which help in regulating solar heat gains of the social infrastructure building. Especially in hot summer regions such as Tehran, shading through curtains or covering of open spaces creates micro-climate benefits.

An element from vernacular architecture is the covering of courtyards through mechanical or textile elements which reduces the direct solar impact and creates a comfortable semi-open space. These elements can be combined with the effect of light guidance (e. g. for naturally shaded space in winter) or the energy benefits of photovoltaic fabrics (potentially through typically flat roof morphology of the social infrastructure buildings in the local context).

Vegetation coverage can also influence environmental comfort and levels of energy consumption in the social infrastructure buildings. It further promotes the desirability of pedestrian and cycling networks by providing shading in hot summer days. With the aim of improving the impact of vegetation on thermal comfort, several compensation measures can be implemented. These are on-site compensation on plot, on-site compensation adjacent to the plots as well as off-site compensation (see Figure 88).

Figure 88. Compensation measures in terms of vegetation coverage and environmental comfort

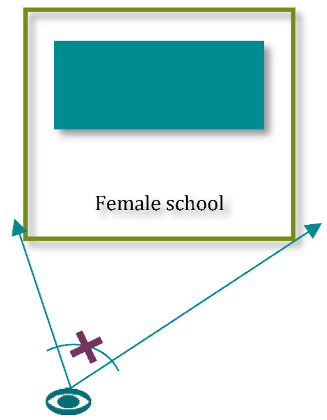


Source. Pahl-Weber et al., 2013

Dense urban form and compact building configurations are other influential measures in maximizing the passive energy use and minimizing the energy loss. As mentioned above, closed coverage reduces facade surface area and, thus, energy loss. Openings, which allow light and air incidence, allow for the proper functioning of the building's volume-envelope relationship. While designing the openings, socio-cultural dimensions of architecture such as privacy shall be considered.

This is specially of importance for planning and configuration of female edcational buildings. Another influential measures which has a bearing on the level of passive energy use is the floor plan and configuration. This aspect is pertinent to architectural design. The floor plan is related to the building type and balances user needs with the site context of the building volume. The floor design represents the user specific arrangement inside the building. This dimension, has limitations when it comes to social infrastructures, as these building often follow the sectoral standards prescriped by the responsible regulatory bodies.

Figure 89. Consideration of socio cultural features i.e. privacy



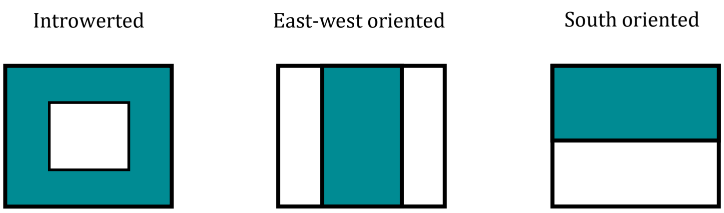
Source. Khodabakhsh, 2017

Regulations and measures generated in an urban planning and design process ought to be compatible with local topography and climate. This shall be implied in building and street design. The aim is to maximize the benefits of local environmental features and minimize their negative effects (i.e. intense topography or climate conditions).

One example are linear building arrangements, as a commonly used pattern in Tehran. This arrangement makes use of passive energy by maximizing the southern orientation of their facades. At the same time, this linear arrangement bears conflicts with topographic and social aspects in District 22. Privacy requirements contradict the need for opening up the facades and the high cooling demand in summer need to be considered in the design as well. Furthermore, the intensive land demand of linear building types runs against overall energy aims at the urban scale. Given the high costs of execution and the need to protect both the natural climate and resources, topographical interventions, which prepare land for large linear building arrangements, would be more effective if economic and ecological effects were considered.

In this context, vernacular building types offer well adapted regional building typologies. The compactness of the traditional courtyard housing scheme is perfectly suited to dense and compact urban form. The shaded courtyards and their micro-climate deliver thermal comfort via air circulation catalysed by the building morphology. But the sun impact and energy gain in winter periods is reduced to southerly oriented subzones. Such typologies can be integrated in the planning and design of social infrastructures.

Figure 90. Building and plot typologies in relation to environmental benefits

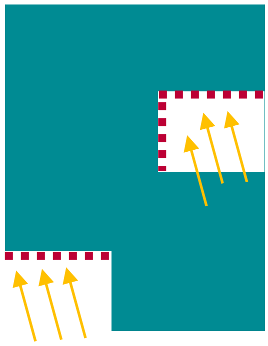


Source. Pahl-Weber et al., 2013

Building volumes in the compact urban design scheme need to take advantage of their positioning. In the case of District 22, the plot design of the majority of social infrastructures is based on a north-south orientation, determined in the urban design layout.

This volumetric organization guarantees a southerly orientation for every plot by keeping the compactness and reducing facade surfaces to west and east. In addition, the strategy of introducing "supplementary south-facing surfaces" via courtyards harnesses two advantages: the energy savings by reducing the cooling and heating demand through the compact form and the energy gains through sunlight impact due to supplementary southerly facades (Brunner et al. 2009).

Figure 91. Optimization of openings



Source. Khodabakhsh, 2017

B. Energy efficiency in the transport sector - social infrastructure planning measures to enhance energy efficiency in transport sector

The second dimension focuses on urban movement, mobility and access to social infrastructure. Planning and design features, define different form and functional aspects of cities such as population and building densities, land use and activities pattern, as well as infrastructural systems such as access networks. The combination of the above mentioned factors, influence the distribution of population, goods and services. Urban development patterns can influence the length of routes, need for movement as well as modes of transport that are used. By creating synergies among densities, street layout as well as land uses (here social infrastructure such as schools, health care, administration, sport etc.) end users can have the possibility to walk or cycle. This has an impact on reducing the share of motorized transport and brings about less congestion. If public transport becomes a safe, attractive and affordable option, the users might prefer using public transport instead of using private cars. There are examples that urban form can influence on trip behaviour and consumption of individuals in the transport sector (The World Bank 2010b:1). The overall target of the above mentioned measures is to minimize the use of private vehicles and encouraging walking, cycling and more use of public transport services. This will result in reduced VMT and less energy consumption in the transport sector.

Urban planning helps to improve the mobility and optimization of synergies through land division and use. It integrates a variety of different and sometimes contradicting movement demands in cities. In the context of current reseaerch, the relation between mobility and social infrastructures provides possibilities for creating site specific synergies in relation to energy consumption. As a general code, urban planning and design measures such as dense urban configuration and reduced distances between housing and social infrastructure, minimize motorized mobility demand and therefore, lower energy consumption in the transport sector. Social infrastructure patterns and their allocation in urban areas determine the length of average daily trips. Reducing the trips would mean that the social infrastructure services would have to be wider distributed throughout a greater number of locations and located closer to the sources of demand (Pahl-Weber et al., 2013).

The theory of Central Places by Christaller is a good example, which classifies services (here social infrastructures) according to their centrality in the city context. For example, an elementary school has a smaller service area than a high school. Considering the above mentioned transportation features in the city context, planners can, to a certain extent, guide the length of all types of daily transportation flows. Thus, a sustainable approach would try to centralize traffic origins and destinations in the same neighbourhood or district as much as possible (Schnabel and Lohse, 2011).

In order to support the use of more efficient transport modes, planners need to create an environment to ensure that walking, cycling, and Public Transport are more attractive than private vehicles. In this instance, there needs to be an optimal connection between origin and destination. Walking trips are especially sensitive when it comes to trip length[68]. Moreover, pedestrians are also quite sensitive to accessibility barriers, long waiting times at crossings, path steepness, and unattractive walking environments. Nearly the same criteria are valid for cyclists and include the need for cyclist-specific facilities such as safety, separated bicycle lanes, and parking facilities.

The main advantage of bicycles is that they make longer trips more accessible[69] (Schnabel and Lohse, 2011). In order to mitigate energy consumption and CO_2 emissions, the planned system and urban form need to provide optimal accessibility and mobility for non-motorized modes of transportation to social infrastructures. In urban growth areas, there may be more opportunities for larger physical changes. However, a large extent of policies consists of “soft”, that is, rather organization related measures which enable significant changes in mobility patterns. Below are examples of these measures:

[68] For example, in Germany the average walking trip is 1.1 km long (Schnabel and Lohse, 2011).
[69] The average trip-distance in Germany is 3.4 km, versus the 1.1 km for walking. Regarding long-distance travel or daily commuting, public transport and cars are direct competitors with daily average trip-lengths (9.6 km for car; 9.3 km for public transport) (Schnabel and Lohse, 2011).

Minimizing the demand for mobility (i.e. application of mixed-use concept of social infrastructures)

In order to optimize efficiency by reducing the demand for transportation, planning disciplines must coordinate transportation needs (accessibility to social infrastructures) and restrictions (such as limited amount of parking spaces). To bring origin and destination closer and reduce the number of trips, it is important to work towards low-centrality by assuring that daily consumed goods and services are provided directly within the neighbourhood (e.g. below ten minutes walking distance). Social infrastructures with higher centrality should follow a similar approach with adequate accessibility by public transport or bicycle to lower the amount of traffic. The mixed social infrastructure concept prioritizes efficient land-use, shorter travel distances and increased use of public transport. For this reason planners shall connect the social infrastructure planning concept with the public transport system as well as with walking and cycling networks (Pahl-Weber et al., 2013).

Prioritizing walking, cycling for short distance access

A prioritization of low-impact transport modes connected to the social infrastructure locations focuses on planning measures that consider the needs of pedestrians, cyclists, and public transport first, and then those of car users. The planner shall first create an optimal network for pedestrians and cyclist and then adds facilities for additional modes of transport without negatively influencing the non-motorized. For example a pedestrian crossing is more important than a car parking place and that the street should be designed for safety and not for average capacities of motorized traffic (ibid.).

Stimulating the use of public transportation with efficient connections to the social infrastructures

An approach that supports the use of public transport should be prioritized over those characteristics that are usually considered as the strengths of individual motorization. This means that public transport services should have shorter access and departure times than the walking time between car and place of destination/origin. In the context of social infrastructures, the acceptable distance to access public transport should not exceed six minutes walking time (i.e. according to German standards). Inside the neighbourhoods, other concepts such as stop on demand could be an efficient solution. Here, the system may consist of different categories. Small services, like mini-buses, can function as a “feeder” to higher capacity systems such as city-bus, light-rail, or metro as a means for inter-district connection. Such combination of services reduces the number of stops for high capacity services and, hence, the commuting time. It is also essential to assure inter-modality between the different transportation systems, for instance through the creation of Bike & Ride or Park & Ride facilities. To improve the attractiveness of public transport, promotional marketing and barrier-free access to information on the services needs to be provided (i.e. through local media and online means, by providing informational brochures and test tickets for public transport in combination with assistance) (Ibid.).

Enhancing safety in access network – especially for networks connecting the social infrastructures at the neighbourhood level

Transport safety is an important issue, especially if it is related to a strategy that prioritizes walking and cycling. In all transport systems, pedestrians and cyclists are the weakest traffic participants. The level of traffic safety ought thus to be prioritized for cyclists and pedestrians. This measure is of utmost importance when it comes to access network to neighboud level social infrastructures such as primary schools. Here, the following requirements are fundamental: lines of sight are kept free, there are a sufficient number of crossings, walking phases at crossings cater to the slowest participant, the speed of motorized vehicles is reduced inside neighbourhoods, and bicycle lanes are separated from motorized traffic (Ibid.).

Removing barriers in accessibility (barrier free access possibilities to social infrastructures)

For people who do not depend on motorized vehicles, the planner has to meet several requirements: steep inclinations are minimized (less than 12 %), streets are kept free of waste, sidewalks and crossings are equipped with a guiding system such as traffic lights with a noise signal system. High curbs and pedestrian bridges are obstacles for people with disabilities and need to be changed to provide barrier-free access. Because of District 22's topography, there needs to be special designations for maximum road and path inclinations. To guarantee unimpeded access for disabled people as well as service, rescue, and delivery vehicles, the maximum inclination of access roads has to be limited to 5 % in access network to social infrastructure (Ibid.).

4.4.1 An integrated planning checklist

As one of the main outputs of this research and with the aim of providing a comprehensive guidance for integrating energy related measures into urban planning practices, a detailed checklist is developed (Table 39). The checklist integrates the results from consultations with experts and are derived from theoretical knowledge as well as global experiences. It supports local expert and authorities for integrating energy efficiency and design measures in the process of planning and implementation of social infrastructure.

The checklist comprises of a comprehensive list of the spatial planning and design measures, which are influential on energy consumption level of the built environment (as well as social infrastructures). It also illustrates the implication level of each measure, namely; building and urban scale[70]. Types of development plans and their scale is another demonstration in the checklist. It specifies, which types of design measures are influential in which scale (i.e. from comprehensive planning to architectural design) and through which types of instrument (i.e. strategic measures, regulations, plans, design code or detailed architectural plans).

[70] Obviously several of the measures are applicable in both levels.

Table 39. Energy efficiency and design measures checklist for social infrastructures

Sector	Energy efficiency and design measures	Implication scale		Urban development plans/instruments				Legal controlling body/system
		Building	Urban structure	Comprehensive/Strategic plan (1:10000)	Detailed plan (1:2000)	Urban design (1:500)	Architecture (1:50)	
Building sector	Density and compactness configurations	×	×	S/R*	R/UP	DC/UP	R/AP	Municipality as the main controlling body
	Building volume (i.e. surface to volume ratio)	×	×	-	R/UP	DC/UP	R/AP	
	Building typology (Length of the building body, Depth of the building, Number of floors, Roof shape / roof pitch)	×	×	S/R	R/UP	DC/UP	R/AP	
	Surface design and materials	×	×	-	R	DC/UP	R/AP	
	Architectural design (i.e. floor plans & openings)	×		-	-	-	R/AP	
	Vegetation coverage and configuration (i.e. for shadowing purposes)	×	×	-	R	DC/UP	R/AP	
	Utilizing the topographical conditions (i.e. south facing slopes)	×	×	S	R/UP	DC/UP	R/AP	
	Building and block orientation to regulate passive wind utilization	×	×	S/R	R/UP	DC/UP	R/AP	
	Building and block orientation to regulate passive solar utilization	×	×	S/R	R/UP	DC/UP	R/AP	
	Street network orientation and dimension to regulate passive solar and wind utilization		×	S/R	R/UP	DC/UP	-	
	Configuration of urban blocks and building arrangements	×	×	S/R	R/UP	DC/UP	R/AP	
	Mass & space configuration & positioning	×	×	-	R	DC/UP	R/AP	
	Renewables, technologies and external devices	×	×	S/R	R	DC	R/AP	
Transport sector	Urban development pattern (synergies among densities, street layout & land uses)		×	S/R	R/UP	DC/UP	-	
	Integrated land use concept (allocation and coordination with the transport system)		×	S/R	R/UP	DC/UP	-	
	Vertical & horizontal mixed use concepts	×	×	S/R	R/UP	DC/UP	R/AP	
	Providing safe, attractive and affordable public transport		×	S/R	R/UP	DC/UP	-	
	Optimized accessibility of non-motorized transport mode (i.e. cycling and walking) i.e. through Barrier free access (steep inclinations, equipped sidewalks, obstacle free access for disables etc.)		×	S/R	R/UP	DC/UP	-	
Improving users behaviour and culture		×	×	Training programmes/Promotional measures				

*** Strategy measures (S), Regulatory measures (R), Urban Plans (UP), Design Code (DC), Architectural Plan (AP).**

Source. Khodabakhsh, 2017

Electronic service delivery

Similar to spatial planning energy measures discussed above, there should be an integrated set of measures for the development of electronic services. These measures can be classified along the following categories:

- Infrastructure dimension (enhancing infrastructure readiness)
- Organizational dimension (enhancing organizational readiness)
- Services and system dimension (enhancing services and system readiness)

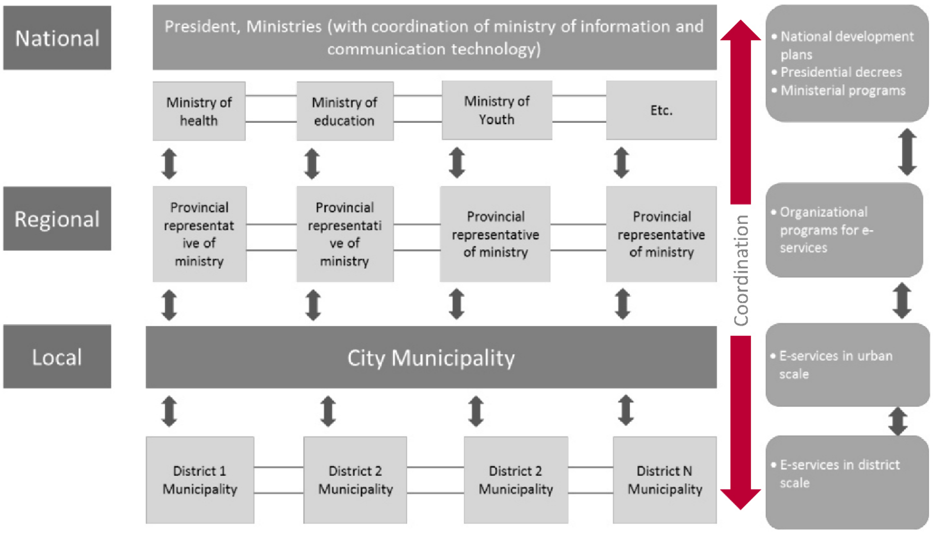
There are different shortcomings in each of the above mentioned dimensions in the local context. However, one fundamental shortcoming is related to digital competences and level of awareness. Combining research on digital divide and electronic service delivery in the public sector has the potential to create new insights relevant for environmental achievements (Helbig et al, 2009). Analysing the digital divide yields detailed information on which groups of society are not capable of using information technology or the Internet and thus are unlikely to use e-services in the public sector either. We argued that not every resident is able to use information technology and the Internet is necessarily capable of using (transactional) e-services from public institutions.

Besides bare access, proficient use of internet technology requires "technical competencies", i.e. "skills needed to operate hardware and software, such as typing" (Mossberger et al, 2003). Mossberger et al. name "information literacy" as an important dimension: "Information literacy is the ability to recognize when information can solve a problem or fill a need and to effectively employ information resources" (Ibid.).

In addition to the promotion of general information literacy among users, e-services themselves need to assure user-friendliness as well (Becker et al, 2008): “If a potential user is unable to directly complete an online-form of a public e-service, e.g. due to difficult or ambiguous technical terms, the user does not benefit from the public e-services, since s/he simply does not conceive the content. Hence, without any further online assistance, he is denied to access to the information (i.e. to the respective public e-service)” (Becker et al, 2008). Overall, the potential user group for public e-services consists of all residents (a) having access to the Internet (i.e. no digital access divide), who (b) possess technical and informational capability to using the Internet (i.e. no digital capability divide) and (c) have the skills related to the public sector domain (Barth & Daniel, 2011).

Furthermore, against the background of the analysis carried out in this study, there is a need for more efficient and coordinated procedures among different influential actors on different levels. A bottom up approach is vital for the successful provision of e-services, especially in the local context. In addition, there should be a central information point in place coordinating all sectoral service providers. As municipalities are the main steering authority on the local level, they are well suited to fulfil the role of a coordinator and central information point. Figure 92 shows the proposed conceptual model depicting the main actors and their interactions in the planning and provision of e-services.

Figure 92. Schematic concept for electronic services - actors, instruments and interactions

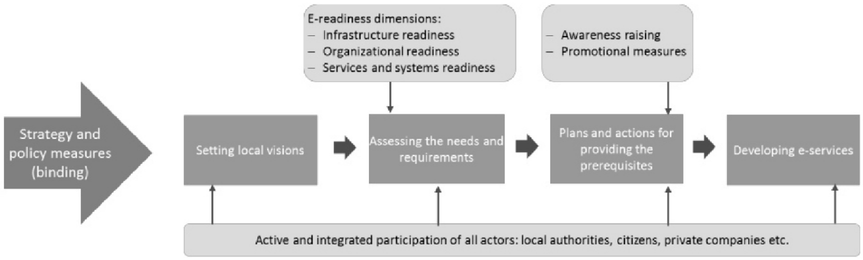


Source. Khodabakhsh, 2017 (based on energy efficient social infrastructure planning and provision interviews – Annex 1)

In order to enhance the development of e-services, an integrated approach is required which brings together all required dimensions (namely: reliable infrastructure, digital content, user's skills, e-services design).

It also requires active participation of the relevant actors as well as adequate legal frameworks and political commitment to support an integrated transformation process. Intensive capacity building and awareness raising programs for all actors (e.g. citizens, private companies, local authorities, governments, etc.) are yet another crucial requirement for successful transformation. Figure 93 models the main stages of the planning and preparation of e-services is the local context.

Figure 93. Proposed model for planning and provision of local e-services



Source. Khodabakhsh, 2017 (based on energy efficient social infrastructure planning and provision interviews – Annex 1)

Content matters as well. Table 40 below lists potential e-services content for different types of social infrastructure as a guide post for practitioners and scholarly case studies alike. The table is provided in accordance to a comprehensive survey on exiting online services from different cities. It demonstrates examples about online procedures /services for each category of social infrastructures and in different provision phases. This includes:

- Information provision phase: i.e. general information about the availability of services such as locational information as well as regulations, programs, opening times etc.
- Administrative procedure phase: i.e. application processes, payments and book-ings as well as admission and reservation.
- Core service delivery phase: this comprises of examples about the core services such as e-learning course, tele-medicine services, e-libraries etc.

Table 40. Examples of electronic delivery of social infrastructures

Social Infrastructure	E-services provision phases: Information provision phase	Administrative procedure phase	Core service delivery phase

Health services	• Overview on the health care system
	  ○ Public hospitals and institutions (Links, Contacts, Locations & addresses)
	• Private hospitals and institutions
	• Fees and charges for health care services
	• Insurance system and institutions
	• Pharmacies (Links, Contacts, Locations & addresses)
	• Child care centres (Links, Contacts, Locations & addresses)
	• Links/contacts to ministries and other city wide, national and international organizations
	• Transport links
		• Insurance provision process
		• Payment and bookings
		• Primary care directory
		  ○ Family doctor
		  ○ Appointments
		  ○ Registration
		  ○ Reservation
		  ○ Online prescriptions
		• Apply for help at home
			• Online monitoring system
			• Tele Health
			• Social work services
			• Electronic medical records

Education services × **Pre-primary** × **Primary** × **Secondary** × **Post-secondary** × **Special other education services**	• Overview on the education system • Public educational centres (Links, Contacts, Locations & addresses) • Private educational centres (Links, Contacts, Locations & addresses) • Fees and financial assistance • Links/contacts to ministries and other city wide, national and international organizations • Transport links	• Choice of an appropriate school/educational centre • Admission & reservations (required documents) • Payments • Certificates	• Out of school learning • Educational sources • Examinations and assessments • Monitoring the performance • Internet learning (e-learning) • Further studies and career guidance
Culture – **Recreation and sport**	• Leisure facilities (Links, contacts, locations and addresses) – i.e. Leisure activities, Swimming pools, Parks, Major sport events, Sport organizations, Sport clubs and spaces	• Leisure activities booking services • Payments • Reservation	-

	• Links/contacts to ministries and other city wide, national and international organizations • Transport links		
Libraries	• Overview on the libraries system • Libraries information (Links, Contacts, Locations & addresses) • Links/contacts to ministries and other city wide, national and international organizations • Transport links	• Application for libraries card • Payments • Reservation	• Online library services ○ Searching sources ○ Renewing sources ○ Online e-sources
Culture & art	• Art venues and opening times • Cultural programs • Links/contacts to ministries and other city wide, national and international organizations • Transport links	• Application and booking • Payments	-
Museums	• Exhibition info (Links, Contacts, Locations & addresses) • Links/contacts to ministries and other city wide, national and international organizations • Transport links	• Tickets and booking Payments	-
Community halls and centres	• Centre info (Links, Contacts, Locations & addresses) • Links/contacts to ministries and other city wide, national and international organizations • Transport links	• Application and booking	• Online programs
Administration	• Regulations on administration services • Standards • Procedures on administration services • Contacts, location and addresses • Organization of city administration • Information and application forms • Decisions, news and meetings results	• Appointments with corresponding members • Online applications and inquiries • Payments	• Buildings permits & tax payment • Elections/voting • Electronic communication with the administration • Address registration and change, report police • Driving license, ID card and passport, vehicle registration

Source. Khodabakhsh, 2017 adopted from good e-services examples (Wien[71], Aberdeen[72], Hong Kong[73], Stockholm[74], Dubai: Government Website Excellence Model[75], Web Content Accessibility Guideline[76], T-City Friedrichshafen[77] (Hatzelhoffer, 2012))

[71] Wien city portal. (n.d.). Retrieved January 10, 2018, from https://www.wien.gv.at/english/
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APPENDICES

Annexes

Annex 1. Energy efficiency questionnaire for experts

Annex 2. Electronic services planning and provision questionnaire for experts

Annex 3. Spatial analysis maps of District 22 – Tehran

Annex 4. Reviewed publications, books, conferences and presentations

Annex 1. Energy efficiency questionaire for experts

PhD Questionnaire

PHD RESEARCH QUESTIONNAIRE

پرسشنامه تحقیق دکترا

Researcher: Peyman Khodabakhsh — محقق: پیمان خدابخش

Field of study: Urban and Regional Planning — رشته تحصیلی: برنامه ریزی شهری و منطقه ای

Thesis: Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency (Based on Smart City Approach Principles).

موضوع تحقیق: بررسی و ارزیابی تاثیر برنامه ریزی زیرساخت های اجتماعی بر کاهش مصرف انرژی شهری (با رویکرد شهر هوشمند)

Name نام :	Organization سازمان:
Affiliation مسئولیت در سازمان:	Email پست الکترونیک:
	Telephone تلفن:

***Rationale:** urban planning consulting engineers are one of the most influential actors in the planning process in Iran as well as the district 22, as they provide local governments with short, medium and long term development plans and consultancy.*

Questionnaire for Experts concerning energy efficiency for planning and implementation of social infrastructure

پرسشنامه متخصصین برنامه ریزی و طراحی شهری – کارایی انرژی و برنامه ریزی زیرساخت های اجتماعی/خدمات شهری

1. Social Infrastructure planning and provision

برنامه ریزی و فراهم آوری زیرساخت های اجتماعی/خدمات شهری

1.1. How important is the topic of social infrastructure for an urban area?

موضوع زیرساخت های اجتماعی/خدمات شهری دارای چه میزان اهمیت در برنامه ریزی مناطق شهری می باشد؟

Researcher: Peyman Khodabakhsh
Summer 2015

PhD Questionnaire

1.2. What are the main social infrastructure in planning urban areas from your point of view?

کدامیک از زیرساخت های اجتماعی/خدمات شهری در لیست زیر دارای اهمیت بیشتری در برنامه ریزی طرح های توسعه شهری می باشند؟

Service category		Yes/No بلی/خیر	Explanation توضیحات
Health services خدمات درمانی و بهداشتی	Hospital and Clinics in different levels بیمارستان ها و کلینیک های درمانی در سطوح مختلف		
	Sub Centers سایر خدمات مربوطه		
Education Services خدمات آموزشی	Kindergartens and hords مهدکودک		
	Schools مدارس		
	Higher education آموزش عالی		
	Research Institutions مراکز تحقیقاتی		
Cultural and Recreation Services خدمات فرهنگی و تفریحی	Libraries, theaters, museums کتابخانه، تئاتر، موزه و ...		
	Sport (indoor and outdoor) & recreation مراکز ورزشی و تفریحی		
	Community Centers مراکز اجتماعی		
Administrative and security خدمات اداری و امنیتی/ایمنی	public administration امور اداری عمومی		
	Police services خدمات پلیس		
	disaster management (i.e. Fire stations خدمات مدیریت بحران		
	Ambulance services آمبولانس		

1.3. What is basically the best approach for planning social infrastructure from your point of view?

رویکرد شما در برنامه ریزی زیرساخت های اجتماعی/خدمات شهری در تهیه طرح های توسعه شهری به چه صورت می باشد؟

Approach رویکرد	Yes/No بلی/خیر	Explanation توضیحات
General comprehensive planning رویکرد برنامه ریزی جامع و عمومی	Yes بلی ☐ No خیر ☐	
Strategic planning رویکرد برنامه ریزی راهبردی	Yes بلی ☐ No خیر ☐	
New innovative approach (Including new criteria, methods and processes) بکارگیری رویکردهای خلاقانه و نوین (درزمینه معیارهای برنامه ریزی، روش ها و فرآیندهای برنامه ریزی و ...)	Yes بلی ☐ No خیر ☐	

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1.4. What are the main criteria to be applied in planning for social infrastructure in development plans?

برخی از معیارهای مورد استفاده در برنامه ریزی زیرساخت های اجتماعی در تهیه طرح های توسعه شهری را نام ببرید؟

	Criteria معیارها	Description توضیحات
1		
2		
3		
4		
5		
6		

2. Position of Energy Efficiency in spatial planning

جایگاه کارایی انرژی در برنامه ریزی فضایی

2.1. How important is the topic of Energy Efficiency in urban planning from your point of view?

به چه میزان بحث کارایی انرژی در برنامه ریزی فضایی دارای اهمیت می باشد؟

Very Important بسیار با اهمیت ☐ Important دارای اهمیت ☐ No Importance بدون اهمیت ☐ Not relevant بی ارتباط ☐ No Idea بدون نظر ☐

2.2. Do you believe that energy efficiency can be achieved through appropriate planning as well?

آیا شما به امکان کاهش مصرف انرژی از طریق برنامه ریزی فضایی اعتقاد دارید؟

Yes بلی ☐ No خیر ☐

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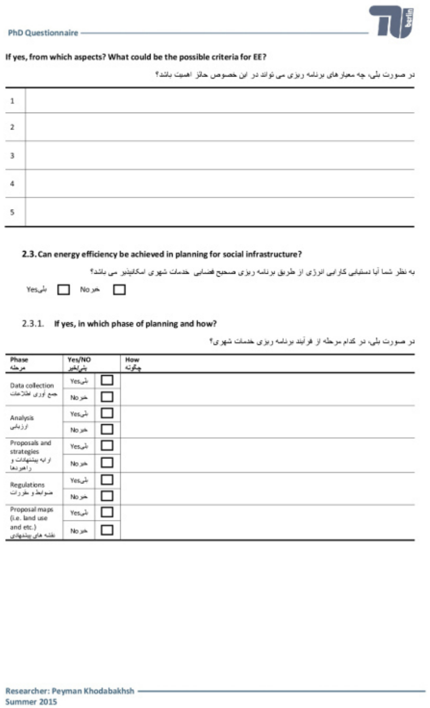

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If yes, from which aspects? What could be the possible criteria for EE?

در صورت بلی، چه معیار های برنامه ریزی می تواند در این خصوص حائز اهمیت باشد؟

1	
2	
3	
4	
5	

2.3. Can energy efficiency be achieved in planning for social infrastructure?

به نظر شما آیا دستیابی کارایی انرژی از طریق برنامه ریزی صحیح فضایی خدمات شهری امکانپذیر می باشد؟

Yesبلی ☐ Noخیر ☐

2.3.1. **If yes, in which phase of planning and how?**

در صورت بلی، در کدام مرحله از فرآیند برنامه ریزی خدمات شهری؟

Phase مرحله	Yes/NO بلی/خیر		How چگونه
Data collection جمع آوری اطلاعات	Yesبلی	☐	
	Noخیر	☐	
Analysis ارزیابی	Yesبلی	☐	
	Noخیر	☐	
Proposals and strategies ارایه پیشنهادات و راهبردها	Yesبلی	☐	
	Noخیر	☐	
Regulations ضوابط و مقررات	Yesبلی	☐	
	Noخیر	☐	
Proposal maps (i.e. land use and etc.) نقشه های پیشنهادی	Yesبلی	☐	
	Noخیر	☐	

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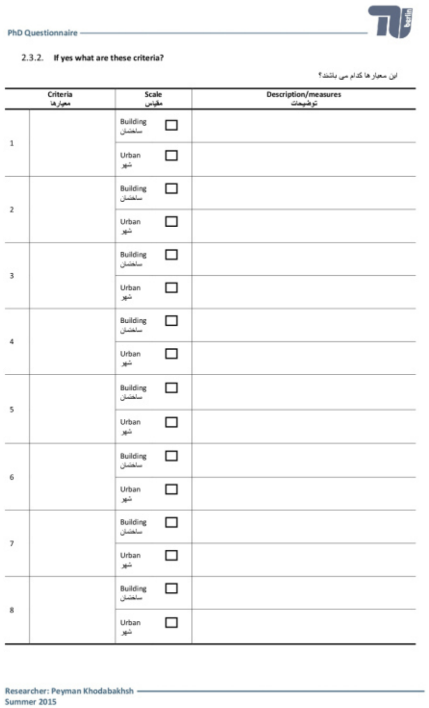

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2.3.2. **If yes what are these criteria?**

این معیار ها کدام می باشند؟

Criteria معیارها		Scale مقیاس		Description/measures توضیحات
1		Building ساختمان	☐	
		Urban شهر	☐	
2		Building ساختمان	☐	
		Urban شهر	☐	
3		Building ساختمان	☐	
		Urban شهر	☐	
4		Building ساختمان	☐	
		Urban شهر	☐	
5		Building ساختمان	☐	
		Urban شهر	☐	
6		Building ساختمان	☐	
		Urban شهر	☐	
7		Building ساختمان	☐	
		Urban شهر	☐	
8		Building ساختمان	☐	
		Urban شهر	☐	

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3. Energy efficiency criteria and social infrastructure

معیارهای کارایی انرژی و برنامه ریزی زیرساختهای اجتماعی/خدمات شهری

3.1. Which of the following criteria can be considered in planning/proposal for social infrastructure in an urban district?

کدامیک از معیارهای زیر را می توان در فرآیند برنامه ریزی شهری با تاکید بر برنامه ریزی خدمات شهری استفاده نمود؟

Field of action حیطه مداخله	Criteria معیار	Sub-criteria زیر معیار	Through which measures از طریق کدامیک از ابزارهای زیر			
Urban planning & design برنامه ریزی و طراحی شهری	Compact structure and layout of the building ساختار فشرده و متراکم کالبد شهری	Optimization of the A(area)/V(Volume)e ratio, بهینه سازی ضریب سطح به حجم ساختمان و بلوک های شهری	Strategy استراتژی	Regulation ضوابط	Map نقشه	Other سایر
		Compressed design / building typology (Length of the building body, Depth of the building, Number of floors, Roof shape / roof pitch) طراحی فشرده/ گونه های ساختمانی (طول ساختمان، عمق ساختمان، تعداد طبقات و ...)	Strategy استراتژی	Regulation ضوابط	Map نقشه	Other سایر
		Shadowing considerations ملاحظات سایه اندازی	Strategy استراتژی	Regulation ضوابط	Map نقشه	Other سایر
	Topography توپوگرافی	Utilizing the topographical conditions to minimize the thermal energy consumption بکارگیری ملاحظات توپوگرافی و شیب	Strategy استراتژی	Regulation ضوابط	Map نقشه	Other سایر
		Wind consideration ملاحظات مربوط به باد	Strategy استراتژی	Regulation ضوابط	Map نقشه	Other سایر
	Passive use of solar energy استفاده از انرژی خورشیدی	Building and access orientation جهت گیری ساختمان، بلوک های شهری و شبکه دسترسی	Strategy استراتژی	Regulation ضوابط	Map نقشه	Other سایر
Transport حمل و نقل	Avoiding traffic جلوگیری از تولید ترافیک و سفر	Vertical mixed use اختلاط عمودی کاربری ها	Strategy استراتژی	Regulation ضوابط	Map نقشه	Other سایر
		Horizontal mixed use اختلاط افقی کاربری ها	Strategy استراتژی	Regulation ضوابط	Map نقشه	Other سایر
		Distances to facilities (catchments) فاصله به خدمات (دسترسی)	Strategy استراتژی	Regulation ضوابط	Map نقشه	Other سایر
	Expansion of public transport, walking and cycling توسعه حمل و نقل عمومی، پیاده و دوچرخه	Prioritizing public transport in road space اولویت بخشی به حمل و نقل عمومی و غیر سواره در شبکه دسترسی	Strategy استراتژی	Regulation ضوابط	Map نقشه	Other سایر
		Strengthening of cycling and walking تقویت دوچرخه و پیاده	Strategy استراتژی	Regulation ضوابط	Map نقشه	Other سایر

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4. Promotion measures

معیارهای تشویقی

4.1. Have you experienced/are you familiar with any promotional (i.e. building certificate, guidelines or etc.) measures for enhancing the energy in urban development plans?

آیا تا کنون از هیچ یک از معیارهای تشویقی کارایی انرژی (برای مثال: گواهی نامه انرژی ساختمان، بلوک های شهری، دستورالعمل، راهنمای برنامه ریزی کارایی انرژی و ...) در برنامه ریزی طرح های توسعه شهری استفاده نموده اید؟

1	
2	
3	
4	
5	

5. Proposes

پیشنهادات

5.1. What are your proposes regarding the integration of energy efficiency topics in urban development plans like district 22?

پیشنهادات شما در خصوص ادغام و بکارگیری معیارهای مربوط به کارایی انرژی در فرایند تهیه طرح های توسعه شهری (برای مثال در منطقه 22 تهران چیست)؟

a) **Which scales?**مقیاس مداخله

b) **Through which instruments and which kind of development plans?**
(از طریق چه ابزار و کدامیک از انواع طرح های توسعه شهری)

c) **In which part of development plans? (Maps, regulations or general strategies**

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		Urban Planning & design طراحی و برنامه ریزی شهری						Transportحمل و نقل			
		Compact structure, topography, climate ساختار فشرده و متراکم شهری، توپوگرافی، اقلیم محلی					Passive energy use استفاده پسیو از انرژی	Avoiding traffic اجتناب از ترافیک و تولید سفر		Public transport حمل و نقل عمومی و غیر سواره	
		Optimization of the A(area)/V(Volume)e ratio, بهینه سازی نسبت سطح به حجم ساختمان و بلوک های شهری	Compressed design / building typology (Length of the building body, Depth of the building, Number of floors, Roof shape / roof pitch) طراحی فشرده/ گونه های ساختمانی (طول ساختمان، عمق ساختمان، تعداد طبقات و ..)	Shadowing considerations ملاحظات سایه اندازی	Utilizing the topographical conditions to minimize the thermal energy consumption بکارگیری ملاحظات توپوگرافی و شیب	Wind consideration ملاحظات مربوط به باد	Building and access orientation جهت گیری ساختمان، بلوک های شهری و شبکه دسترسی	Mixed use اختلاط عمودی و افقی کاربری ها	Distances to facilities (catchments) فاصله به خدمات (دسترسی)	Prioritizing public transport in road space اولویت بخشی به حمل و نقل عمومی و غیر سواره در شبکه دسترسی	Strengthening of cycling and walking تقویت دوچرخه و پیاده
Which scale مقیاس	Building ساختمان										
	Urban structure ساختار شهری										
Which phase of planning process مرحله/فاز فرآیند برنامه ریزی	Visioning چشم انداز										
	Aiming اهداف										
	Status Quo مطالعات وضع موجود										
	Analysis ارزیابی و تحلیل										
	Strategies & proposals استراتژی و پیشنهادات										
development plan طرح های توسعه	Master plan طرح جامع										
	Detailed plan طرح تفصیلی										
	Urban design طراحی شهری										
	Architecture معماری										
Through which measure ابزار مداخله	Map نقشه										
	Regulation ضوابط و مقررات و راهنما										
	Strategy استراتژی										

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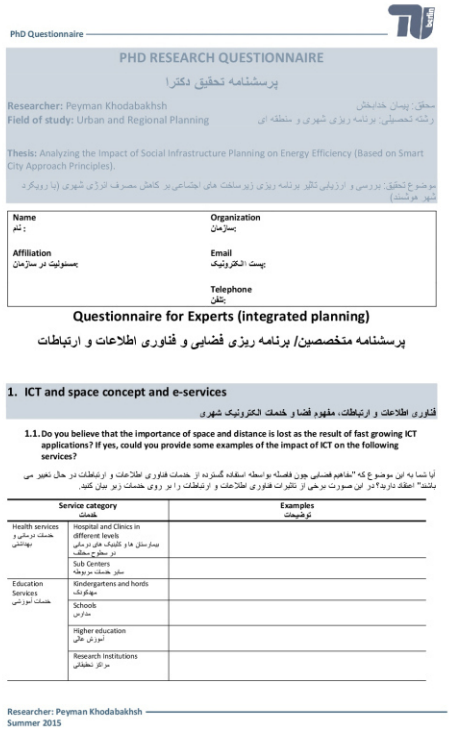
Annex 2. Electronic services planning and provision questionaire for experts



PhD Questionnaire

PHD RESEARCH QUESTIONNAIRE

پرسشنامه تحقیق دکترا

Researcher: Peyman Khodabakhsh — محقق: پیمان خدابخش

Field of study: Urban and Regional Planning — رشته تحصیلی: برنامه ریزی شهری و منطقه ای

Thesis: Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency (Based on Smart City Approach Principles).

موضوع تحقیق: بررسی و ارزیابی تاثیر برنامه ریزی زیرساخت های اجتماعی بر کاهش مصرف انرژی شهری (با رویکرد شهر هوشمند)

Name نام:	**Organization** سازمان:
Affiliation مسئولیت در سازمان:	**Email** پست الکترونیک:
	Telephone تلفن:

Questionnaire for Experts (integrated planning)

پرسشنامه متخصصین/ برنامه ریزی فضایی و فناوری اطلاعات و ارتباطات

1. ICT and space concept and e-services

فناوری اطلاعات و ارتباطات، مفهوم فضا و خدمات الکترونیک شهری

1.1. Do you believe that the importance of space and distance is lost as the result of fast growing ICT applications? If yes, could you provide some examples of the impact of ICT on the following services?

آیا شما به این موضوع که "مفاهیم فضایی چون فاصله بواسطه استفاده گسترده از خدمات فناوری اطلاعات و ارتباطات در حال تغییر می باشند" اعتقاد دارید؟ در این صورت برخی از تاثیرات فناوری اطلاعات و ارتباطات را بر روی خدمات زیر بیان کنید.

Service category خدمات		Examples توضیحات
Health services خدمات درمانی و بهداشتی	Hospital and Clinics in different levels بیمارستان ها و کلینیک های درمانی در سطوح مختلف	
	Sub Centers سایر خدمات مربوطه	
Education Services خدمات آموزشی	Kindergartens and hords مهدکودک	
	Schools مدارس	
	Higher education آموزش عالی	
	Research Institutions مراکز تحقیقاتی	

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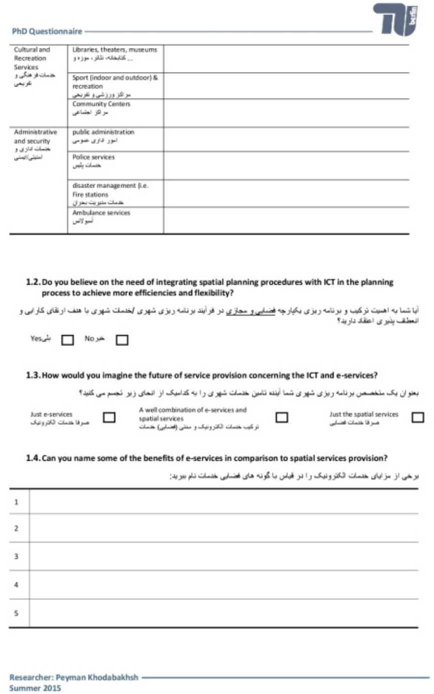

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Cultural and Recreation Services خدمات فرهنگی و تفریحی	Libraries, theaters, museums کتابخانه، تئاتر، موزه و ...	
	Sport (indoor and outdoor) & recreation مراکز ورزشی و تفریحی	
	Community Centers مراکز اجتماعی	
Administrative and security خدمات اداری و امنیتی/ایمنی	public administration امور اداری عمومی	
	Police services خدمات پلیس	
	disaster management (i.e. Fire stations خدمات مدیریت بحران	
	Ambulance services آمبولانس	

1.2. Do you believe on the need of integrating spatial planning procedures with ICT in the planning process to achieve more efficiencies and flexibility?

آیا شما به اهمیت ترکیب و برنامه ریزی یکپارچه فضایی و مجازی در فرآیند برنامه ریزی شهری /خدمات شهری با هدف ارتقای کارایی و انعطاف پذیری اعتقاد دارید؟

Yes بلی ☐ No خیر ☐

1.3. How would you imagine the future of service provision concerning the ICT and e-services?

بعنوان یک متخصص برنامه ریزی شهری شما آینده تامین خدمات شهری را به کدامیک از انحای زیر تجسم می کنید؟

Just e-services صرفا خدمات الکترونیک ☐ A well combination of e-services and spatial services ترکیب خدمات الکترونیک و سنتی (فضایی) خدمات ☐ Just the spatial services صرفا خدمات فضایی ☐

1.4. Can you name some of the benefits of e-services in comparison to spatial services provision?

برخی از مزایای خدمات الکترونیک را در قیاس با گونه های فضایی خدمات نام ببرید:

1	
2	
3	
4	
5	

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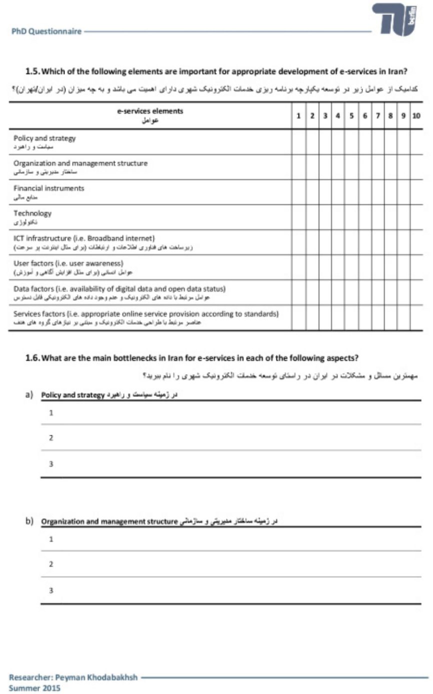

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1.5. Which of the following elements are important for appropriate development of e-services in Iran?

کدامیک از عوامل زیر در توسعه یکپارچه برنامه ریزی خدمات الکترونیک شهری دارای اهمیت می باشد و به چه میزان (در ایران/تهران)؟

e-services elements عوامل	1	2	3	4	5	6	7	8	9	10
Policy and strategy سیاست و راهبرد										
Organization and management structure ساختار مدیریتی و سازمانی										
Financial instruments منابع مالی										
Technology تکنولوژی										
ICT infrastructure (i.e. Broadband internet) زیرساخت های فناوری اطلاعات و ارتباطات (برای مثال اینترنت پر سرعت)										
User factors (i.e. user awareness) عوامل انسانی (برای مثال افزایش آگاهی و آموزش)										
Data factors (i.e. availability of digital data and open data status) عوامل مرتبط با داده های الکترونیک و عدم وجود داده های الکترونیکی قابل دسترس										
Services factors (i.e. appropriate online service provision according to standards) عناصر مرتبط با طراحی خدمات الکترونیک و مبتنی بر نیازهای گروه های هدف										

1.6. What are the main bottlenecks in Iran for e-services in each of the following aspects?

مهمترین مسائل و مشکلات در ایران در راستای توسعه خدمات الکترونیک شهری را نام ببرید؟

a) **Policy and strategy** در زمینه سیاست و راهبرد

1

2

3

b) **Organization and management structure** در زمینه ساختار مدیریتی و سازمانی

1

2

3

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c) Financial instruments در زمینه منابع مالی

1

2

3

d) Technology در زمینه تکنولوژی

1

2

3

e) ICT infrastructure (i.e. Broadband internet)(در زمینه زیرساخت های فناوری اطلاعات و ارتباطات (برای مثال اینترنت پر سرعت

1

2

3

f) User factors (i.e. user awareness)(در زمینه عوامل انسانی (برای مثال افزایش آگاهی و آموزش

1

2

3

g) Data factors (i.e. availability of digital data and open data status)
در زمینه عوامل مرتبط با داده های الکترونیک و عدم وجود داده های الکترونیکی قابل دسترس

1

2

3

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h) Services factors (i.e. appropriate online service provision according to standards)
در زمینه عناصر مرتبط با طراحی خدمات الکترونیک و مبتنی بر نیازهای گروه های هدف

1

2

3

1.7. Which organization do see the most suitable to provide e-services in the frame of one stop shop approach?

کدامیک از نهادهای زیر بعنوان مناسبترین نهاد ارائه کننده کلیه خدمات الکترونیک شهری در قالب یک درگاه اطلاعاتی واحد می باشد؟

Municipality (A new department in municipality in coordination with all service providers) شهرداری (تاسیس واحد جدید در شهرداری در هماهنگی با تمامی ارگان های برنامه ریز و تامین کننده خدمات شهری)	☐
A new integrated organization on behalf of all urban service providers and municipalities نهادی جدید (به نمایندگی از شهرداری و تمامی ارگان های برنامه ریز و تامین کننده خدمات شهری)	☐
No need for one stop shop approach عدم نیاز به تامین یکپارچه خدمات الکترونیک شهری از یک درگاه واحد	☐

1.1. Which of the following services & sub-services can be developed online?

با فرض فراهم بودن تمامی پیش نیازهای فنی و انسانی، کدامیک از خدمات زیر قابلیت ارائه بصورت الکترونیک را دارند؟

Service category خدمات		Phase of service مرحله تامین خدمات	Orientations and potentials رویکرد تامین خدمات Fully FtF کاملا فیزیکی 1	2	3	4	Fully e کاملا الکترونیک 5
Health services خدمات درمانی و بهداشتی	Hospital and Clinics in different levels بیمارستان ها و کلینیک های درمانی در سطوح مختلف	Informative Phase* ارائه اطلاعات در خصوص خدمات					
		Administrative Phase** انجام امور اداری و پرداختی قبل از خدمات					
		Core phase*** دریافت خدمات بصورت الکترونیک					
	Sub Centers سایر خدمات مربوطه	Informative Phase* ارائه اطلاعات در خصوص خدمات					
		Administrative Phase** انجام امور اداری و پرداختی قبل از خدمات					
		Core phase*** دریافت خدمات بصورت الکترونیک					
Education Services خدمات آموزشی	Kindergartens and hords مهدکودک	Informative Phase* ارائه اطلاعات در خصوص خدمات					
		Administrative Phase** انجام امور اداری و پرداختی قبل از خدمات					
		Core phase*** دریافت خدمات بصورت الکترونیک					
	Schools مدارس	Informative Phase* ارائه اطلاعات در خصوص خدمات					
		Administrative Phase** انجام امور اداری و پرداختی قبل از خدمات					
		Core phase*** دریافت خدمات بصورت الکترونیک					
	Higher education آموزش عالی	Informative Phase* ارائه اطلاعات در خصوص خدمات					
		Administrative Phase**					

Researcher: Peyman Khodabakhsh
Summer 2015

PhD Questionnaire

		انجام امور اداری و پرداختی قبل از خدمات	
		Core phase*** دریافت خدمات بصورت الکترونیک	
	Research Institutions مراکز تحقیقاتی	Informative Phase* ارائه اطلاعات در خصوص خدمات	
		Administrative Phase** انجام امور اداری و پرداختی قبل از خدمات	
		Core phase*** دریافت خدمات بصورت الکترونیک	
Cultural and Recreation Services خدمات فرهنگی و تفریحی	Libraries, theaters, museums کتابخانه، تئاتر، موزه و...	Informative Phase* ارائه اطلاعات در خصوص خدمات	
		Administrative Phase** انجام امور اداری و پرداختی قبل از خدمات	
		Core phase*** دریافت خدمات بصورت الکترونیک	
	Sport (indoor and outdoor) & recreation مراکز ورزشی و تفریحی	Informative Phase* ارائه اطلاعات در خصوص خدمات	
		Administrative Phase** انجام امور اداری و پرداختی قبل از خدمات	
		Core phase*** دریافت خدمات بصورت الکترونیک	
	Community Centers مراکز اجتماعی	Informative Phase* ارائه اطلاعات در خصوص خدمات	
		Administrative Phase** انجام امور اداری و پرداختی قبل از خدمات	
		Core phase*** دریافت خدمات بصورت الکترونیک	
Administrative and security خدمات اداری و امنیتی/ایمنی	public administration امور اداری عمومی	Informative Phase* ارائه اطلاعات در خصوص خدمات	
		Administrative Phase** انجام امور اداری و پرداختی قبل از خدمات	
		Core phase*** دریافت خدمات بصورت الکترونیک	
	Police services خدمات پلیس	Informative Phase* ارائه اطلاعات در خصوص خدمات	
		Administrative Phase** انجام امور اداری و پرداختی قبل از خدمات	
		Core phase*** دریافت خدمات بصورت الکترونیک	
	disaster management (i.e. Fire stations خدمات مدیریت بحران	Informative Phase* ارائه اطلاعات در خصوص خدمات	
		Administrative Phase** انجام امور اداری و پرداختی قبل از خدمات	
		Core phase*** دریافت خدمات بصورت الکترونیک	
	Ambulance services آمبولانس	Informative Phase* ارائه اطلاعات در خصوص خدمات	
		Administrative Phase** انجام امور اداری و پرداختی قبل از خدمات	
		Core phase*** دریافت خدمات بصورت الکترونیک	

* Information Phase: means just provision of online information about the service (i.e. location, opening hours, required documents and etc.)
مرحله ارائه اطلاعات صرفا شامل اطلاعات آنلاین در خصوص خدمات می باشد (برای مثال: مکان خدمات، ساعات بازگشایی، اطلاعات و اسناد مورد نیاز و ...)

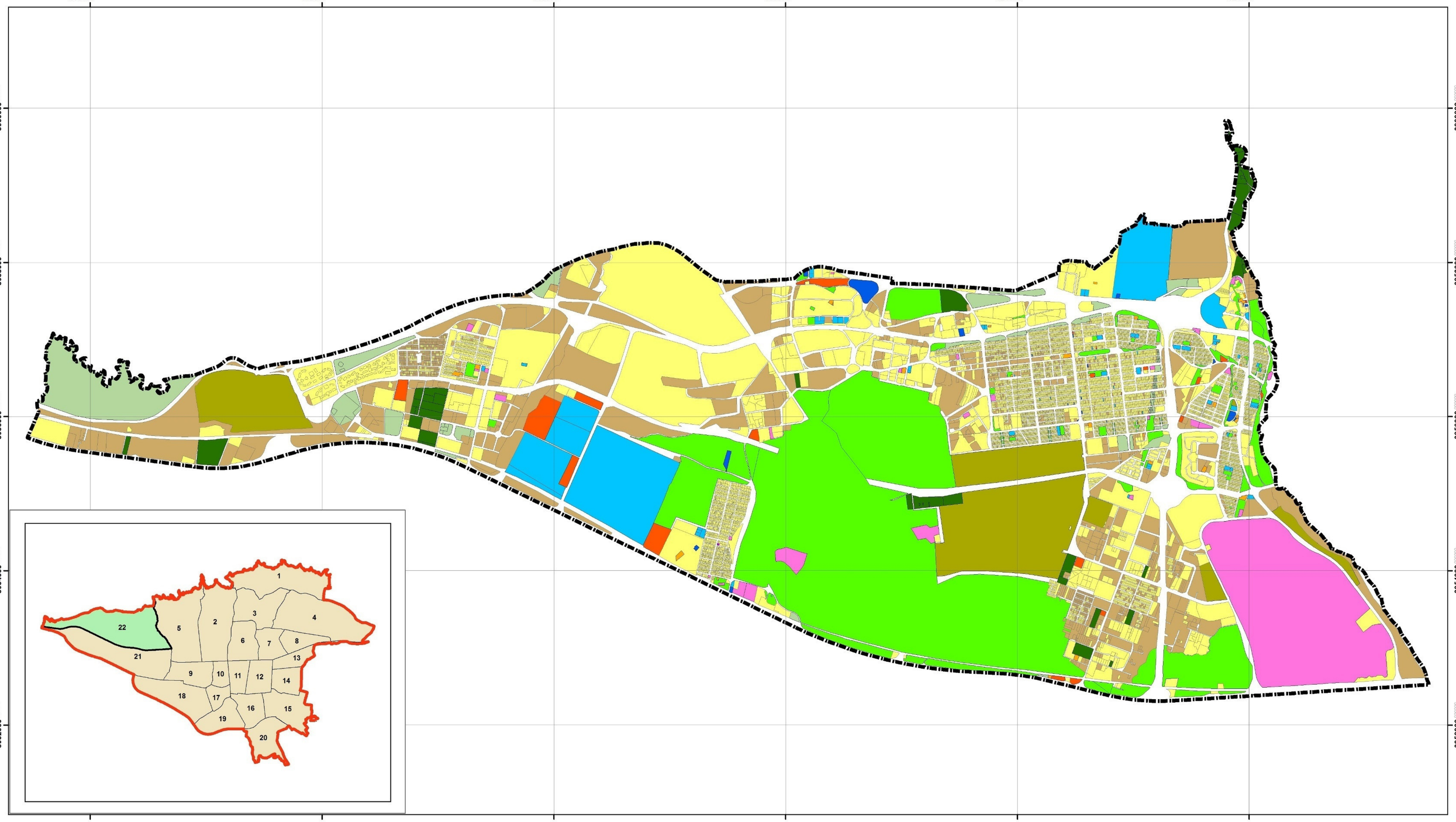
** Administration Phase: means one step further in e-services provision. This include the online formulas, reservation possibilities, payments and etc.
مرحله انجام امور اداری و پرداختی قبل از دریافت خدمات اصلی: شامل فرم های الکترونیک ثبت نام و درخواست، رزرواسیون، پرداخت و...

*** Core phase: this means the full provision of service such as e-learning, e-health (note. This might not fit for all services)
مرحله دریافت خدمات الکترونیک اصلی: شامل آموزش الکترونیک، درمان الکترونیک و .. (این مرحله برای تمامی خدمات صادق نمی باشد)

Researcher: Peyman Khodabakhsh
Summer 2015

Annex 3. Spatial analysis maps of District 22 – Tehran

- Map 1. Location of existing social infrastructure
- Map 2. Social infrastructures mass and space configuration
- Map 3. District 22 topography and location of social infrastructure
- Map 4. Primary education services catchment area analysis
- Map 5. Secondary education (Guidance school) services catchment area analysis
- Map 6. Secondary education (High school) services catchment area analysis
- Map 7. Sub district level health services catchment area analysis
- Map 8. District level health services catchment area analysis
- Map 9. Neighbourhood level cultural and religious services catchment area analysis
- Map 10. District level cultural and religious services catchment area analysis
- Map 11. Neighbourhood level sport & recreation services catchment area analysis
- Map 12. District level sport & recreation services catchment area analysis
- Map 13. Neighbourhood level green spaces services catchment area analysis
- Map 14. District level green spaces services catchment area analysis
- Map 15. District level administrative services catchment area analysis



PhD Thesis:

Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency

Title:

Location of existing Social Infrastructures in District 22

Researcher: Peyman Khodabakhsh

Developer: Khodabakhsh, P; Nouri, A

Map No. 1

Date: Dec. 2017

Technische Universität Berlin

1st Supervisor: Prof. Elke Pahl-Weber

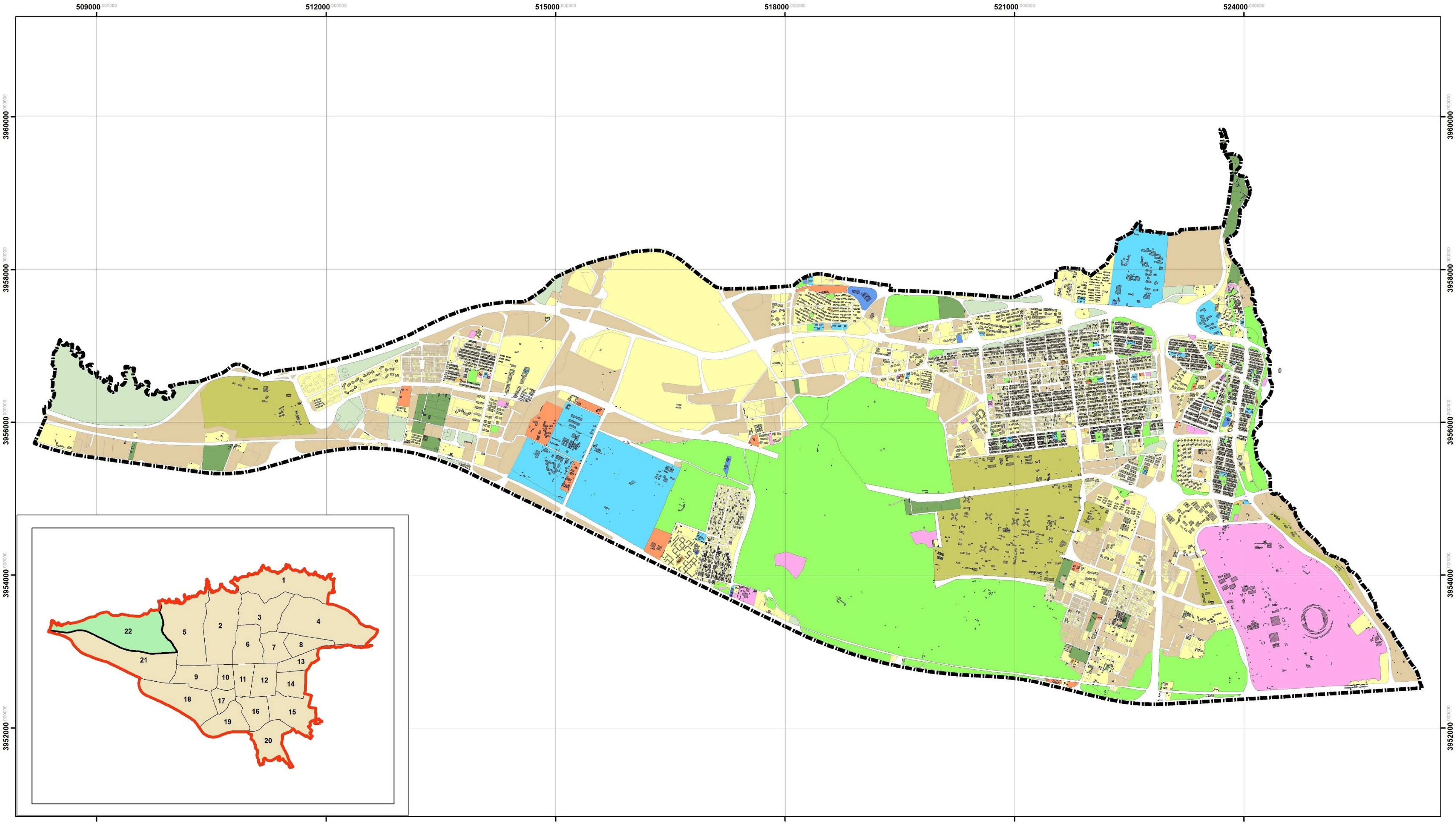
2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut

N W E S

0 0.4 0.8 1.6 2.4 3.2 Kilometers

Legend

- District 22 limit
- Health centers
- Mix of health and religious
- Administration
- Education centers
- Sport & Recreation
- Culture & Religious
- Military
- Green spaces
- planting trees
- Agriculture
- Barren lands
- Other (including residential)



PhD Thesis:

Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency

Researcher: Peyman Khodabakhsh **Map No. 2**

Developer: Khodabakhsh, P; Nouri, A **Date: Dec. 2017**

1st Supervisor: Prof. Elke Pahl-Weber
2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut

Title:

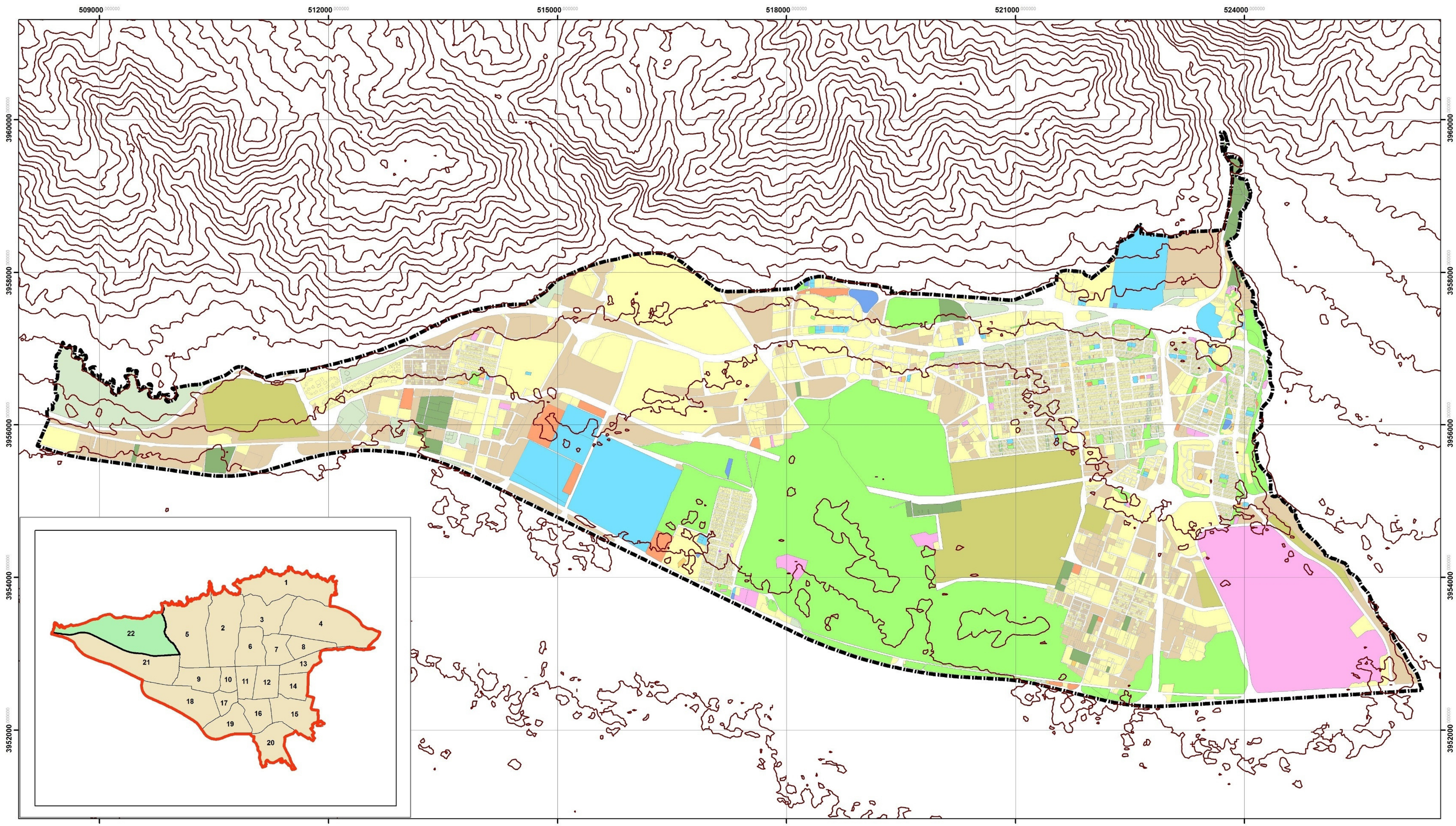
Social infrastructures mass and space configuration

N W E S

0 0.4 0.8 1.6 2.4 3.2 Kilometers

Legend

- District 22 limit
- Health centers
- Mix of health and religious
- Administration
- Education centers
- Sport & Recreation
- Culture & Religious
- Military
- Green spaces
- planting trees
- Agriculture
- Barren lands
- Other (including residential)
- Building mass



PhD Thesis:

Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency

Researcher: Peyman Khodabakhsh

Developer: Khodabakhsh, P; Nouri, A

Map No. 3

Date: Dec. 2017

1st Supervisor: Prof. Elke Pahl-Weber
2nd Nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut

Title:

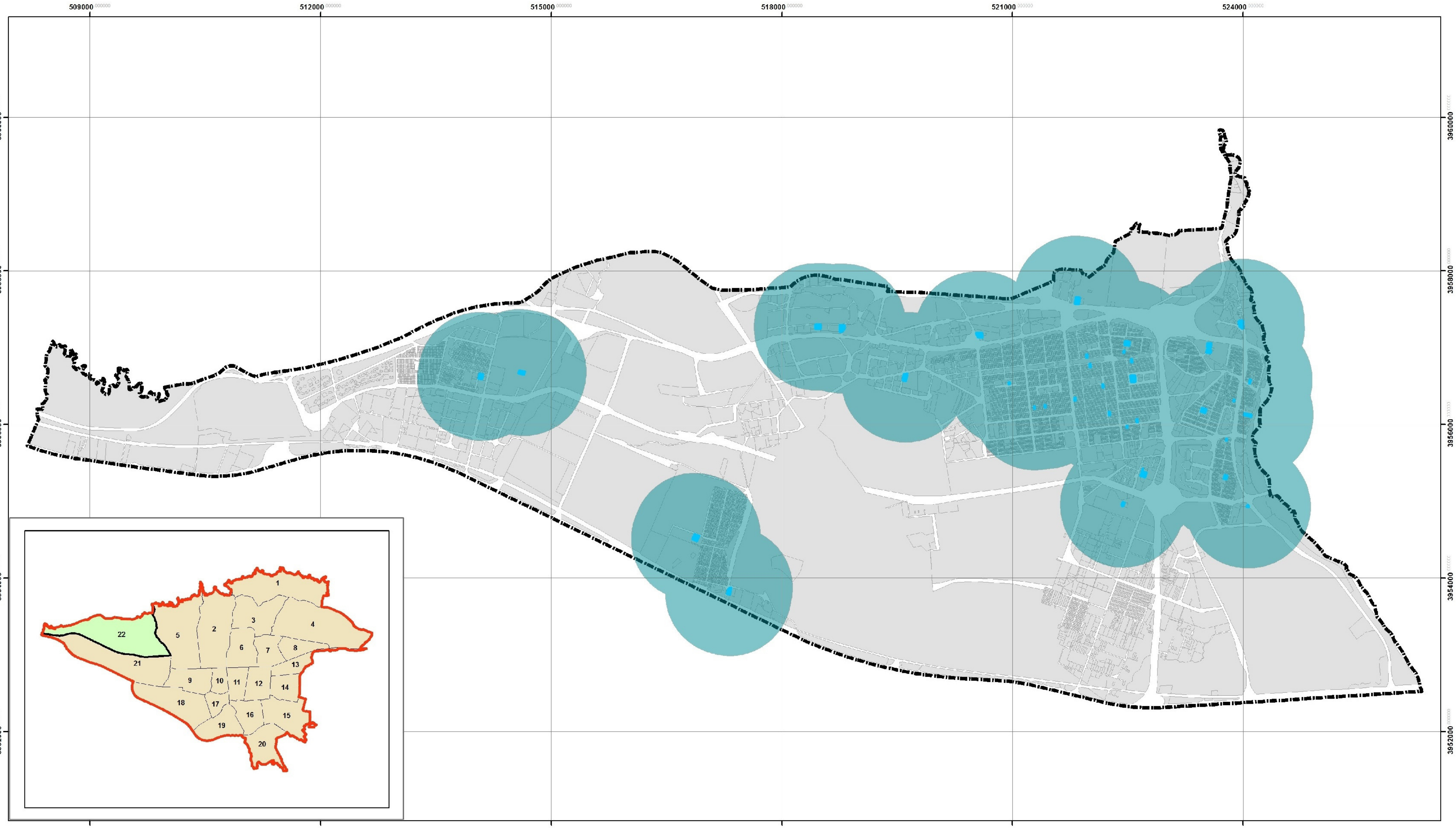
District topography and location of social infrastructure

N W E S

0 0.4 0.8 1.6 2.4 3.2 Kilometers

Legend

- District 22 limit
- Contour (topographic line)
- Health centers
- Mix of health and religious
- Administration
- Education centers
- Sport & Recreation
- Culture & Religious
- Military
- Green spaces
- planting trees
- Agriculture
- Barren lands
- Other (including residential)



PhD Thesis:

Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency

Title:

Primary education services catchment area

Legend

District 22 limit

Primary education

Service catchment area

Researcher: Peyman Khodabakhsh | **Map No. 4**

Developer: Khodabakhsh, P; Nouri, A | **Date: Dec. 2017**

N W E S

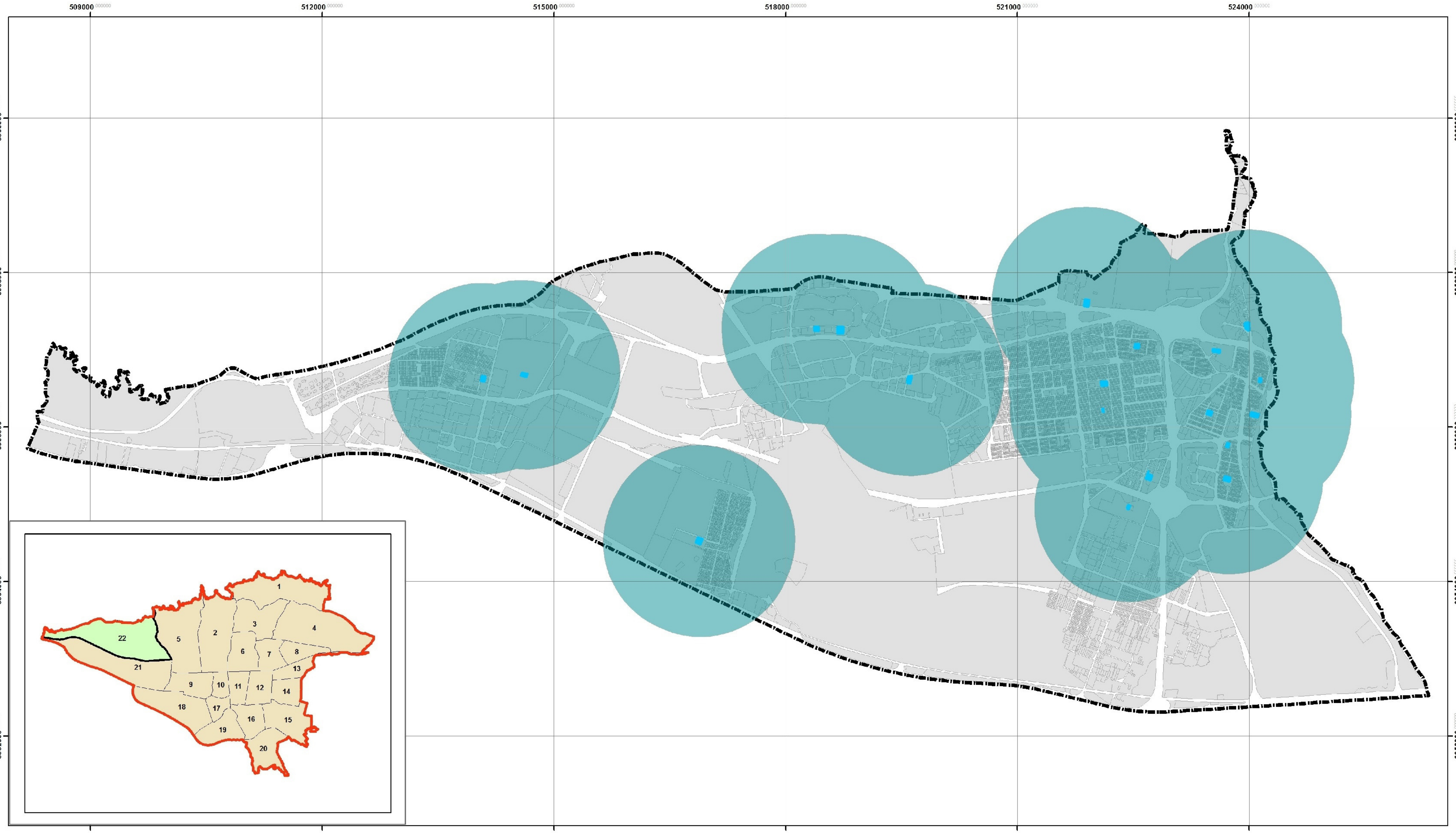
0 0.4 0.8 1.6 2.4 3.2 Kilometers

Technische Universität Berlin

1st Supervisor: Prof. Elke Pahl-Weber

2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut

Calculated Catschment Radious - 800 m



PhD Thesis:

Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency

Title:

Secondary education - guidance school services catchment area

Legend

District 22 limit

Secondary education - guidance school

Service catchment area

Researcher: Peyman Khodabakhsh

Map No. 5

Developer: Khodabakhsh, P; Nouri, A

Date: Dec. 2017

N W E S

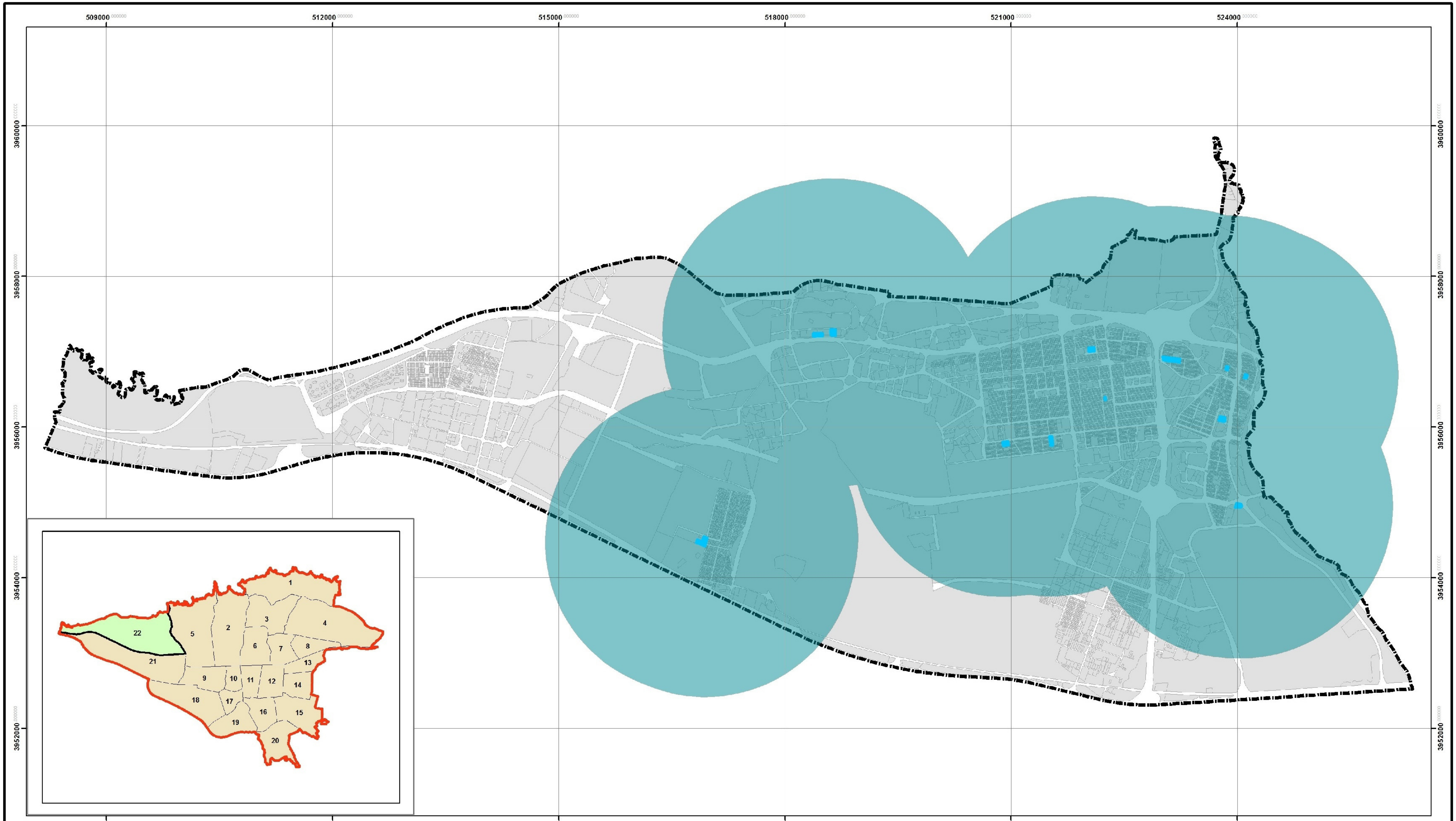
0 0.4 0.8 1.6 2.4 3.2 Kilometers

Technische Universität Berlin

1st Supervisor: Prof. Elke Pahl-Weber

2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut

Calculated Catschment Radious - 1200 m



PhD Thesis:

Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency

Title:

Secondary education - high school services catchment area

Legend

District 22 limit

Secondary education - high school

Service catchment area

Researcher: Peyman Khodabakhsh

Developer: Khodabakhsh, P; Nouri, A

Map No. 6

Date: Dec. 2017

N W E S

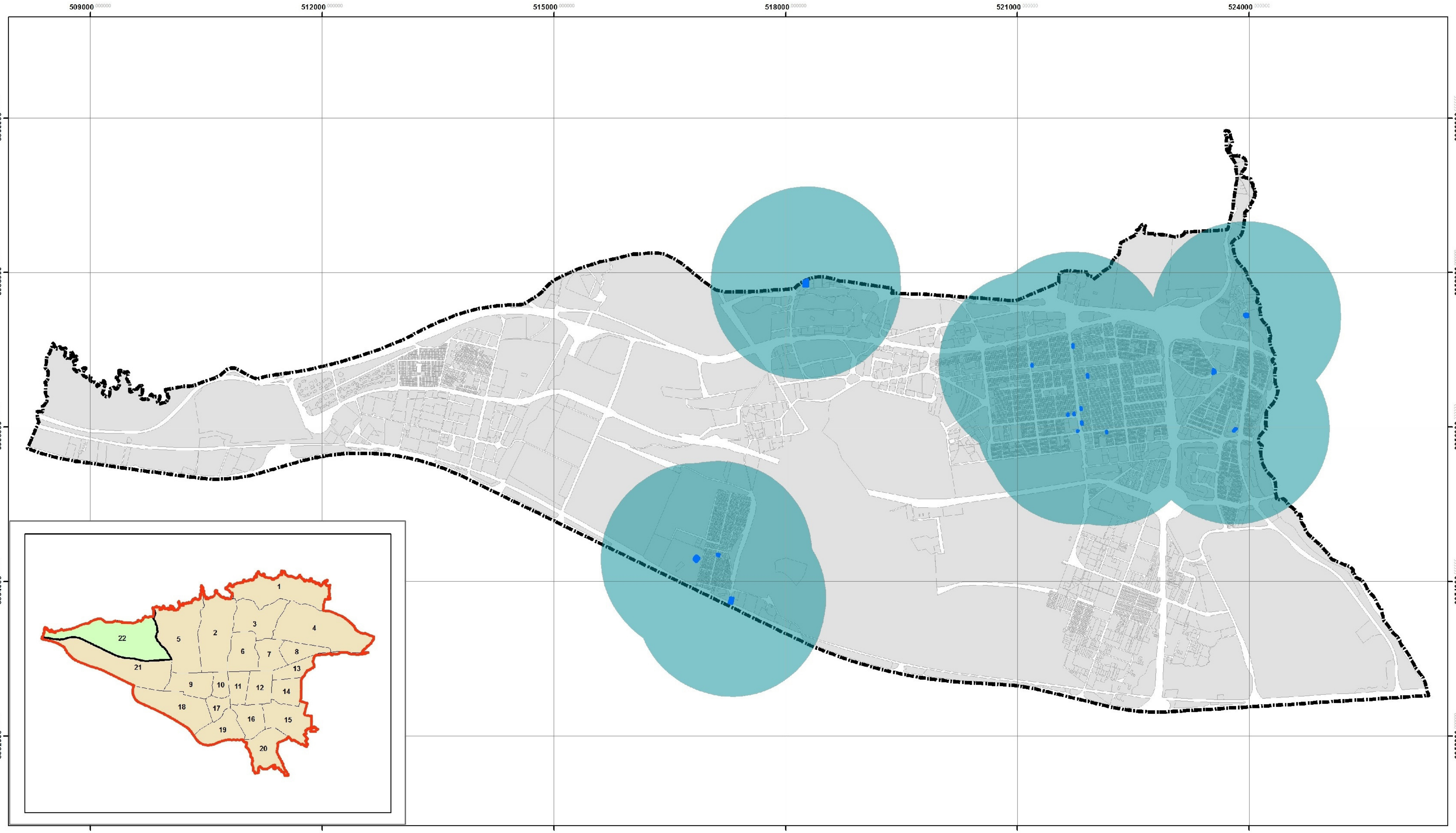
0 0.4 0.8 1.6 2.4 3.2 Kilometers

Technische Universität Berlin

1st Supervisor: Prof. Elke Pahl-Weber

2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut

Calculated Catschment Radious - 2000 m



PhD Thesis:

Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency

Title:

Sub district level health services catchment area

Researcher: Peyman Khodabakhsh

Developer: Khodabakhsh, P; Nouri, A

Map No. 7

Date: Dec. 2017

Technische Universität Berlin

1st Supervisor: Prof. Elke Pahl-Weber

2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut

N W E S

0 0.4 0.8 1.6 2.4 3.2 Kilometers

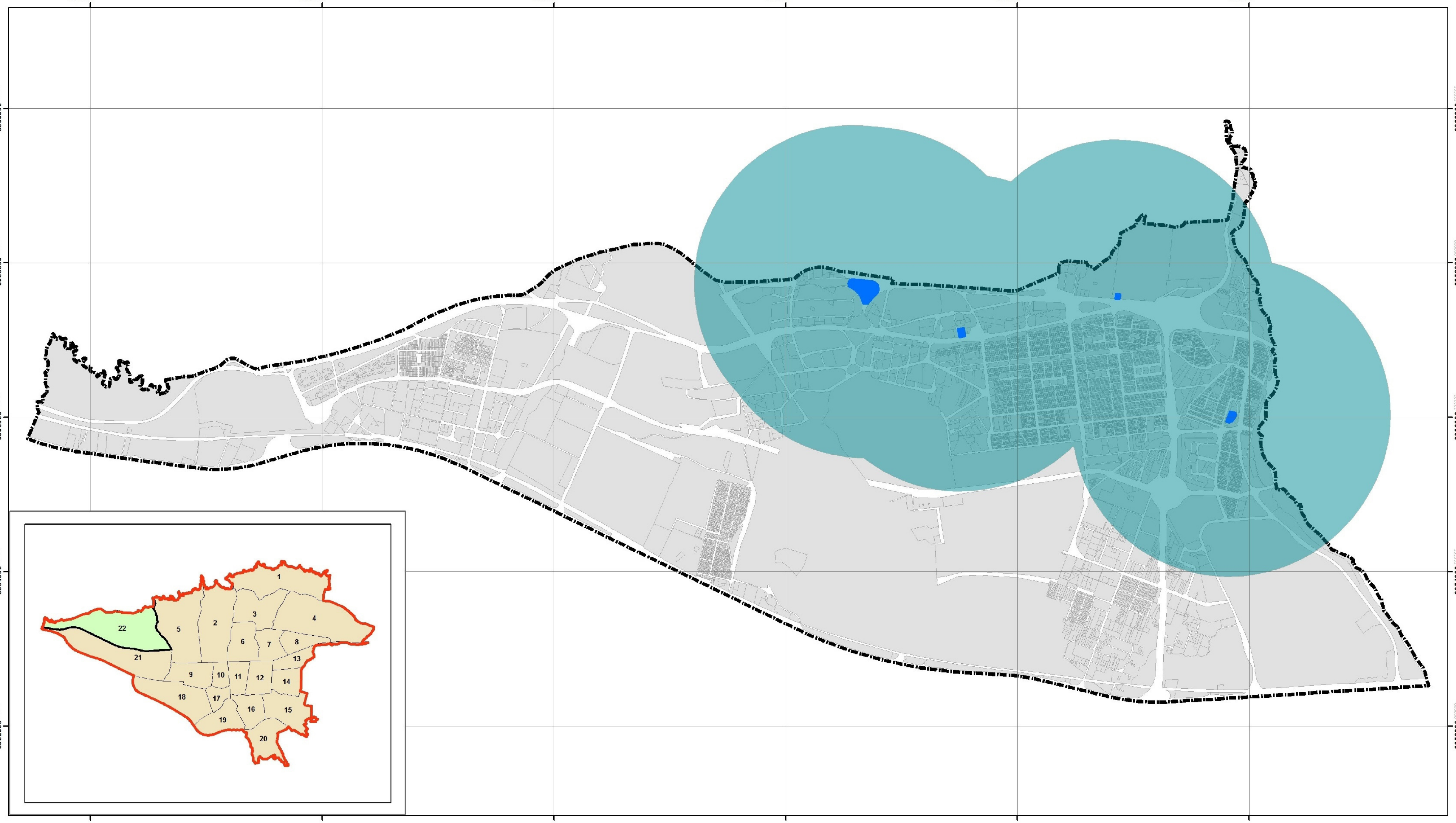
Legend

District 22 limit

Sub-district level health services

Service catchment area

Calculated Catschment Radious - 1200 m



PhD Thesis:

Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency

Title:

District level health services catchment area

Researcher: Peyman Khodabakhsh **Map No. 8**

Developer: Khodabakhsh, P; Nouri, A **Date: Dec. 2017**

Technische Universität Berlin

1st Supervisor: Prof. Elke Pahl-Weber
2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut

N W E S

0 0.4 0.8 1.6 2.4 3.2 Kilometers

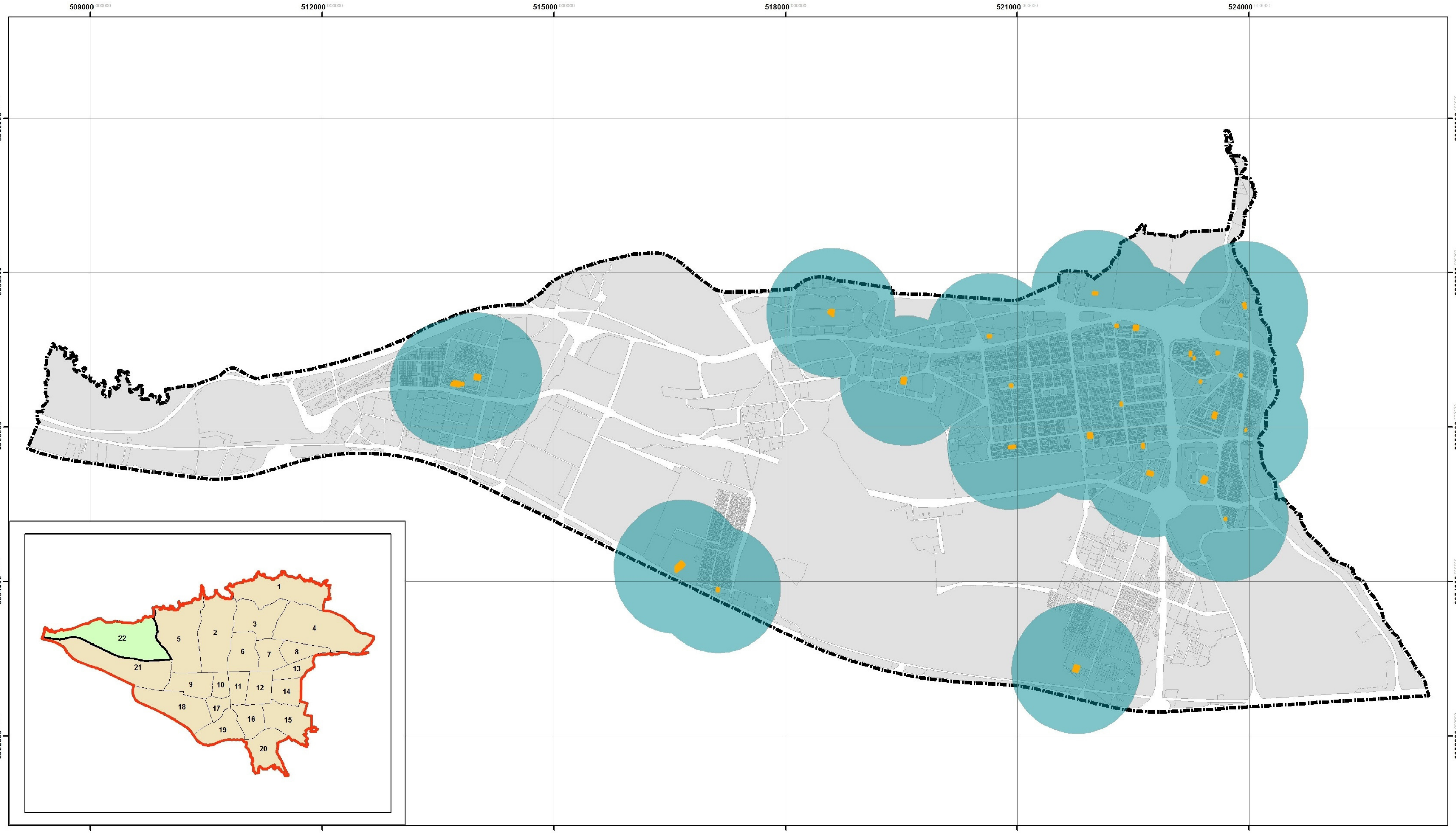
Legend

District 22 limit

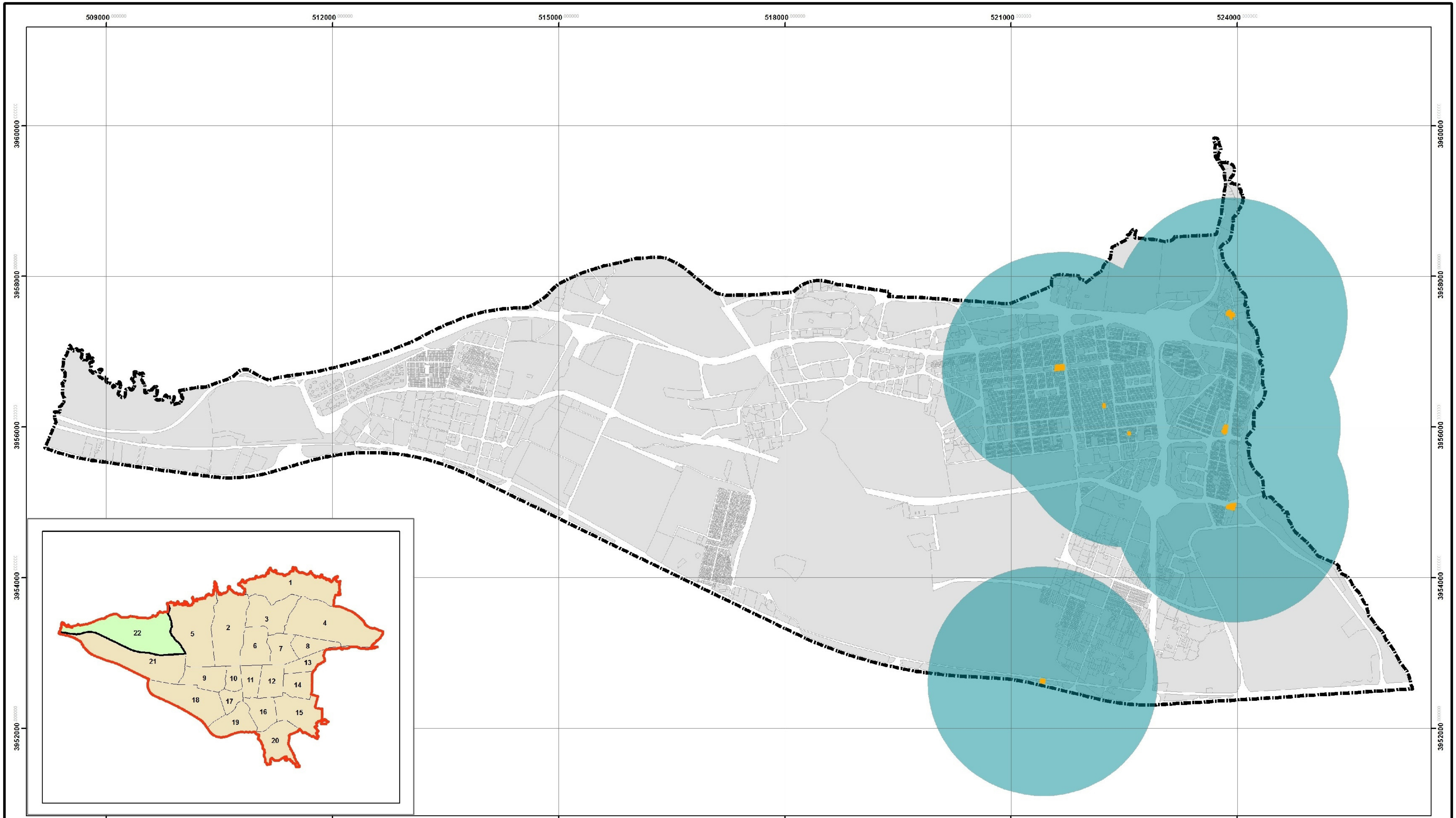
District level health services

Service catchment area

Calculated Catschment Radious - 2000 m



PhD Thesis: Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency	Title: Neighbourhood level cultural & religious services catchment area	Legend
Researcher: Peyman Khodabakhsh — Map No. 9 Developer: Khodabakhsh, P; Nouri, A — Date: Dec. 2017	N / W / E / S 0 0.4 0.8 1.6 2.4 3.2 Kilometers	District 22 limit Neighbourhood level cultural & religious services Service catchment area
Technische Universität Berlin 1st Supervisor: Prof. Elke Pahl-Weber 2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut		Calculated Catschment Radious - 800 m



PhD Thesis:

Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency

Title:

District level cultural & religious services catchment area

Legend

District 22 limit

District level cultural & religious services

Service catchment area

Researcher: Peyman Khodabakhsh

Developer: Khodabakhsh, P; Nouri, A

Map No. 10

Date: Dec. 2017

N W E S

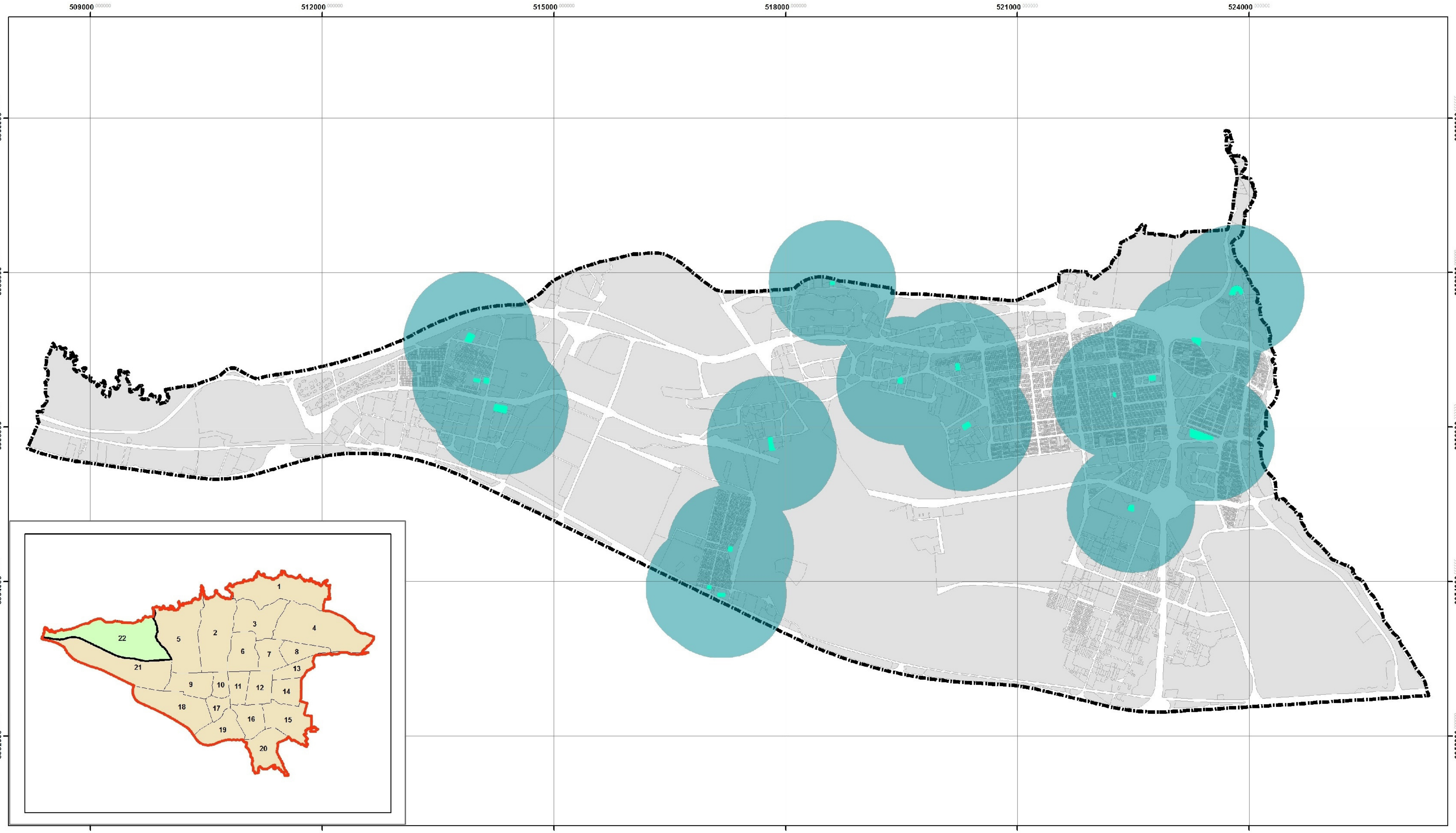
0 0.4 0.8 1.6 2.4 3.2 Kilometers

Technische Universität Berlin

1st Supervisor: Prof. Elke Pahl-Weber

2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut

Calculated Catchment Radious - 1500 m



PhD Thesis:

Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency

Title:

Neighbourhood level sport and recreation service catchment area

Legend

- District 22 limit
- Neighbourhood level sport & recreation services
- Service catchment area

Researcher: Peyman Khodabakhsh | **Map No. 11**

Developer: Khodabakhsh, P; Nouri, A | **Date: Dec. 2017**

N W E S

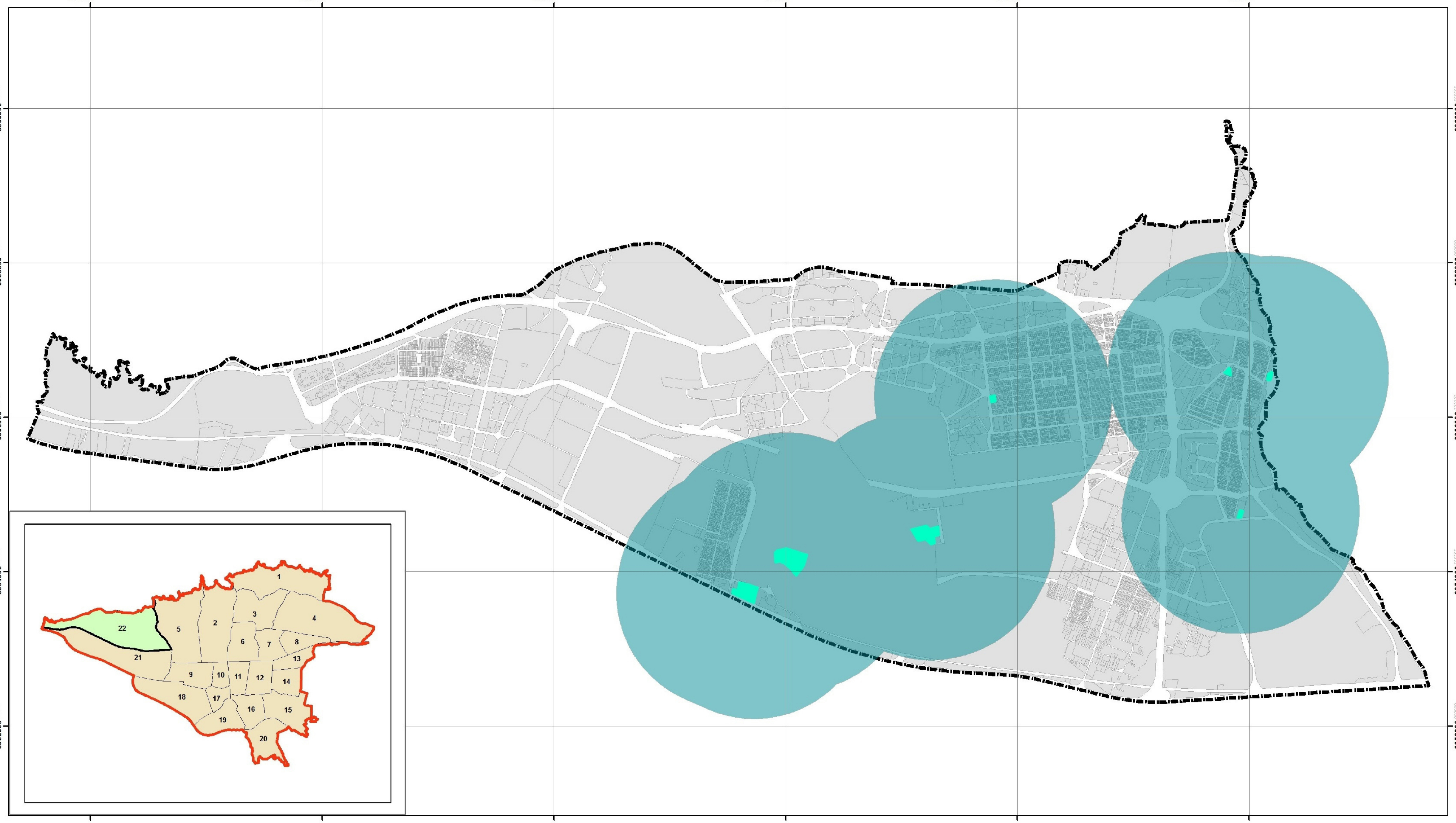
0 0.4 0.8 1.6 2.4 3.2 Kilometers

Technische Universität Berlin

1st Supervisor: Prof. Elke Pahl-Weber

2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut

Calculated Catchment Radious - 800 m



PhD Thesis:

Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency

Title:

District level sport and recreation service catchment area

Researcher: Peyman Khodabakhsh **Map No. 12**

Developer: Khodabakhsh, P; Nouri, A **Date: Dec. 2017**

Technische Universität Berlin

1st Supervisor: Prof. Elke Pahl-Weber
2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut

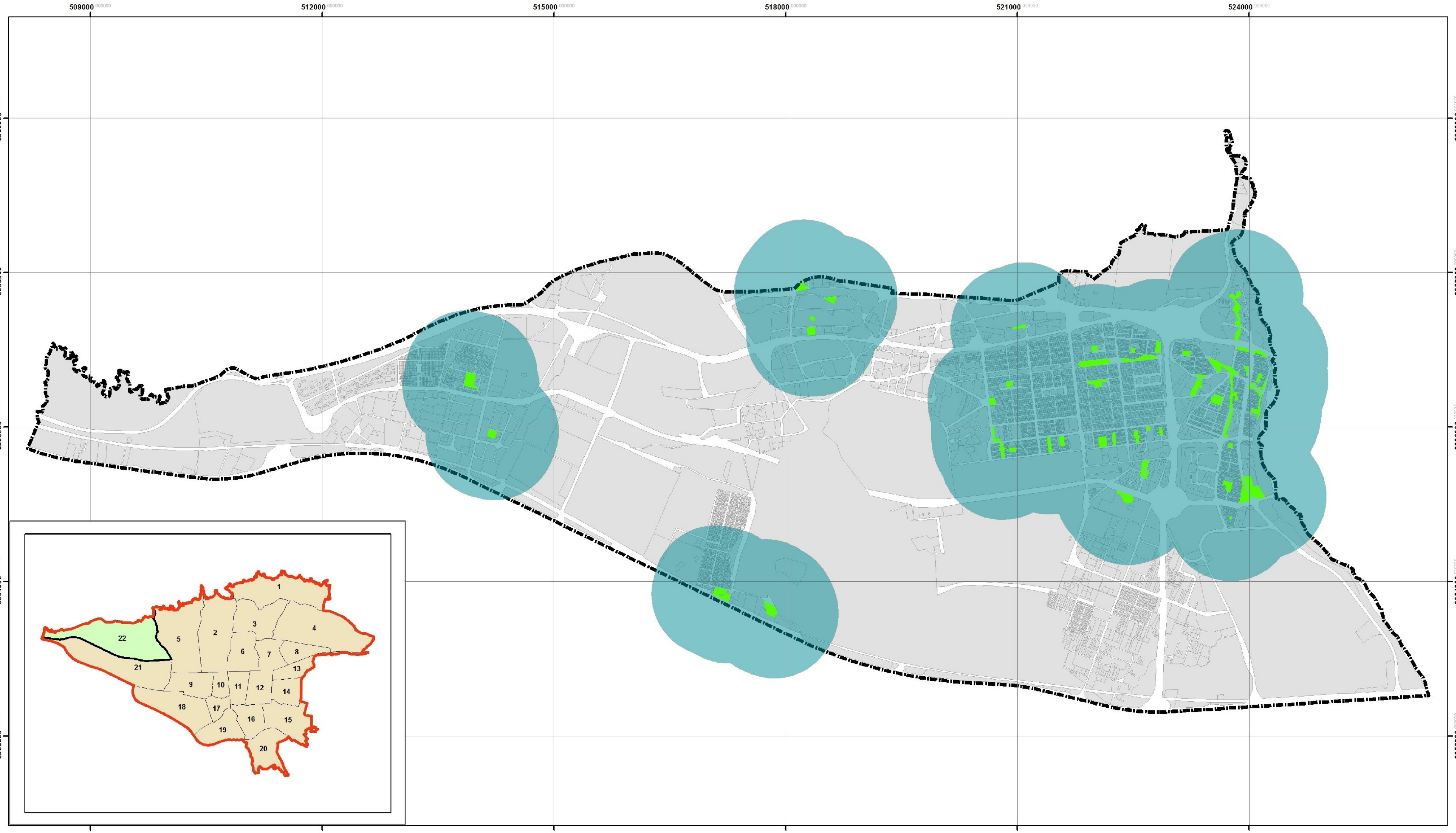
N W E S

0 0.4 0.8 1.6 2.4 3.2 Kilometers

Legend

District 22 limit
District level sport and recreation services
Service catchment area

Calculated Catschment Radious - 1500 m



PhD Thesis: **Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency**	**Title:** **Neighbourhood level Green space service catchment area**	**Legend** District 22 limit Neighbourhood level Green space service Service catchment area
Researcher: Peyman Khodabakhsh **Map No. 13** **Developer: Khodabakhsh, P; Nouri, A** **Date: Dec. 2017**	N W E S 0 0.4 0.8 1.6 2.4 3.2 Kilometers	
Technische Universität Berlin **1st Supervisor: Prof. Elke Pahl-Weber** **2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut**		**Calculated Catschment Radious - 800 m**

PhD Thesis:

Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency

Title:

District level green space service catchment area

Researcher: Peyman Khodabakhsh

Developer: Khodabakhsh, P; Nouri, A

Map No. 14

Date: Dec. 2017

N W E S

0 0.4 0.8 1.6 2.4 3.2 Kilometers

Technische Universität Berlin

1st Supervisor: Prof. Elke Pahl-Weber

2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut

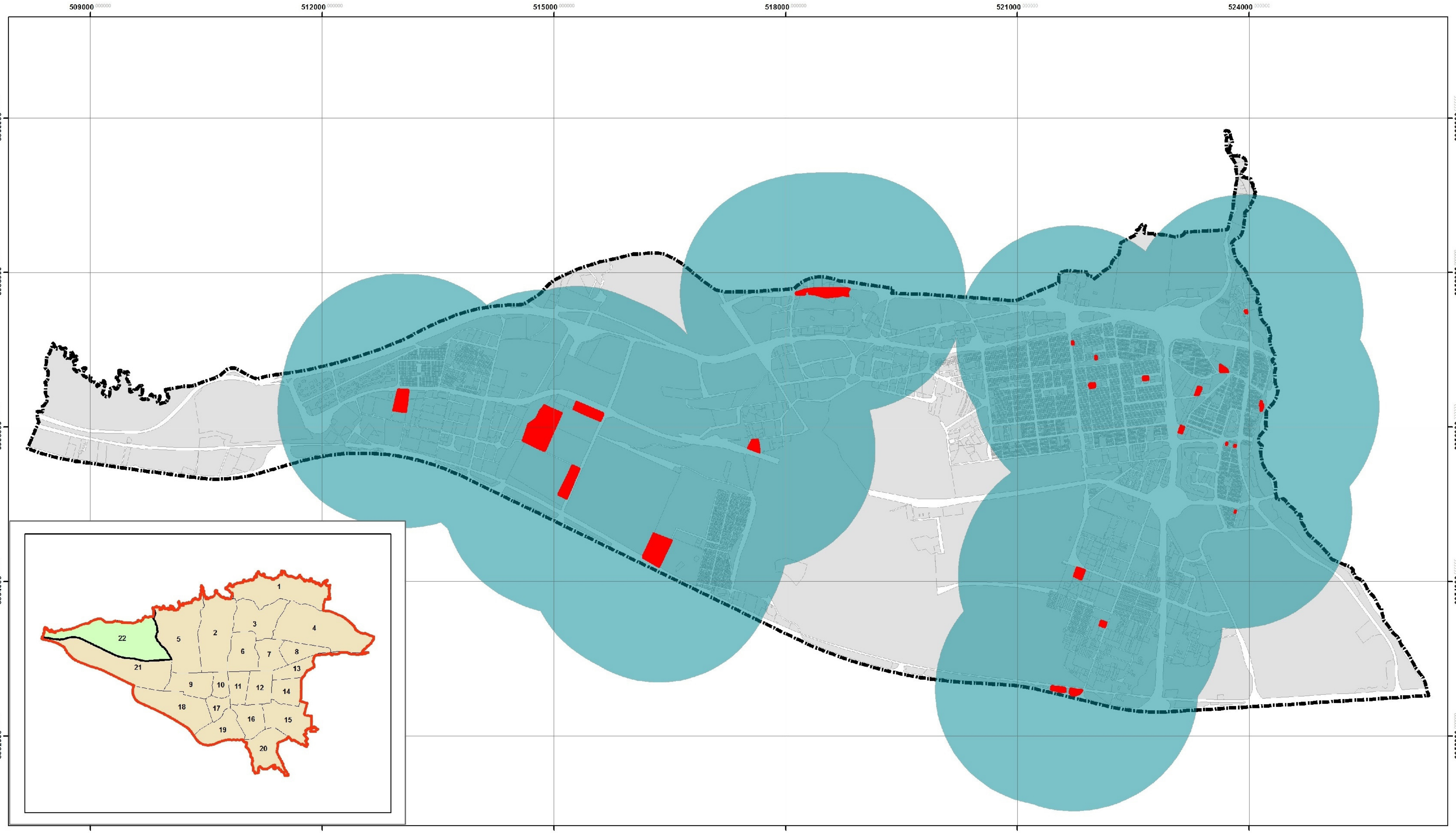
Legend

District 22 limit

District level green spaces

Service catchment area

Calculated Catchment Radious - 1500 m



PhD Thesis:

Analyzing the Impact of Social Infrastructure Planning on Energy Efficiency

Researcher: Peyman Khodabakhsh

Developer: Khodabakhsh, P; Nouri, A

Map No. 15

Date: Dec. 2017

1st Supervisor: Prof. Elke Pahl-Weber

2nd Supervisor: Prof. Dr.-Ing. Wolfgang Dickhaut

Title:

District level administrative services catchment area

N W E S

0 0.4 0.8 1.6 2.4 3.2 Kilometers

Legend

District 22 limit

District level administrative services

Service catchment area

Calculated Catschment Radious - 1500 m

Annex 4. Reviewed publications, books, conferences and presentations

Reviewed publications

- Khodabakhsh, P., & Brauckmüller, J. 2017. SMART CITIES PARTNERSHIP – INNOVATION FOR E-SERVICES. Informationen zur Raumentwicklung, Heft 1.2017. BBSR.
- Khodabakhsh et al. (2017). Study on National Broadband Plans in the EU-28. A study prepared for the European Commission DG CNECT.
- Khodabakhsh, P., Mashayekhi. S., Khodabakhsh, Po. Towards Energy Efficiency Policies in Urban Planning System, The Case of Iran. Armanshahr Architecture & Urban Development ISC Journal, 11 (20), Autumn 2017 (ISSN: 2008-5079).
- Khodabakhsh, P., Fathi, H., & Mashayekhi. S. (2016). Planning for Future Urban Services in the Smart City Era: Integrating E-Services Architecture in Urban Planning Process. Armanshahr Architecture & Urban Development ISC Journal. July 2016.
- Pahl-Weber, E., Khodabakhsh. P., & Fathejalali, A. (2016). YOUNG CITIES – Energy Efficient Structure for Urban Areas. NAX online Journal (http://www.nax.bak.de/service/newsletter/archiv/newsletter-lang/nax-report-05-2105-langform/nax-report-05-15-young-cities-energieeffiziente-urbane-struktur-fuer-einen-stadtteil-in-der-new-town-hashtgerd-im-iran/).
- Khodabakhsh, p., Fathi, H., & Mashayekhi, S. (2015). Achieving energy efficiency through designing Eco-friendly built environment. International Journal of Sustainable Building Technology and Urban Development, DOI: 10.1080/2093761X.2015.1025449
- Khodabakhsh,p., Boloukian Roudsari, R., & Mashayekhi, S. (2014). Planning for Public Services in Transition Era: Application of PSI (Public Services Information) in Planning Process. The second

Urbanism & Spatial Mobility Conference, IUST University. October 2014.

- Khodabakhsh,p., & Mashayekhi, S. (2014). Looking for a New Order in Urban Energy Efficient Strategies in Urban Studies. Armanshahr Architecture & Urban Development ISC Journal. October 2014.
- Khodabakhsh,p., Mashayekhi, S., & Malekpou Asl, B. (2014). Analyzing the Impact of Services Accessibility Enhancement on Urban Energy Efficiency Based on GIS Network Analysis. Armanshahr Architecture & Urban Development ISC Journal. October 2014.
- Khodabakhsh,p., Mashayekhi, S., & Malekpou Asl, B. (2014). An Analytical View on Resilience Urban Planning, Focusing on Urban Transportation Systems and Climate Change. Athens Journal of Social Sciences, December 2014.

Books

- Participation in writing a chapter of a book: Pahl-Weber, E., & Schwartze, F. 2014. Space Planning and Design: Integrated Planning and Design Solutions for Future Megacities. The book series Future Megacities. Berlin: JOVIS vorlag, 88-106.

Presentations

- Khodabakhsh. P. (2017). Chances and challenges of digitalization in rural areas of the EU. North Sea Conference annual conference 2017. Gottingen, Germany.
- Khodabakhsh. P. (2016). Energieeffizienz und solares Bauen im Iran – Herausforderungen, Strategien und Chance. Deutsche Energie-Agentur-DENA
- Khodabakhsh. P. (2016). Urban Energy Transformation; Perspectives for Integrated Energy Efficient Urban Planning in Practice. International Sustainability Transitions Conference (August 8th 2016). Wuppertal. Germany.

- Khodabakhsh, P. (2014). An analytical view on resilience urban planning, focusing on urban transport systems and climate change. 4th Annual International Conference on Urban Studies & Planning, 9-12
- Khodabakhsh, P. (2014). Analysis the impact of spatial form and functional strategies on urban energy efficiency. Future city Iran national conference.

Awards

- Best Poster Award presentation for the article entitled ''Planning for Public Services in Transition Era: Application of PSI (Public Services Information) in Planning Process'' in the second Urbanism & Spatial Mobility Conference, held in IUST. October 2014.