

## EVALUATION OF ENVIRONMENTAL FACTORS IN SMART HOMES IMPLEMENTATION (CASE STUDY: CITIES OF MAZANDARAN PROVINCE IN IRAN)

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### ABSTRACT:

The growing trend of IT technologies has continued at a faster pace in recent decades. The efforts of experts in this field have always been reducing the problems and challenges existing in urban communities and improving the quality of citizens' lives. They have concentrated on using the artificial intelligence and Internet of Things in a way which leads to maximize self-actualization of citizens. Among these technologies, IoT has played a significant role. Since it can improve the urban infrastructures, and also can be implemented in the scale of home facilities and equipment, can improve the quality of life in smart homes. However, it seems that the implementation of smart residential buildings in the context of smart cities is not simple as been defined in theory and may be accompanied by challenges. In this paper, an attempt has been made to evaluate the environmental factors affecting this field by SWOT analysis tool in a case study in cities of Mazandaran Province in Iran. As a result, strategy and tactics to emphasize strengths, to make the most of existing opportunities, to eliminate the weaknesses, and to reduce the risk of perceived threats, have been identified and been introduced. Based on the results, OS strategy should be held to obtain the most valuable goals of a smart city; since the points of opportunities and strengths are relatively more than others.

### 1. INTRODUCTION

Global warming, which has become the focus of energy and environment issues in recent years, makes environmental and economic effects. These effects can be mentioned as one of the major challenges humans will face during this century. The main cause of this effect is attributed to CO<sub>2</sub> emissions. Because of the cost of energy, homeowners, who can be considered a major energy user, are very interested in reducing their energy consumption. (John et al., 2010). Whereas sustainable development is assumed as a common global solution; attempts have been done to achieve its goals all around the world. Sustainable development focuses on three dimensions which are economic, social, and environmental issues.

One of the concepts resulting from this common global goal is the smart city, which can have a tremendous impact on the quality of life of urban communities while reducing the environmental damages caused by changes in urban life.

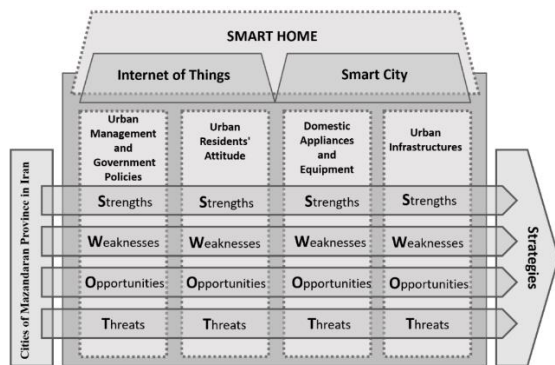
Smart cities are made up of smart spots that interact with each other seamlessly with a fully smart neural network. Smart points refer to buildings of urban management, services, businesses, leisure and residential houses, and the neural network refers to urban infrastructure. Since in most cities, the highest mass of the city is allocated by residential use; quantitatively these buildings require special attention. On the other hand, the residential buildings of a city must be able to survive at all hours of the day; As a result, the service process should not be stopped even for a few minutes. The importance of this issue has led to the invention of a concept called Smart Home.

The concept of domestic mechanization has become popular since the late 1970s in spite of the fact that with the progression in technologies, people's desires of what a home ought to be or how the services ought to be at domestic proceeds to alter. Smart Home depicts a home that has appliances, lighting, heating, cooling, air conditioning, televisions, computers, entertainment (audio and video systems), security, and camera systems that can communicate and can be controlled automatically based on a time plan, or manually by a switch button in the house, or even remotely from anywhere in the world using phone or internet (Davies and Anireh, 2019). In spite of the fact that most renewable energy technologies are financially competitive compared to conventional ones; in any case, due to a wide extend of specialized, market-related and organization boundaries, the execution of such innovations has not reached its full potential (Pezzutto et al., 2016). This paper focuses on identifying the reasons for this failure, with emphasize on the cities of Mazandaran province in Iran and have tried to identify the challenges and obstacles in the way of smart homes implementation in Iranian cities and strategies to deal with it.

The rest of paper proceeds as follows: In Section 2, related works have been reviewed. In reviewing related works, the focus is on theoretical fundamentals of smart city and smart homes using IoT. The third section focuses on declaration of the research method and the conceptual model of the research process is being presented. Section 4 is devoted to assessment of environmental factors. By defining four different aspects for the implementation of smart homes in cities of Mazandaran province in Iran, distinct evaluations have been done for each of these four aspects, resulted in concluding suggested strategies. In order to make the strategies as much as possible, the tactics are classified into three categories: short-term, medium-term, and long-term. Finally, Section 5,

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summarizes the research process, and emphasizes on applying suggested strategy and tactics in related aspect to each of them.



**Figure 1.** Conceptual framework of research method of this paper.

## 2. RELATED WORK

A literature review has been used to identify environmental factors encountered during project implementation, and then the most common factors have been selected from the list. Filtering pertinent investigates, it has been found that a few related studies as well as practical projects exist within the most themes tended to in this paper, which are middleware for IoT, energy awareness and monitoring and mobile interaction with the real world.

### 2-1 Smart City

A smart city is a city uses new technologies, especially information and communication technology, to improve the quality of life of citizens and to create sustainable development. A smart city has sub-categories, subsystems and main components of smart life. These components are smart governance and security, smart energy, smart building, smart transportation, smart urban infrastructure, smart technology, smart health care, and smart citizen (Tajfar et al., 2019).

### 2-2 IoT and Smart City

A smart city is based on information and communication technology (ICT) that seeks to meet the needs of citizens through planning, design, development and renovation of communities to improve the sense of place while maintaining natural and cultural resources, equitable distribution of development costs and benefits, increasing ecological integration in the short and long term, as well as increasing the quality of life through the development of a range of transportation, employment and housing options in a financially sound manner. In fact, the smart city is a reality that enters the field due to the increasing advancement of information technology (IT) within the city, and in order to meet the modern needs of citizens for data, information, hardware and software facilities in their urban life (Mahdizade, 2019).

### 2-3 Smart Building

A smart building incorporates a dynamic and cost-effective environment by integrating the four key elements of systems, structure, services, management, and the relationship between them in an emergency. In the definition of smart building, the concept of resilience should not be overlooked. Resilience, as the capacity of a system, considers a community to be potentially exposed to risks in order to adapt, withstand, or make changes in

order to "through" continue and achieve an acceptable level of performance and structure (Kamali et al., 2019).

### 2-4 Smart Home

Smart Home is an organic natural combination of different subsystems related to domestic life through progressed innovations such as fiber optic composite cable. It can both share resources and communicate inside the domestic. Its fundamental objective is to supply individuals with an efficient, effective, comfortable, secure, convenient and environment-friendly living environment integrating system, service and management. Smart home is the utilize of computer technology, control technology, and communications technology will be associated through the network of different facilities together to meet the automation requirements of the entire integrates system to supply more helpful control and management. The conventional smart home implementation for the most part controls and communicates building facilities through the wiring of wired lines, it is troublesome to get rid of the restraints of various cables, the installation cost is high, and the scalability of the system is also poor. The smart home framework based on remote sensor network technology cannot get freed of the shackles of, decrease the establishment cost, but moreover significantly move forward the scalability of the framework (Li et al., 2018).

By studying and considering different elements and aspects of a smart city, it is obvious that as a system of systems, it is made and developed through a systematic network which is functioning like a living organism. It has vulnerabilities based on its weaknesses and encountering threats and can tolerate them depending on its resiliency.

## 3. PROPOSED METHOD

As shown in figure 1, for the research process of this paper, two convergent paths can be considered. On one side, the theoretical literature in the field of smart city and smart home has been reviewed. On the other side, the identification and evaluation of environmental factors related to smart homes in Iranian cities has been done as a result of interviews with experts and city managers.

As mentioned, a literature review was used to identify environmental factors encountered during smart home implementation, and then the most common ones have been listed. After the list was created, interviews with experts and city managers were held to assess the effectiveness of each factor.

SWOT Analysis technique has been used for assessment of environmental factors. SWOT investigation could be a process that includes four aspects into two measurements. It has four elements: Strengths, weaknesses, opportunities, threats. Strengths and weaknesses are internal elements and variables of the environment, opportunities and threats are external elements and variables of the environment. In this measurement, solid and frail sides of an environment are recognized by analyzing the variables in its organization while environmental opportunities and threats are analyzed by examining the factors based on outside (Gürel and Tat, 2017).

All through the examination, it was expected that strengths and weaknesses are internal elements or variables of a smart home project itself. The opportunities and threats are considered to be external elements or variables describing the environment encompassing a smart home implementation project.

Through analyzing the impact of each factor by using SWOT technique, it has become possible to suggest the strategy and tactics which can be useful for facilitating the smart home

implementation in cities of Mazandaran province in Iran. The detected factors and the suggested strategies are mentioned in section 4 of paper.

#### 4. EVALUATION

As mentioned in section 3, environmental factors are divided into four general aspects. In the urban infrastructure sector, the analysis is focused on the current situation and the ongoing development perspective. In the second aspect, which focuses on domestic appliances and equipment, environmental factors affecting this dimension have been examined according to the current conditions in the industry and market of this field. The third aspect emphasizes citizens' attitudes and examines the operation of smart homes from a socio-cultural perspective. In the fourth aspect, the rules and regulations are discussed. Laws are analyzed in two micro and macro levels that are national levels which refer to government budgets; and municipal dimension which refers to urban management.

##### 4-1 Urban Infrastructures

In short, City infrastructure are structures and services that act as a basis for the life of a city. This includes both hard infrastructure such as bridges and soft infrastructure such as IT services. Since most of the cities of Mazandaran province in Iran, had been developed gradually from an ancient fabric, modernizing them is encountering with different challenges and problems that some of the most important ones of them have been mentioned in the following table.

Internal Factors	
Strengths	Weaknesses
<ul style="list-style-type: none"> <li>Attempts being done for improving urban infrastructures in recent years, especially for improving IT infrastructures</li> </ul>	<ul style="list-style-type: none"> <li>Inefficiency of telecommunication networks in response to the maximum load in the current situation</li> <li>The large number of vulnerabilities in urban infrastructures identified so far</li> </ul>
External Factors	
Opportunities	Threats
<ul style="list-style-type: none"> <li>Being able to provide the equipment needed to improve the quality of the infrastructure network</li> <li>Availability of graduates in this field in the provinces of the country</li> </ul>	<ul style="list-style-type: none"> <li>Being a time-consuming process to modernize urban infrastructure network</li> <li>Being a costly process to modernize urban infrastructure network due to the provision of required devices and equipment</li> </ul>

**Table 1.** Evaluation of environmental factors in urban infrastructures.

##### 4-2 Domestic Appliances and Equipment

Smart home technologies (SHTs) include sensors, screens, interfaces, machines and gadgets organized together to empower automation as well as localized and remote control of the residential environment. Controllable appliances and gadgets include heating and hot water systems (boilers, radiators), lighting, windows, window ornaments, garage doors, refrigerators, TVs, and washing machines. Sensors and screens identify environmental factors counting temperature, light, motion, and humidity. Control functionality is given by software on computing devices (such as smartphones) or through equipment interfaces (such as wall-mounted controls). These distinctive SHTs are networked, in most cases wirelessly, using standardized communication protocols (Wilson et al., 2017). Although these devices are readily available in the current market conditions of this field, installation in homes and periodic maintenance are associated with challenges that differentiate the actual result from what is expected in theories. Not to mention that considering the current economic conditions, the issue of cost of providing smart home appliances and equipment is a relatively challenging issue.

Internal Factors	
Strengths	Weaknesses
<ul style="list-style-type: none"> <li>Ease of handling and installing most of the required devices</li> <li>Compatibility with the existing network in home installation systems</li> </ul>	<ul style="list-style-type: none"> <li>Lack of user-friendly interfaces in most of softwares and hardwares</li> </ul>
External Factors	
Opportunities	Threats
<ul style="list-style-type: none"> <li>Being able to provide the necessary equipment and devices from national providers or foreign companies</li> <li>Availability of graduates in this field in the provinces of the country</li> </ul>	<ul style="list-style-type: none"> <li>Imposing unforeseen expenses on families living in going-to-be smart homes</li> </ul>

**Table 2.** Evaluation of environmental factors in urban infrastructures.

##### 4-3 Urban Residents' Attitude

IP-enabled cameras, motion sensors, and connected door locks offer superior realization of domestic smartness framework. Be that as it may, it is accepted that attackers can control smart gadgets to cause physical, financial, and psychological harm. For instance, burglars can simply target a network-based entry to unlock access codes, and can easily steal all household gadgets and devices by unlocking the primary access code established for entry door. Lately, a few companies have presented more current frameworks that are much easier for consumers to setup, are cloud-backed, and give a programming framework for third-party developers to construct applications that can discern smart home benefits (Fernandes et al 2016). So, many of urban residents hesitate about installing IoT equipment in their homes. Even it had been reported that installing cameras within their homes for the

health purposes would be violating the residents' privacy (Demiris et al 2004). And since they are suspicious; they prefer to continue using the traditional methods of domestic electrical and mechanical installations. But it has gotten to be obvious that smart home could be a domestic prepared with technologies that improves security, especially for patients at home, since it can monitor their wellbeing conditions. Hence, the gadgets and sensors chosen to be installed and maintained in the older adults' homes have to be address utilitarian limitations and social and health care needs.

All members felt that the utilize of cameras inside their homes for the reason of distinguishing falls or other accidents was prominent and would be abusing the residents' privacy (Ibid).

In recent months, the global pandemic of Covid-19 has made new emerging concepts as a reality for everyone. Hence, it seems that based on the new experiences of the last few months, the public attitude towards receiving remote technical services has grown favorably.

In other words, when the role of the Internet of Things and smart homes in improving the health and safety of residents is established; making decisions to use the new generation of installation systems will be easier for the general public.

Internal Factors	
Strengths	Weaknesses
<ul style="list-style-type: none"> <li>Getting emergency medical or tehcnical help</li> <li>Safety control of stoves, ovens, etc</li> </ul>	<ul style="list-style-type: none"> <li>Public perception about being monitored by using IoT</li> <li>Having difficulties while using smart equipment by elderly residents</li> </ul>
External Factors	
Opportunities	Threats
<ul style="list-style-type: none"> <li>Advertising benefits on social media</li> <li>Advertising benefits on TV programs</li> </ul>	<ul style="list-style-type: none"> <li>Sharing plenty of non-expert analysis on social media</li> </ul>

**Table 3.** Evaluation of environmental factors in urban residents' attitude.

#### 4-4 Urban Management and Government Policies

The issue of legislation should be considered in two different dimensions. First of all, laws and regulations determine the general direction of actions and decisions.

So that if the laws be properly explained at the national level; city managers will act best within the framework of the explained rules. So that, engineers and architects will have a specific path for designing and implementing smart homes and the possibility of possible mistakes and errors will be minimized.

In other words, if national and municipal laws are properly and clearly explained; the whole system, from legislators to engineers

and architects, operates as an integrated system, and their decisions and actions can be more effective.

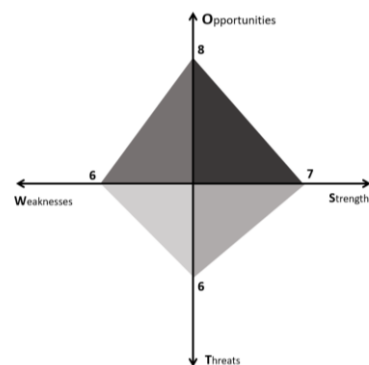
Internal Factors	
Strengths	Weaknesses
<ul style="list-style-type: none"> <li>Successful managerial experiences, especially during the Covid-19 Pandemic</li> <li>Presence of expert and specialized managers in relevant organizations</li> </ul>	<ul style="list-style-type: none"> <li>Uncertainty of the decision makers about the smartening of cities in relevant organizations</li> </ul>
External Factors	
Opportunities	Threats
<ul style="list-style-type: none"> <li>Ability to interact with academic communities and elites specializing in the field to review the existing laws</li> <li>Easy access to sample laws approved in other countries via the Internet and international communications</li> </ul>	<ul style="list-style-type: none"> <li>Possibility of interfering with other current laws in the country</li> <li>Possibility of interfering technical considerations with the requirements of legal regulations</li> </ul>

**Table 4.** Evaluation of environmental factors in urban management and government policies.

#### 4-5 Suggested Strategy and Tactics

By evaluating environmental factors relevant to smart home implementation in cities of Mazandaran in Iran, it has become possible to propose suggested strategies.

Based on the results, OS strategy should be held to obtain the most valuable goals of a smart city; since the points of opportunities and strengths are relatively more than others.



**Figure 2.** Conceptual framework of suggested strategy.

The Suggested strategies have been divided into three time-based groups. First group is short-term strategies. It refers to urgent decisions that should be done as primary steps through first six months. Second group is mid-term strategies, for up to two years

ahead. The third group refers to long-term strategies, that can be done up to five years from the beginning point.

Short-Term Tactics	
Urban Infrastructures	<ul style="list-style-type: none"> <li>Review and evaluation of urban infrastructure network in terms of communication capabilities and network required by smart cities</li> <li>Urgent action to address the reported problems in urban infrastructure in light of the recent pandemic experiences of Covid-19</li> </ul>
Domestic Appliances and Equipment	<ul style="list-style-type: none"> <li>Facilitating the process of supplying the required devices by national production companies or importing from exporting countries</li> <li>Educating citizens through educational brochures to learn how to use smart devices and facilities</li> </ul>
Urban Residents' Attitude	<ul style="list-style-type: none"> <li>Promoting and introducing the benefits of smart home residential housing to the general public by emphasizing the recent experiences of the Covid-19 Pandemic</li> <li>Installing smart systems as an auxiliary system along with traditional systems with the aim of familiarizing residents with smart systems</li> </ul>
Urban Management and Government Policies	<ul style="list-style-type: none"> <li>Developing facilitating laws for knowledge-based start-up companies</li> <li>Dividing cities into separate zones and appointing a specific urban manager to oversee the implementation of existing laws in each of the urban zones, for example following the municipal divisions, in order to reduce parallel works</li> </ul>
Mid-Term Tactics	
Urban Infrastructures	<ul style="list-style-type: none"> <li>Activating control center to continuous and integrated control of the urban infrastructure network</li> <li>Organizing the urban infrastructure network with the aim of improving the level of resilience against possible problems and difficulties, based on executive experiences</li> </ul>

Mid-Term Tactics	
Domestic Appliances and Equipment	<ul style="list-style-type: none"> <li>Strengthening national companies in the field of producing the required hardwares or devices, and developing the required and supporting softwares</li> <li>Development of training centers to train specialized technicians</li> </ul>
Urban Residents' Attitude	<ul style="list-style-type: none"> <li>Designing and launching online and telephone answering centers for remote answering to citizens' problems</li> <li>Regular reporting about the outcomes of smart homes, in the relevant fields such as economic, medical, social, etc. in order to reassure citizens about the benefits of smart home implementation</li> </ul>
Urban Management and Government Policies	<ul style="list-style-type: none"> <li>Developing legal processes to facilitate the evaluation and licensing process for startups and companies concerned and committed in this field</li> <li>Defining specific lines and issues in yearly government budgets</li> </ul>
Long-Term Tactics	
Urban Infrastructures	<ul style="list-style-type: none"> <li>Establishing smart systems for analyzing big data collected at reporting intervals in need of improvement in order to improve urban infrastructure services</li> <li>Establishment of an integrated system at the national level in order to control all of urban infrastructures simultaneously all around the country as a supersystem</li> </ul>
Domestic Appliances and Equipment	<ul style="list-style-type: none"> <li>Periodic and continuous monitoring of devices and softwares at the level of smart homes in each city</li> <li>Continuous monitoring and evaluation of the performance of technical experts</li> </ul>
Urban Residents' Attitude	<ul style="list-style-type: none"> <li>Collecting periodic surveys from smart home residents to identify possible defects</li> <li>Arranging specialized committees to monitor and resolve problems reported by citizens and monitored by specialized committees</li> </ul>

Long-Term Tactics	
Urban Management and Government Policies	<ul style="list-style-type: none"> <li>▪ Creating training and retraining courses for employees</li> <li>▪ Training expert urban managers and empowering them in smart city management</li> <li>▪ Establishing new academic fields and courses with an interdisciplinary approach</li> </ul>

**Table 5.** Suggested tactics.

## 5. CONCLUSION

In this paper, the issue of implementation of smart homes with emphasis on the infrastructure required for using Internet of Things has been analyzed. In order to make the research results more practical, four aspects of urban infrastructures, domestic appliances and equipment, urban residents' attitude, and urban management and government policies have been defined and environmental factors were assessed under this quadruplet framework. Due to the gap in researches related to this field, in this paper, an attempt was made to emphasize on the cities of Mazandaran Province in Iran and the assessment of environmental factors has been done by the opinion of experts and urban managers and according to the theoretical and practical records in these cities. Therefore, considering this geographical constraint, SWOT technique have been used to assess environmental factors and the most important strengths, weaknesses, opportunities and threats in these four aspects have been identified and introduced.

In result, the suggested strategy and tactics were extracted and introduced for the use of future researchers, technical experts in this field, government legislators and city managers. The suggested tactics were categorized into three periods: short-term, medium-term, and long-term to provide better use and more practical modeling for future researchers in this field, experts and managers.

With the hope that suggested strategy and tactics mentioned in this paper may facilitate implementing smart homes with greatest use of emerging opportunities in the field of IT and Internet of Things, by considering existing and future urban infrastructures conditions in Iranian cities.

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