HOUSEHOLDS ENERGY CONSUMPTION AND CARBON DIOXIDE EMISSIONS OF MAHABAD CITY, IRAN

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DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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ABSTRACT

This study seeks to find a method to identify the dominant pattern of energy choice and consumption in households, centring on demographic factors affecting the use of home appliances. To this aim, this research dealt with a variety of energy sources that were widely used by households, namely LPG, electricity, and kerosene for cooking, heating and cooling, lighting, and home appliances. Additionally, significant associations for household energy choice and consumption were identified for demographic variables, including household size, gender, age of household head, educational level, and income group. A binary logistic regression was performed to obtain quantitative data provided by a survey from 821 households across residential districts of urban and rural areas in Mahabad Region, northwest of Iran. Collected data were analyzed within a proposed three-energy dimensions model (3-ED). The results showed that if the other variables remain constant, income may lead to variation in LPG and electricity consumption. Unlike other independent variables, the household-head age failed to have a significant impact. The findings can contribute to a better understanding of effective factors on household energy choice and consumption in other cities and be useful for the support of policymakers in their consumption patterns. This research explores the impact of different household demographic characteristics on energy-saving behaviours and carbon dioxide (CO2) emissions in Mahabad city located in the northwest of Iran. The structural model adopted was composed of six variables, including household age, household size, educational qualification, income quintile, gender, and energy conservation behaviour concerning demographic features, energy sources, and consumptions. To compare the predictability power of these variables' effects on households' energy conservation and CO2 emissions, a crisp instruction on how to evolve a statistical technique for analyzing data was provided by Partial Least Squares Structural Equation Modelling (PLS-SEM). It was revealed that households consume approximately 89.71% on liquefied petroleum gas (LPG), 9.87% on electricity, and the rest 0.43% on kerosene, petrol, and diesel on a monthly basis. Eventually, the results of this research showed that age, family size, and carbon dioxide emissions, except education background and income level, are significantly correlated with energy-saving behaviour.

ABSTRAK

Kajian ini bertujuan mencari satu kaedah bagi mengenal pasti corak pemilihan tenaga yang dominan dan penggunaan tenaga oleh isi rumah, berasaskan kepada faktor demografi mempengaruhi penggunaan perkakasan rumah. Untuk tujuan ini, kajian ini melibatkan pelbagai sumber tenaga yang digunakan secara meluas oleh isi rumah, iaitu LPG, elektrik, dan minyak tanah, untuk kegunaan seperti memasak, memanas dan menyejukkan, pencahayaan, dan perkakasan rumah. Tambahan pula, hubungan yang signifikan antara pilihan tenaga isi rumah dan penggunaannya telah dikenalpasti sebagai pemboleh ubah demografi merangkumi saiz isi rumah, jantina, umur ketua isi rumah, tahap pendidikan, dan pendapatan. Regresi logistik binari telah dijalankan bagi memperolehi data kuantitatif daripada kaji selidik 821 isi rumah di seluruh kawasan perumahan di bandar dan luar bandar di Wilayah Mahabad, barat laut Iran. Data yang diperolehi dianalisis dalam model tiga dimensi (3 ED) yang telah dicadangkan. Hasil kajian menunjukkan bahawa sekiranya pemboleh ubah yang lain adalah malar, pendapatan boleh menjurus kepada perubahan dalam penggunaan LPG dan elektrik. Tidak seperti pemboleh ubah bebas yang lain, umur ketua isi rumah tidak mempunyai implikasi yang signifikan. Penemuan ini dapat menyumbang kepada pemahaman mengenai faktor-faktor yang berkesan terhadap pilihan dan penggunaan tenaga isi rumah di bandar-bandar lain dan berguna bagi membantu pembuat dasar dalam corak penggunaannya. Kajian ini meneroka kesan bagi ciri-ciri demografi isi rumah yang berbeza terhadap tingkah laku penjimatan tenaga dan pelepasan karbon dioksida (CO2) di bandar Mahabad. Model struktur yang diguna pakai terdiri daripada enam pemboleh ubah termasuk umur isi rumah, saiz isi rumah, latar belakang pendidikan, tahap pendapatan, jantina, dan tingkah laku penjimatan tenaga yang berkait dengan ciri demografi, sumber tenaga dan penggunaannya. Bagi membandingkan kebolehramalan kesan pemboleh ubah keatas penjimatan tenaga dan pelepasan CO2 oleh isi rumah, arahan yang jelas berkaitan bagaimana untuk mengembangkan teknik statistik bagi menganalisis data telah disediakan oleh *Partial Least Squares Structural Equation Modelling* (PLS-SEM). Ia telah dikenalpasti bahawa isi rumah telah menggunakan kira-kira 89.71% gas cecair petroleum (LPG), 9.87% elektrik, dan baki 0.43% bagi minyak tanah, petrol dan diesel secara bulanan. Akhirnya, hasil kajian ini menunjukkan bahawa umur, saiz isi rumah dan pelepasan karbon dioksida, kecuali latar belakang pendidikan dan tahap pendapatan, adalah sangat berkait dengan tingkah laku penjimatan tenaga.

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LIST OF SYMBOLS

α	-	Cronbach's alpha
Xv	-	household features' vector
γ	-	household size
t	-	linear time trend
d_v	-	dependent parameter
rv	-	random variable

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Reviewing the previous works conducted, whether locally or globally, household energy consumption has attracted considerable attention (Munksgaard et al., 2000; Reinders et al., 2003; Bin and Dowlatabadi, 2005; Lutz et al., 2006; Jeong et al., 2011; Monahan and Powell, 2011; Scheer et al., 2013; Zhang et al., 2015; Long et al., 2017; Froemelt et al., 2018; Kurniawan et al. 2018; Elias et al., 2019; Soltani et al., 2019; Soltani et al., 2020). The fact of the matter is that the growing consumption of energy sources is believed to be one of the important causes of environmental changes (Ahmed et al., 2016; Sarkodie and Strezov, 2018; Sarkodie et al., 2019). Referring to the United Nations Environment Programme in 2016, households consume 40% of the primary energy that is based on natural resources, in the world. According to Terés-Zubiaga et al. (2018) and Sepehr et al. (2018), households are responsible for one-third of related global greenhouse gas (GHG) emissions. In addition, energy as a determinant factor for the growing Iranian economy is mainly derived from natural resources (Farajzadeh and Bakhshoodeh, 2015; Barkhordari and Fattahi, 2017). To compare the energy consumption over 2010-2013, it was observed that the average rate of energy-use in Iran is about 169 kg of oil, equivalent to per USD1000 GDP (gross domestic product), while this rate in the world has been 133.85 kg of oil. Furthermore, the research conducted by Farajzadeh and Nematollahi (2018) shows that the rate of energy intensity in Iran is 1.5 times higher than its average rate in the developed countries. In other words, as the prevailing evidence shows that energy consumption in Iran is responsible for 2% of global carbon dioxide (CO_2) emissions in comparison to total population which is 1% of globally rate (Hafeznia et al., 2017), Iran is transitioning to a consuming country. It is simply due to the fact that the demand for energy is increasingly

growing in Iran, such that even an energy-efficient system in producing sectors fails to prevent such a rapid shift.

To date, a plethora of research has been devoted to the investigation of factors impacting on the increased energy consumption from both supply and demand perspectives (Kowsari and Zerriffi, 2011; Pothitou et al., 2016). From the supply aspect, a variation in energy consumption can be associated with the consumption pattern, energy efficiency, production system, and consumption rate. Analysis of the household deals with the investigation of the role of behavioral pattern (Pothitou et al., 2016), climate (Zhou et al., 2014), socio-demographic and cultural (Yun et al., 2011), and socio-economic (Zhang et al., 2017) factors in the energy consumption pattern of households. Also, the association between energy consumption and behavioral pattern, cultural differences, and demographic changes like aging has been addressed in the research conducted by Muller and Yan (2018). It has been proved that the energy consumption of households is highly influenced by socio-economic characteristics and climate (Sánchez-Guevara Sánchez et al., 2017).

On the other hand, much of the literature on energy use by households has only emphasized the importance of effective factors on consumption side (Pothitou et al., 2016; Zhou et al., 2014; Yun et al., 2011; Muller and Yan, 2018) and determinants of variation energy choice in households have mainly been neglected in this regards. Therefore, the best method to adopt for this investigation is to address the issues in relation to all aspects of household energy use in terms of both choice and consumption. Regarding the above gap in the respective literature, this research aims to empirically identify the dominant pattern of energy choice and consumption in households from Mahabad City, Northwest of Iran. To this aim, this research considers the changes that the pattern of energy choice and consumption may steadily undergo, and it adopts a three-energy dimensions (3-ED) model, which exists among energy choice, energy consumption, and energy device (Figure 1.1).

energy consumption is affected by several variables, including household size, household age, income and educational level, and gender. In this regard, total energy demand and, therefore, total energy consumption in the residential sector have considerably increased, as a result of population growth in Iran (Tofigh and Abedian, 2016).

Knowing the key elements that impact energy consumption has become very significant (Wiesmann et al., 2011). To gain a better understanding of household energy choice and consumption patterns in an area, it is required to integrate energy sources used by households to meet their energy demands and needs. Several techniques have been developed to model an origin for explanation of household energy consumption. In this regard, the modeling origin for explanation of household energy consumption is "energy ladder" model. It models the correlation between the increase of household incomes and their fuel choices for energy consumption (Muller and Yan 2018). The determining hypothesis of energy ladder theory referred to the fact that households' energy source choices can be categorized between the least and the most technologically advanced energy sources either ascendingly or descendingly. However, the energy ladder model has been vigorously challenged in recent years by researchers (van der Kroon et al., 2013; Ruiz-Mercado and Masera, 2015; Choumert-Nkolo et al., 2019).

In Iran, such a hypothesis rules households' energy source choices since the farther they go financially, the more sophisticated energy sources they choose. However, there are certain drawbacks associated with the use of energy ladder model in Iran; due to the betterment of households' income, it does not necessarily move from a particular kind of energy source towards an ideal source. In other words, households' energy choices cannot be put in a linear continuum whose lowest end includes dung, crop residue, and fuelwood and whose the highest end is made up of liquefied petroleum gas (LPG) and electricity. Unlike "energy ladder" model, "energy services" model does not believe in a linear developmental path in households' energy source choices. It is thought that "energy services" refer to the benefits of a particular energy source that facilitate human beings' welfare (Sovacool, 2011). Being an exclusivist model, energy ladder model only emphasizes

the determining role of households' income in their energy source choices. While it needs to be acknowledged that households' income does play a key part in their energy source choices, it also needs to be heeded that other factors also affect households' energy source choices.

Iran, as one of the top 10 countries for CO_2 emissions, is being faced by a fast rate of urbanization and a trend of migration from rural settlements to urban areas (Afsharzade et al., 2016), inasmuch the ratio of urban settlements has raised from more than one-third (33.73%) to about three-fourth (74.34%) in 1960 to 2017, respectively (World Bank, 2018). Industrialization and social-political transformation are considered as the leading causes of this rapid shift in settlement distribution. This high rate of urbanization in fifty-eight years clears that the increasing amount of energy demand, especially in urban parts of the country, should be considered as the primary factor of energy consumption for plans. In recent years, in Iran, there has been a definite shift from oil products to natural gas and now around three-fourths of national energy consumption is covered by this sector. Notably, the pattern of energy consumption in Iran is not the same as that defined by the Environmental Kuznets Curve that is an increase in income is likely to be accompanied by an increase in energy consumption. This growing trend in energy consumption by the developed and developing nations could be because of entertainment devices and information technology (Kerkhof et al., 2009) and an improvement in the standard of living (Wang and Yang, 2014).

The industrial revolution brought a new kind of life to the people living on the earth. Indeed, it is easy to define two different worlds before and after the industrial revolution (18^{th} century). The rapid growth of population, as one of the first results of the new Age (i.e., after the industrial revolution), made people to increase their abilities in consuming and providing energy from nature (United Nations Development Programme, 2004). The invention of steam engine increased human's capability in transforming different forms of energy used for delivering goods and services (TWAS, 2008). Global energy consumption from 3.3 Gtoe in 1960 has arrived 10 Gtoe in 2012 and predicted to be 14.0 Gtoe in 2020 (Bahrami and Abbaszadeh, 2013). Households, as residential sector of energy consumers,

provide 40% and 17% of global energy consumption and global CO_2 emissions, respectively. Global residential energy consumption grew by 14% from 2000 to 2011, most of them in developing countries where population, urbanization and economic growth have been the main driving factors (Nejat et al., 2015).

Because the residential sector accounts for nearly one-third of total carbon emissions and two-fifths of total energy consumption in Iran (Farajzadeh and Nematollahi, 2018), a research in this field is deemed to be of great importance. As a case study, the essential factors in selecting the MC are its locational advantage to Iraq and Turkey borders and its play as a political and cultural center in northwest of Iran. Overall, using the 3-ED model, the current research centers on the use of appliances for cooking, space lighting, heating and cooling to recognize factors overshadowing the changes in the household energy choice and consumption in addition to the demographic feature of the households. It is also possible that the findings of this research might be applicable to other areas in most developing countries, especially in Asia. What stands out in this regard is that the given pattern of energy choice and consumption by households makes a significant contribution to reduce GHG emissions, especially CO_2.

It is further emphasized that more than 50% of the world's inhabitants are in urban areas now, and this distribution is rising over time, predicted to arrive at 60 and 70 % by 2030 and 2050, respectively. Increasing urbanization will lead to a noteworthy extent in energy use and CO_2 emission, mainly in Africa and Asia, where urban energy demand is shifting from CO_2-neutral power resources such as waste and biomass to CO_2-concentrated energy sources. On the other hand, power demands are strongly dependent on population, and the people that live in urban regions are the main sources for CO_2 emission, which is one of the most essential factors in greenhouse effect and global warming. Consuming supplies and services by households leads to increase in CO_2 emission. The using models of households have differences within countries due to diversity in household features such as income, the number, age and level of education of household members, population density, and the place- rural or urban that they are living. These variations in household CO_2

emissions may have major effects on climate change related policies, as it can offer a close view of the equity measurement of those policies.

Climate change is a global environmental problem that scientists, environmentalists, politicians, and policy-makers are dealing with today, and urban planners are increasingly concerned about the connection between urban form and transportation at a local level and climate change (Betsill and Bulkeley, 2006; Bulkeley and Kern, 2006; Betsill and Bulkeley, 2007). Land development directly impacts transportation behavior by determining *where* the people live, and *how* or *how much* people travel for work, school, family, entertainment, personal business, and social activities. Transportation is directly related to fossil fuel consumption and, hence, influences the amount of GHG emissions. Spatial planners are examining the ways in which land-use characteristics of density, diversity, neighborhood design, access to transit, local and regional accessibility, centrality of development, and others impact household travel. In the past decade, dozens of studies have been published that explore the inter-relationships between land-use or built-form characteristics and vehicular travel from the perspectives of environmental sustainability, public health, quality of life, safety, and resource management. Studies from the perspective of environmental sustainability have been increasingly focusing on the massive CO_2 emissions from personal-household vehicles that contribute to climate change in a big way. In addition, there are large-scale local and state government efforts to implement carbon reduction strategies. There is a new synergy in spatial planning today that focuses on integrated land use and transportation solutions as essential carbon reduction strategies.

The past decade has seen the rapid development of urbanization and industrialization in Iran caused to accelerate the energy portfolio. Iran has vast oil and gas reservoirs that are caused to consume these fossil fuels, mainly natural gas, to supply its energy chain. Recently, the residential sector accounts for one-third of total final consumption (TFC), which makes it the largest energy-consuming sector in the country. This sector's demand increased sharply by 60% during the period from 2000 to 2011 and consequently surpassed 49 MTOE (million tonnes of oil equivalent). Because Iran has 18% of world natural gas reserves (the most extensive

reserves in the world), natural gas is the greatest option in the energy basket of the sector, and its share reaches 74% of TFC in the industry. The new government policy to replace oil products with natural gas has led to rapid development of natural gas distribution pipelines and 130% growth in natural gas consumption, from 16.2 MTOE in 2000 to 37.3 MTOE in 2011. Oil products are the second primary energy source for dwellings in Iran. Although Iran holds the fourth-largest oil reserves in the world, oil production has dipped considerably, by 40% from 10.8 MTOE in 2000 to 6.5 MTOE in 2011 because of replacement with natural gas. Like natural gas, electricity consumption also grew significantly, by 80% during that period, but electricity's share was only 10% of TFC in 2011. Coal and biomass resources constitute minor resources, representing only 1.5% of TFC.

Among the top10 emitters, Iran has had the most growth in CO_2 emissions during the last forty years, nearly 500% (Figure 1.2). The same trend is observed in residential direct CO_2 emissions, which exceeded 105 Mt in 2011, a level 245% higher than it was in 1990. Huge energy consumption in this sector has forced the government to take prompt measures in last decade to control this trend. In 2009, the government decided to raise energy prices and gradually cut energy subsidies. This policy caused a slump in demand, and consequently, the growth rate of oil and electricity consumption fell to -15% and -8%, respectively (Nejat et al., 2015). Moreover, the government provides incentives for highly efficient equipment such as cooling systems and solar water heaters (Nejat et al., 2015).

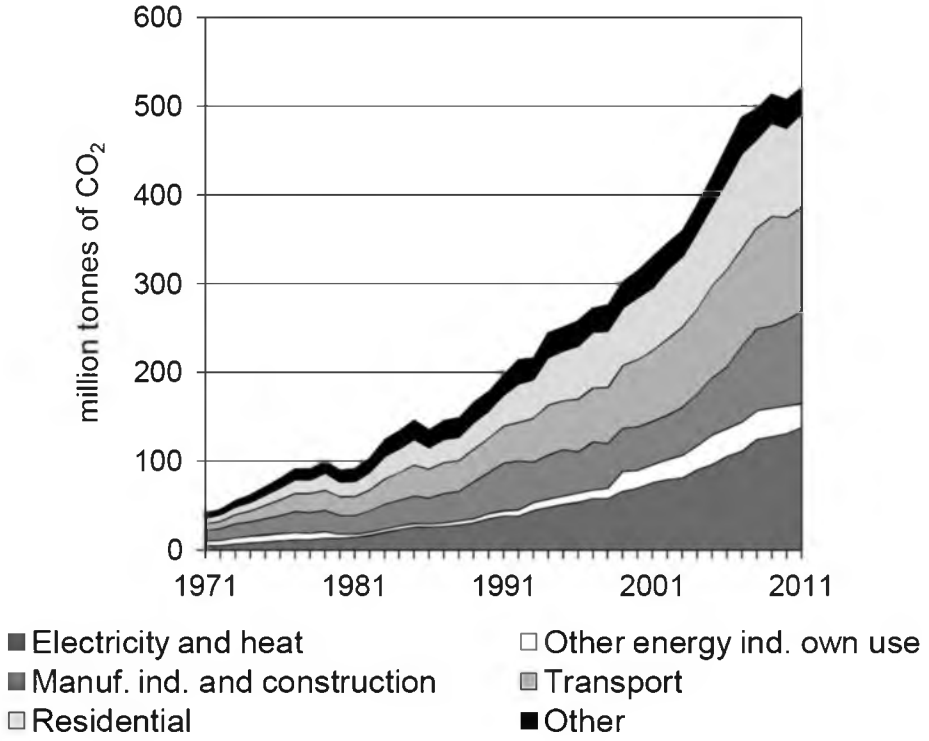

Figure 1.2 Sectorial CO_2 emissions in Iran from 1971 to 2011 (adopted from Nejat et al., 2015)

Energy use and sustainable development are complex issues for researchers as the wide difference between energy supply, demand, distribution and use at global and local levels derive from different socio-economic and cultural factors among countries. Hard access to modern energy services and environmental hazards of using traditional fuels are the main challenges of energy sector in developing countries. The increasing rate of urbanization had made it more dangerous to supply more energy for city dwellers as it is necessary for lighting, cooking, heating, cooling, and using electrical appliances.

Iran, as one of the top 10 countries in CO_2 emissions (Table 1.1), is the main owner of oil and natural gas resources and tries to resolve most of its national energy demand by preparing and using fossil fuels. In recent years, there has been a clear shift from oil products to natural gas and now around ¾ of national energy consumption is covered by this sector. Iran is a vast country with different environment-friendly natural energy sources (such solar energy or wind power). Current programs lead to increasing rate of CO_2 emissions, and still there is no clear and significant plan for applying clean energy sources.

Table 1.1 Main countries responsible for global CO_2 emissions

Rank	Country	Emissions in 2017 ($MtCO_2$)	% of Global Emissions
#1	China	9,839	27.2%
#2	United States	5,269	14.6%
#3	India	2,467	6.8%
#4	Russia	1,693	4.7%
#5	Japan	1,205	3.3%
#6	Germany	799	2.2%
#7	Iran	672	1.9%
#8	Saudi Arabia	635	1.8%
#9	South Korea	616	1.7%
#10	Canada	573	1.6%
#11	Mexico	490	1.4%
#12	Indonesia	487	1.3%
#13	Brazil	476	1.3%
#14	South Africa	456	1.3%
#15	Turkey	448	1.2%
	Top 15	26,125	72.2%
	Rest of World	**10,028**	**27.7%**

Source: World Economic Forum (2017)

There are very few researches on household energy consumption in Iran. Previous studies (Davoudpour and Ahadi, 2006; Lotfalipour et al., 2010; Pourazarm and Cooray, 2013; Nejat et al., 2015; Moshiri, 2015; Afsharzadeh et al., 2016; Javanroodi et al., 2019) have focused on the proposed plans and rarely concentrated on households CO_2 emissions, so this research could be useful for policymakers and planners. Decreasing carbon dioxide emissions is the only way to reduce the impacts of global warming. Energy consumption and global warming issues are the most essential problems that humans confront. Global warming is one of the most critical issues of the last decade, and the threat of global warming is increasing. Several adverse effects of global warming have been observed. The Intergovernmental Panel on Climate Change (IPCC) reported that the worldwide average combined land and ocean surface temperatures climbed about 0.85 ℃ between1980 and 2012, and global sea level increased by 0.19 m between 1901 and 2010 (IPCC, 2014). The IPCC also predicted the global surface temperature and sea level would increase by a maximum of 4.8 ℃ and 0.82 m, respectively, by 2100 (IPCC, 2014). Therefore, most people or governments feel the need to decrease energy consumption and CO_2 emissions.

1.4 Research Questions

(1) How the household energy consumption differ based on spatial and demographic patterns in Mahabad City, Iran?

(2) To what extent the level of carbon dioxide emissions reduce based on different spatial and demographic patterns in Mahabad City, Iran?

(3) How households energy consumption and carbon dioxide emissions of Mahabad City influenced by spatial and demographic factors?

(4) What is the relation between population density and carbon emissions of Mahabad City?

1.5 Research Objectives

The aim of this research is to provide understanding on influential factors that determine households energy consumption and carbon dioxide emissions of Mahabad City in Iran. The specific objectives are:

(1) To investigate the influence of socio-demographic factors on household energy consumption in Mahabad City.

(2) To examine the level of carbon dioxide emissions based on different spatial and demographic patterns in Mahabad City, Iran.

(3) To analyze households energy consumption and carbon dioxide emissions of Mahabad City influenced by spatial and demographic factors.

(4) To develop a framework for household energy consumption and CO_2 emissions in Mahabd City, Iran.

1.6 Significance of the Research

Iran had a rapid rate of urbanization and industrialization during 20th century. Based on the first Iranian National Census in 1956, around 31% of people were living in 199 city centers with total urban population of 6 million. After five decades (in 2006), urban rate and number arrived to 68.5% and 48.2 million. The last census in 2016 shows the 71.4% of urbanization and more than 53.6 million urban dwellers reported by Statistical Center of Iran (SCI, 2018).

As an OPEC (The Organization of the Petroleum Exporting Countries) member, Iran has a huge amount of fossil fuels and is the fourth and second largest oil and natural gas producer of the world, respectively (Mohammadnejad et al., 2011). The increasing population and easy access to energy sources, led to a not-controlled level of energy consumption in different sectors of Iranian society and as a result, final fossil fuel consumption increased by about 617% and carbon emissions increased by about 610% from 1967 to 2007 (Lotfalipour et al., 2010).

During the past three decades of rapid economic development, Iranian households have experienced huge lifestyle changes starting in near poverty conditions in the 1970s to fulfil basic household needs and then toward pursuing higher living standards. According to Statistical Center of Iran (SCI), per capita annual disposable income for urban residents increased by 150% from 10 USD in 1990 to 25 USD in 2015 (SCI, 2018). With increased disposable income, per capita residential direct energy use rose 51% from 56.6 kg standard coal equivalents (SCE) in 1990 to 85.5 kg SCE in 2015 (SCI, 2018). However, residential direct energy consumption has been growing more slowly than total energy use in Iran. The share of residential direct energy use decreased from 16.4% in 1990 to 10.7% in 2015. Because of the low share of household consumption in GDP and the low share of residential direct energy use, most of Iran's energy conservation policies are focused on industries and primarily neglect households.

Considering the fact that the residential sector accounts for nearly one-third of total carbon emissions and two-fifths of total energy consumption in Iran

(Farajzadeh and Nematollahi, 2018), a study in this field is deemed to be of great importance. Overall, using the 3-ED model, the current research centers on the use of appliances for the purpose of cooking, space lighting, heating, and cooling to recognize factors overshadowing the changes in household energy choice and consumption, in addition to the demographic features of the households. Besides, to compare predictability power of the impact of the demographic characteristics concerning households' energy conservation in Mahabad City, this research uses a confirmatory factor analysis through Smart Partial Least Squares (SmartPLS) software. The given pattern of this research might be applied by other countries and make a valuable contribution with regard to reducing CO_2 emission by households.

1.7 Scope of the Research

This research focuses on household energy choice and consumption with an emphasis on CO_2 emissions of residents in Mahabad City. These emissions could be a result of energy used by households for lighting, cooking, heating, cooling, and operating appliances. Therefore, in accounting for the CO_2 emissions from household energy consumption in the research area, it was limited to only emissions from electricity, water, oil, and natural gas consumption and petrol and diesel used by households.

As a case study, the important factors in selecting Mahabad City are its locational advantage in terms of the Iraq and Turkey borders and its role as a political and cultural center in northwest of Iran. The selection of Mahabad among the various cities in Iran for this research is based on some factors. First, this city has special importance both for the Iranian government and Kurdish people. Second, global warming has a noticeable effect on the region, as is visible. Urmia Lake, in 35 km of Mahabad's north side, is in danger, and most of its surface has been dried. Although there were a lot of governmental and public plans and programs to prevent disappearing Urmia Lake, all of them were defeated as a simple result of climate change and unsustainable development. Now there is a severe vital risk for all the cities and human settlements around this lake. Third, inside the city, increasing levels

of private transportation and natural limitations led to drastic daily traffic problems and is a significant challenge for urban planners. Mahabad City is classified into three residential areas (low, medium, and high density) and two rural areas (with easy and hard access to the main roads) from which respondents were randomly selected, and this constituted the scope of household carbon emission survey. At last 821 questionnaires collected from different settlements and places in Mahabad City.

To precisely predict the household CO_2 emissions scenario occurring in the coming years, knowledge about age-emission profiles specifying how larger families can scale their expenditure is of importance. It is possible that the findings of this research might be applicable to other areas in most developing countries, especially in Asia. What stands out in this regard is that the given pattern of energy choice and consumption by households makes a major contribution to reduce GHG emissions. It is also believed that the results of this research could be useful for local and national policymakers interested in investigating the impact of demographic characteristics on carbon dioxide emissions.

1.8 The Study Area

In 17^{th} century, the city of Mahabad became the capital of Mukriyan principality and from the time, has an undeniable role in most of the sociological, political, and cultural events. Mahabad City is the historical center of the Mukriyan Region, located in West Azerbaijan province and southern part of Urmia Lake. The city is built on several hills, with average 1300 meters above the sea level. The majority of the city's population is Kurdish and Shafi'i Muslims. Mahabad is located on longitude 45°43′20″E of the Greenwich Meridian and 36°45′47″N of equator (Figure 1.3). The city is on the Zagros Mountains with cold and snowy winters. The locational advantage of Mahabad and its proximity to Iraq and Turkey borders playing an essential role in its choice as the political and cultural center of Mukriyan Region in Kurdistan.

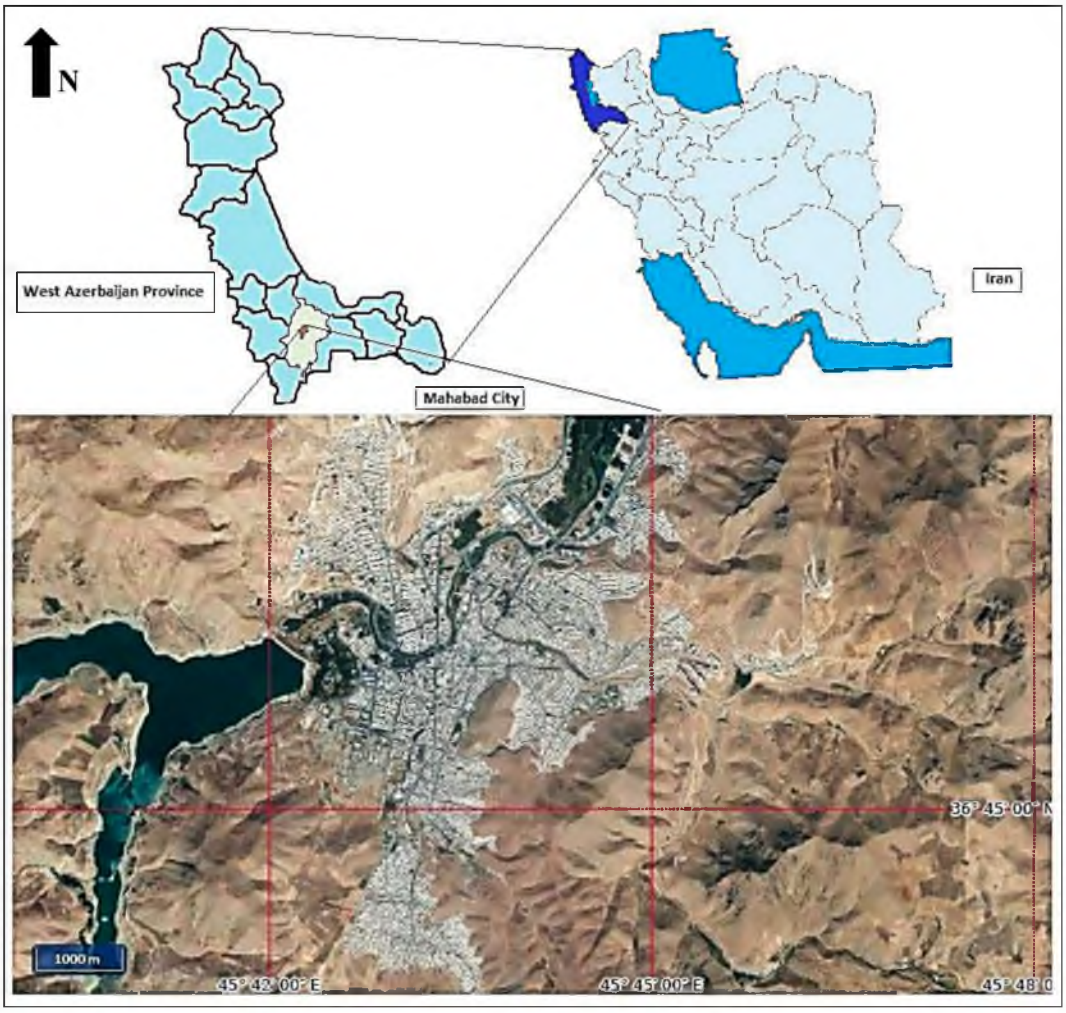

Figure 1.3 A Locational map of the studied area, Mahabad City in the northwest of Iran

1.9 Overview of the Research

According to the primary research objectives, this research involves some main chapters as follows. This chapter is organized into five sections. Sections 1 and 2 present the background of the research and energy consumption by households, respectively; Section 3 identifies the main research problem; Sections 4 and 5, respectively, present the main research questions and objectives; Sections 6 and 7 describe the research approach in household energy consumption including significances and scopes of the research, respectively; Section 8 introduces the study area, Mahabad City.

In Chapter 2, a review of the existing household energy consumption is discussed. Chapter 2 also allocates to study area with a basic view of Iran's national carbon policy as an essential global carbon emitter. Subsequently, Chapter 3 describes the methodology of data selection for this research, the data sources, the scope of this research, and the process of organizing this vast set of information to match the requirements of this research. It describes the methodology of variables selected for questionnaire from the travel data and Iran census.

Chapter 4 presents the regression model development and the iterative process adopted to choose them, the model specifications and analysis of the results, and their interpretations. Chapter 5 presents the fundamental analysis and describes in detail the results attained from variables that influence household CO_2 emission and energy consumption within the study area.

Finally, Chapter 6 discusses the research findings in the context of regional and metropolitan development theory and the possible planning applications of the research outcomes. It also briefly summarizes the impact of households' energy consumption, the scope and limitations of this research, and points out a few directions for future research.

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